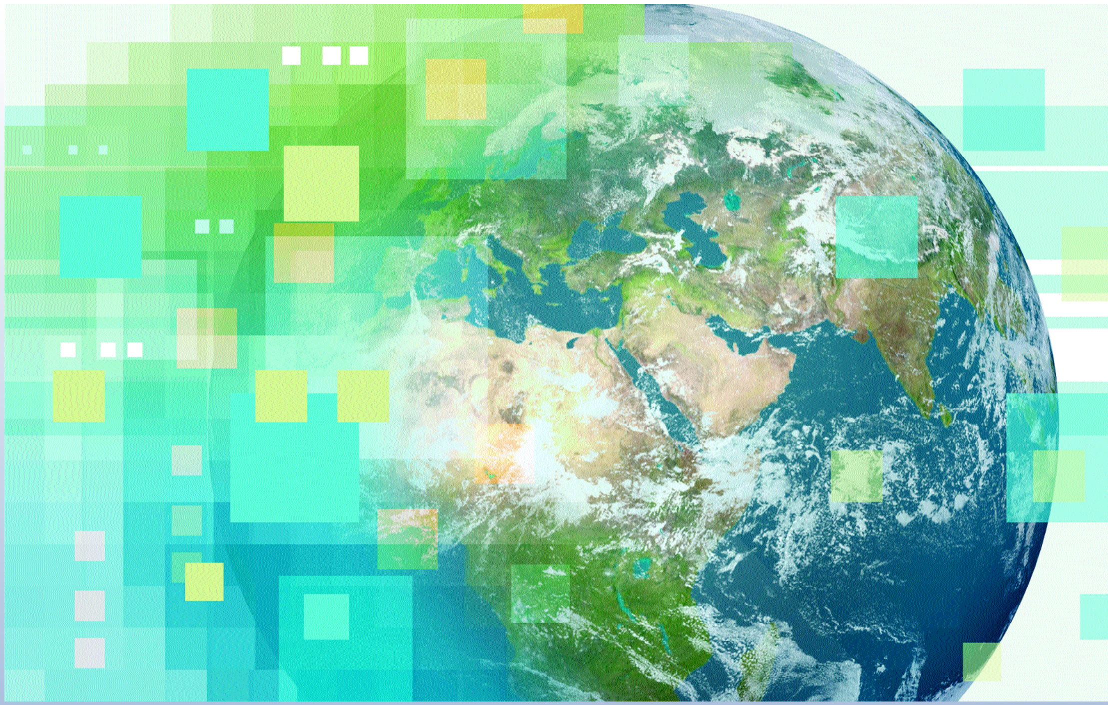
Globalization and Offshoring of Software

A Report of the ACM Job Migration Task Force



Association for Computing Machinery
Advancing Computing as a Science & Profession

The Association for Computing Machinery (ACM) is an educational and scientific society uniting the world's computing educators, researchers, and professionals to inspire dialogue, share resources, and address the field's challenges. ACM strengthens the profession's collective voice through strong leadership, promotion of the highest standards, and recognition of technical excellence. ACM supports the professional growth of its members by providing opportunities for life-long learning, career development, and professional networking.

For more information about ACM,
visit http://www.acm.org

For an electronic version of all or parts of this report,
visit http://www.acm.org/globalizationreport

Globalization and Offshoring of Software

A Report of the ACM Job Migration Task Force

William Aspray, Frank Mayadas, and Moshe Y. Vardi, Editors

Association for Computing Machinery
Advancing Computing as a Science & Profession

The ACM Job Migration Task Force

Alok Aggrawal (Founder and Chairman of Evalueserve)

Frances E. Allen (Fellow Emerita at the T. J. Watson Research Center)

Stephen J. Andriole (Thomas G. LaBrecque Professor of Business Technology at Villanova University)

Ashish Arora (Professor of Economics and Public Policy at Carnegie Mellon University)

William Aspray (Rudy Professor of Informatics and Special Advisor on Information Technology and Professional Partnerships in the Office of the Vice President for Research at Indiana University)

G. Balatchandirane (Teacher of East Asian Economic History and Japanese language at the Department of East Asian Studies, University of Delhi)

Burt S. Barnow (Associate Director for research and Principal Research Scientist at the Institute for Policy Studies at the Johns Hopkins University)

Orna Berry (Venture Partner in Gemini Israel Funds Ltd. and the Chairperson of Adamind (LSE: ADA) Ltd. and Prime Sense, Inc.)

Michael Blasgen (Consultant in information technology)

Arndt Bode (Professor of Informatics of Technische Universität München, Germany)

Jean Camp (Associate Professor in the School of Informatics, Adjunct Professor of Telecommunications, and Adjunct Professor of Computer Science at Indiana University)

Seymour E. Goodman (Professor of International Affairs and Computing at the Sam Nunn School of International Affairs and the College of Computing, Georgia Institute of Technology)

Vijay Gurbaxani (Associate Dean, Professor of Information Systems, and Director of the Center for Research on IT and Organizations Industry-University Consortium at the Graduate School of Management, University of California at Irvine)

Juris Hartmanis (Walter R. Read Professor of Computer Science and Engineering, Emeritus at Cornell University)

Charles House (Director of Societal Impact of Technology for Intel Corporation)

William Jack (Corporate Vice President with SAIC and currently acting as the senior telecommunications advisor to the Chief of IT IS at the National Security Agency)

Martin Kenney (Professor in the Department of Human and Community Development at the University of California, Davis and a Senior Project Director at the Berkeley Roundtable on the International Economy)

Stefanie Ann Lenway (Dean of the College of Business Administration at the University of Illinois at Chicago, as well as Professor of Management)

Vivek Mansingh (A Country Manager for India Development Center of Dell Products Group, Bangalore)

Göran Marklund (Science and Technology Attaché at the Swedish Offices of Science and Technology within the Swedish Embassy in Washington DC)

Frank Mayadas (Program Officer at the Alfred P. Sloan Foundation)

Peter Mertens (Professor for information systems at the University of Erlangen-Nuremberg, Germany)

Rob Ramer (Information security consultant)

Bobby Schnabel (Vice Provost for Academic and Campus Technology at the University of Colorado at Boulder)

Bankim Shah (Founder and president of BRS Associates, Inc)

Marie Stella (Lead security engineer for the FAA's National Airspace Communications Effort)

Valerie E. Taylor (Head of the Dwight Look College of Engineering's Department of Computer Science and holder of the Royce E. Wisenbaker Professorship II at Texas A & M University)

Takashi Umezawa (Professor of Human Resource Management in Kokushikan University, Tokyo, Japan)

Moshe Y. Vardi (George Professor in Computational Engineering and Director of the Computer and Information Technology Institute at Rice University)

Roli Varma (Regents Lecturer and an associate professor in the School of Public Administration at the University of New Mexico)

Richard C. Waters (President and CEO of Mitsubishi Electric Research Laboratories (MERL))

John White (Executive Director and Chief Executive Officer of the Association for Computing Machinery (ACM))

Stuart Zweben (Associate Dean of Academic Affairs and Administration in the College of Engineering at The Ohio State University)

Globalization and Offshoring of Software
A Report of the ACM Job Migration Task Force

Foreword

For the past six decades, the Association for Computing Machinery (ACM) has been an integral part of the evolution of computing as a science and profession. In early 2004, ACM members began expressing concern about the future of computing as a viable field of study and work. There were daily stories in national and international media describing major shifts in employment that were occurring largely as a result of offshoring. Combined with the impact of the end of the dot.com boom, these reports raised more questions than they answered in the minds of many ACM members.

Given these concerns, ACM Council commissioned a Task Force to look at the facts behind the rapid globalization of IT and the migration of jobs resulting from outsourcing and offshoring. Being an international organization, ACM expected the task force to look at the issue from a global perspective, as compared to a country-centric one. This was not intended to be a study of offshoring from the United States to India and China and the impact of that offshoring on the computing profession in the United States. Instead, the task force was charged with looking at the forces shaping the migration of jobs worldwide in the computing and information technology fields. Prior to this effort, no study has looked at offshoring on a global scale.

ACM Presidents Maria Klawe (2002-04) and David Patterson (2004-06) invited Frank Mayadas of the Sloan Foundation, Moshe Y. Vardi of Rice University, and Bill Aspray of Indiana University to lead the effort. This group commissioned a task force of computer scientists, social scientists, and labor economists from around the world. The Task Force held four in-person meetings at which the facts and data surrounding the issue were presented and discussed. In the process, trends emerged, myths were debunked, and a more realistic picture of the current state and likely future of the information technology field, profession, and industry emerged.

The report resulting from this study is significant. Moreover, the annotated bibliography available on the ACM Web site provides the most comprehensive list of reports, resources, and papers assembled on the topic of offshoring. As described in detail in the eight chapters that comprise the report, the field of computing and information technology has experienced a dramatic shift in the past five years to a truly global industry. The forces that have driven and shaped this change are still at play and will continue. The implications for every ACM member are significant. Full participation in the systems, software, and services portion of the global information technology field will require deep grounding in the fundamentals of computing, new knowledge surrounding business processes and platforms, and a deeper understanding of the global community in which work will be done. The educational systems that underpin our profession will need to change.

The future of IT is exciting, but it is a future very different from the past, and even from the present.

John R. White

ACM Chief Executive Officer

CONTENTS

APPENDICES

Globalization and Offshoring of Software
A Report of the ACM Job Migration Task Force

Executive Summary and Findings

Why this Study?

This study reports on the findings of a Task Force established by The Association for Computing Machinery (ACM) to look at the issues surrounding the migration of jobs worldwide within the computing and information technology field and industry. ACM initiated this study to provide a deeper understanding of the trends in, and the forces behind, the globalization and offshoring of software. Because ACM is an international educational and scientific computing society, the study approached the issue of offshoring of software from an international as opposed to a United States-centric perspective. Moreover, the task force that conducted the study comprised not only computer scientists (ACM's traditional constituency) but also labor economists and social scientists from around the world. We believe that this approach, and this perspective, are unique. Most reports on globalization and offshoring are produced either by governments or national organizations, and thus provide an inherently national perspective, or by consulting firms in pursuit of their own or their clients' business interests.

The primary purpose of the study is to provide ACM's 83,000 members, the computing field, the IT profession, and the public an objective perspective on current and future trends in the globalization of the software industry so that ACM members can better prepare themselves for a successful future in the system, software, and services portion of the global information technology field. We also believe this extensive study will be of value to those shaping the policies, priorities, and investments any country must make if it desires to remain or become a part of the global software-systems-services industry.

Scope of the Study

This study reports on the current state of globalization and offshoring of software and related information technology (IT) services. (*Outsourcing* refers to having work for a company done by another organization. *Offshoring* refers to having this work done in another country, whether or not it is done by part of the same company.)

The report is focused primarily on software systems work carried out in developing countries for export, as opposed to work done in a developing country for their local market. The ACM Task Force reviewed existing reports and data from around the world, and heard in-person from many experts, on issues relevant to globalization and offshoring. In the process, the Task Force took an in-depth look at the following:

1. The economic theories and data that underpin our current understanding of the forces shaping globalization today and in the future.
2. Offshoring from the perspective of different countries—both developed and developing.
3. Offshoring from the perspective of different types of corporations.
4. The globalization of computing research.
5. The risks and exposure that offshoring engenders.
6. The implications for educational systems throughout the world.

7. The political responses to the opportunities and disruptions that accompany globalization.

Each of these areas is explored in detail in a chapter of the report.

Findings and Recommendations

In reviewing many existing reports, data, theories, and perspectives, a number of key findings and recommendations emerged.

1. Globalization of, and offshoring within, the software industry are deeply connected and both will continue to grow. Key enablers of this growth are information technology itself, the evolution of work and business processes, education, and national policies.

The world has changed. Information technology is largely now a global field, business, and industry. There are many factors contributing to this change, and much of this change has occurred within the past five years. Offshoring is a symptom of the globalization of the software-systems-services industry.

This rapid shift to a global software-systems-services industry in which offshoring is a reality has been driven by advances and changes in four major areas:

1. *Technology*—including the wide availability of low-cost, high-bandwidth telecommunications and the standardization of software platforms and business software applications.
2. *Work processes*—including the digitalization of work and the reorganization of work processes so that routine or commodity components can be outsourced.
3. *Business models*—including early-adopter champions of offshoring, venture capital companies that insist the companies they finance use offshoring strategies to reduce capital burn rate, and the rise of intermediary companies that help firms to offshore their work.
4. *Other drivers*—including worldwide improvements in technical education, increased movement of students and workers across national borders, lowering of national trade barriers, and the end of the Cold War and the concomitant increase in the number of countries participating in the world market.

2. Both anecdotal evidence and economic theory indicate that offshoring between developed and developing countries can, as a whole, benefit both, but competition is intensifying.

The economic theory of comparative advantage argues that if countries specialize in areas where they have a comparative advantage and they freely trade goods and services over the long run, all nations involved will gain greater wealth. As an example, the US and India have deeply interconnected software industries. India benefits from generating new revenue and creating high-value jobs; the US benefits from having US-based corporations achieve better financial performance as a result of the cost savings associated with offshoring some jobs *and* investing increased profits in growing business opportunities that create new jobs. This theory is supported to some extent by data from the US Bureau of Labor Statistics (BLS). According to BLS reports, despite a significant increase in offshoring over the past five years, more IT jobs are available today in the US than at the height of the dot.com boom. Moreover, IT jobs are predicted to be among the fastest-growing occupations over the next decade.

Some economists have recently argued that in certain situations offshoring can benefit one country at the expense of another. While debate continues about this aspect of theory/policy, the majority of the economic community continues to believe that free trade is beneficial to all countries involved, though some argue that globalization may lead to technology leaders' losing their current dominant position.

In any event, economists agree that even if a nation as a whole gains from offshoring, individuals and local communities can be harmed. One solution to this potential negative impact is for corporations or their governments to provide programs that aid these individuals and their related communities in once again becoming competitive. The cost of such "safety-net" programs can be high and, thus, difficult to implement politically.

3. **While offshoring will increase, determining the specifics of this increase is difficult given the current quantity, quality, and objectivity of data available. Skepticism is warranted regarding claims about the number of jobs to be offshored and the projected growth of software industries in developing nations.**

Data for making good decisions about offshoring are difficult to obtain. Government data as collected are not very helpful and do not adequately address the specific issue of offshoring. The objectivity and quality of other data sources, especially the data in reports from consulting firms and trade associations, is open to question, as these organizations may be serving their own agendas. Projections are always more suspect than data on current employment levels.

It is very difficult to determine how many jobs are being, or will be, lost due to offshoring. The best data available are for the United States. Some reports suggest that 12 to 14 million jobs are vulnerable to offshoring over the next 15 years. This number is, at best, an upper limit on the number of jobs at risk. To date, the annual job loss attributable to offshoring is approximately 2 to 3 percent of the IT workforce. But this number is small compared with the much higher level of job loss and creation that occurs every year in the United States.

Thirty percent of the world's largest 1000 firms are offshoring work, but there is a significant variance between countries. This percentage is expected to increase, and an increase in the amount of work offshored is consistent with the expected growth rate of 20 to 30 percent for the offshoring industries in India and China. Almost all estimates are based on reports from national and international consulting firms and, thus, subject to scrutiny.

4. **Standardized jobs are more easily moved from developed to developing countries than are higher-skill jobs. These standardized jobs were the initial focus of offshoring. Today, global competition in higher-end skills, such as research, is increasing. These trends have implications for individuals, companies, and countries.**

The report considers several case studies of firms and how they are addressing offshoring, including software service firms in low-wage nations and four types of firms in high-wage nations: packaged software firms, software service firms, entrepreneurial start-up firms, and established firms outside the IT sector. These cases show that the amount and diversity of work being offshored is increasing; and companies, including start-ups, are learning how to access and use higher skill levels in developing countries.

One example of a higher-skill area now subject to global competition is computing research. Historically, the bulk of this research was carried out in only a few countries - countries with high purchasing-power-parity adjusted gross domestic product (PPP GDP) and with a relatively large percentage of PPP GDP devoted to research and development. This situation is changing rapidly and the trend looks inexorable. Many companies have established research centers in multiple countries. Most of these companies retain strong research operations in their home country. This fact, combined with increasing national research investment in India and China, is leading to both an increase in the total worldwide investment in research and a wider distribution of research activities around the world.

People are by far the most important asset in research. The historic advantage held by Western Europe and the United States is not as strong today as in the past, given the developments in the graduate education systems in China and India, increased opportunities for research careers in those countries, and the rising national investment in research. The United States, in particular, faces a challenge in its inability to recruit and retain foreign students and researchers in the numbers it did in the past. Its dominance in the research area is likely, therefore, to be challenged.

Finally, while there is no way of ensuring lifetime IT employment, there are steps that students and IT workers can take to improve their chances of long-term employment in IT occupations. These include obtaining a strong foundational education, learning the technologies used in the global software industry, keeping skills up to date throughout their career, developing good teamwork and communication skills, becoming familiar with other cultures, and managing their careers so as to choose work in industries and jobs occupations less likely to be automated or sent to a low-wage country.

5. **Offshoring magnifies existing risks and creates new and often poorly understood or addressed threats to national security, business property and processes, and individuals' privacy. While it is unlikely these risks will deter the growth of offshoring, businesses and nations should employ strategies to mitigate them.**

When businesses offshore work, they increase not only their own business-related risks (e.g., intellectual property theft, failures in longer supply chains, or complexity arising from conflicting legal environments) they also increase risks to national security and individuals' privacy. Businesses have a clear incentive to manage these new risks to suit their own interests, but nations and individuals often have little awareness of the exposures created. For example, many nations have adopted commercial off-the-shelf (COTS) software and Internet Protocol technologies in IT-based military systems and critical infrastructure systems. Many COTS systems are developed, in part or whole, offshore, making it extremely difficult for buyers to understand all source and application code. This creates the possibility that a hostile nation or non-governmental hostile agents (terrorist/criminal) can compromise these systems. Individuals often are exposed to loss of privacy or identity theft. Bank records, transaction records, call center traffic, and service centers all are being offshored today. Voluminous medical records are being transferred offshore, read by clinicians elsewhere, stored and manipulated in foreign repositories, and managed under much less restrictive laws about privacy and security than in most developed countries.

These risks can be managed by companies and governments through the use of risk mitigation strategies. For example, businesses should minimize access to databases by offshore operations and encrypt data transmissions; offshoring providers should be vetted carefully; companies should have security and data privacy plans and be certified to meet certain standards; and service providers should not outsource work without the explicit approval of the client. Nations can adopt stronger privacy policies, invest in research methods to secure this data, or work on the development of nation-to-nation and international treatment of both the data and how compromises will be handled.

6. **To stay competitive in a global IT environment and industry, countries must adopt policies that foster innovation. To this end, policies that improve a country's ability to attract, educate, and retain the best IT talent are critical. Educational policy and investment is at the core.**

Building a foundation to foster the next generation of innovation and invention requires

- Sustaining or strengthening technical training and education systems,
- Sustaining or increasing investment in research and development, and
- Establishing governmental policies that eliminate barriers to the free flow of talent.

Education is one of the primary means for both developed and developing countries to mount a response to offshoring so their workforces can compete globally for IT jobs. In fact, education has been a primary enabler of offshoring in the developing countries. India has responded rapidly to the educational needs of its software export industry, especially through its private universities and training organizations. China is addressing the educational needs of its software industry through centralized planning.

There are, however, problems with both the Indian and Chinese educational systems. India provides poor quality higher education outside its top tier of universities, the quality of the faculty is uneven, research opportunities are not generally available to either students or faculty, and there is a tension between providing a good education to a limited number of people and providing access for all. The Chinese system is burdened with an emphasis on rote learning, a reward system for faculty that has not yet been transformed fully to reward research by faculty and their students, and problems moving from a central planning to a competitive funding system that rewards merit and entrepreneurship.

Developed nations can use education as a response to offshoring in order to protect national interests. It can, however, be complex for a nation to address offshoring through education for several reasons: educational systems are complex, with multiple degrees and multiple majors preparing one for an IT career; the nature of the software work that is being offshored is changing rapidly; it is difficult to forecast national supply and demand needs for software workers; governments can only indirectly affect supply and demand in many nations; and it is difficult to translate an educational response to offshoring into practical curriculum reform. For example, the United States educational system is still trying to understand how to change its curriculum to address application domain knowledge, a global workplace, and maintaining its innovative edge. In addition, the United States faces long-term challenges from falling interest and skills in math and science programs in its primary education system. The European Union is struggling with the implementation of the Bologna Directive to achieve a single European educational framework.

There are some general principles that all countries can follow to mount an effective educational response to offshoring:

1. Evolve computing curriculum at a pace and in a way that better embraces the changing nature of IT.
2. Ensure computing curriculum prepare students for the global economy.
3. Teach students to be innovative and creative.
4. Evolve curriculum to achieve a better balance between foundational knowledge of computing on the one hand, and business and application domain knowledge on the other.
5. Invest to ensure the educational system has good technology, good curriculum, and good teachers.

Conclusion

Globalization of, and offshoring within, the software industry will continue and, in fact, increase. This increase will be fueled by information technology itself as well as government action and economic factors and will result in more global competition in both lower-end software skills and higher-end endeavors such as research. Current data and economic theory suggest that despite offshoring, career opportunities in IT will remain strong in the countries where they have been strong in the past even as they grow in the countries that are targets of offshoring. The future, however, is one in which the individual will be situated in a more global competition. The brightness of the future for individuals, companies, or countries is centered on their ability to invest in building the foundations that foster innovation and invention.

Introduction

In the spring of 2004 we were asked by the Association of Computing Machinery (ACM) to chair a task force to study the phenomenon of information-technology offshoring. Offshoring was a hot topic in early 2004. Since the dot-com and telecommunication crashes of the early 2000s, offshoring appears to be the proverbial "third shoe" to hit the IT sector in the United States. While articles on offshoring and outsourcing appeared in the media weekly, sorting out facts from fiction was exceedingly difficult. While it was clear that offshoring was a boon to providers in developing countries, debates raged on its impact on developed countries. Getting a clear, factual picture of IT offshoring was undeniably important and timely.

ACM offered us a free reign in conducting this study, subject to two constraints. First, the study had to look at offshoring from a global perspective, reflecting ACM's position as an international organization. Previous studies of offshoring have typically taken a national, usually American, perspective. Second, the study had to be completed roughly within one year, which implied that it had to be a secondary study, based on published material, rather than a primary study, doing its own collection of data. Early on we decided to focus on the software side of IT. Offshoring of IT manufacturing has been going on for a number of years; the phenomenon that took off during the early 2000s was the offshoring of software.

Our hope is this report sheds much-needed light on software offshoring. It points out that offshoring is a symptom of globalization, which has been an inexorable economic force since 1990, while examining the specific forces that drive software offshoring, both at the country level and at the firm level. It surveys the debate on the economic impact of offshoring, and examines the available data, pointing out the paucity of reliable relevant data. The report also shows how IT research has been leading the offshoring trend. It highlights risks and exposures to individuals, corporations, and countries created or magnified by offshoring. Finally, it portrays the opportunities and challenges that offshoring poses to IT education in both developing and developed countries.

The Task Force was assembled during the second half of 2004. Bill Aspray, who has experience with work force studies, agreed to serve as executive consultant and primary editor for this study; indeed, it could not have been carried out without him. To ensure a broad perspective, we recruited around 30 Task-Force members, computer scientists, economists and sociologists from the US, Europe, Israel, India and Japan (see listing below and biographies). We are grateful to all of them for volunteering their time and efforts.

The Task Force held four meetings: in Chicago, IL, Oct. 8-9, 2004; Washington, DC, Dec. 3-4, 2004; Palo Alto, CA, March 4-5, 2005; and New York, NY, May 13, 2005. During it first meeting, the Task Force scoped the study, decided what the main topics should be, and divided into several committees, with some members serving on more than one. Roughly, each committee was focused on one topic, which is covered by one chapter in the final report. The next two meetings were dedicated to hearing perspectives by many experts and scholars (listed below), while committees continued their work during and between the meetings. At the final meeting, the committees presented drafts of their reports and received feedback from the rest of the Task Force.

The committees prepared the final drafts of their reports during the summer of 2005. These drafts went then to Aspray for editing. The edited versions were then sent to reviewers; each chapter was vetted by several reviewers. The process of review and revision continued through the fall of 2005.

During its work, the Task Force has reviewed hundreds of articles on the subject of offshoring, and IT offshoring in particular. To aid the Task Force in its work, Aspray prepared an extensive annotated bibliography. While this bibliography is too extensive to be included in the printed report, ACM is making it available online (http://www.acm.org/globalizationreport) as a service to its members.

We appreciate the efforts of the many individuals who helped the Task Force carry out its work.

Frank Mayadas and Moshe Y. Vardi

Task Force Co-Chairs, December 2005.

Contributors

The following people gave generously of their time to serve on the ACM Job Migration Task Force, which produced this report. Biographies of the Task Force members are given in the appendix.

Task Force Executive Committee:

Frank Mayadas (Sloan Foundation), co-chair

Moshe Y. Vardi (Rice University), co-chair

William Aspray (Indiana University), executive consultant

John White (ACM), ex officio

Task Force Members:

Alok Aggarwal (Evalueserve)

Frances E. Allen (IBM)

Stephen J. Andriole (Villanova University)

Ashish Arora (Carnegie Mellon University)

G. Balatchandirane (University of Delhi)

Burt S. Barnow (Johns Hopkins University)

Orna Berry (Gemini Israel Funds, Adamind, and Prime Sense)

Michael Blasgen (consultant)

Arndt Bode (Technische Universität München)

Jean Camp (Indiana University)

Seymour E. Goodman (Georgia Institute of Technology)

Vijay Gurbaxani (University of California, Irvine)

Juris Hartmanis (Cornell University)

Charles House (Intel)

William Jack (SAIC)

Martin Kenney (University of California, Davis)

Stefanie Ann Lenway (University of Illinois at Chicago)

Vivek Mansingh (Dell India Development Center)

Göran Marklund (Swedish Offices of Science and Technology, Washington, DC)

Peter Mertens (University of Erlangen-Nuremberg)

Rob Ramer (TerraFirma Security)

Bobby Schnabel (University of Colorado, Boulder)

Bankim Shah (BRS Associates)

Marie Stella (US Federal Aviation Administration)

Valerie E. Taylor (Texas A&M University)

Takashi Umezawa (Kokushikan University)

Roli Varma (University of New Mexico)

Richard C. Waters (Mitsubishi Electric Research Laboratories)

Stuart Zweben (Ohio State University)

We thank the graduate students who provided research assistance to the Task Force:

Alla Genkina (Indiana University and University of California, Los Angeles)

Matthew Hottell (Indiana University)

We thank the staff of the ACM who supported this project:

Marcia Boalen

Mark Mandelbaum

David Padgham

Cameron Wilson

We appreciate the people who came to make presentations to the Task Force in Washington, DC or Palo Alto, CA:

Josh Bivens (Economic Policy Institute)

Rafiq Dossani (Stanford University)

Ralph Gomory (Sloan Foundation)

Dan Griswold (Cato Institute)

Ron Hira (Rochester Institute of Technology)

Lori Kletzer (University of California, Santa Cruz)

Leonard Liu (Augmentum)

Catherine Mann (Institute for International Economics)

Anita Manwani (Agilent Technologies)

Carol Ann Meares (US Commerce Department)

Peter Neumann (SRI)

Suhas Patil (Cirrus Logic)

John Sargent (US Commerce Department)

Loren Yager (US General Accountability Office)

We also thank the many professionals who reviewed a preliminary draft of sections of the report:

Rakesh Basant (Indian Institute of Management Ahmedabad)

Allan Borodin (University of Toronto)

Erran Carmel (American University)

Lorrie Cranor (Carnegie Mellon University)

Anthony D'Costa (University of Washington)

Dorothy Denning (Naval Postgraduate School)

Peter Denning (Naval Postgraduate School)

Rafiq Dossani (Stanford University)

Ben Fried (Morgan Stanley)

Peter Hart (Ricoh Innovations)

Ron Hira (Rochester Institute of Technology)

John King (University of Michigan)

Randy Kirihara (Target)

Maria Klawe (Princeton University)

Lori Kletzer (University of California Santa Cruz)

Rich LeBlanc (Southern Catholic College)

Peter Lee (Carnegie Mellon University)

Thomas Lookabaugh (University of Colorado Boulder)

Catherine Mann (The Institute for International Economics)

Andrew McGettrick (University of Strathclyde)

J Strother Moore (University of Texas)

Sharon O'Bryan (O'Bryan Advisory Services Inc.)

David Patterson (University of California Berkeley)

Eric Roberts (Stanford University)

Mari Sako (The Saïd Business School Oxford University)

Kevin Schofield (Microsoft)

Alan Selman (University at Buffalo, The State University of New York)

Manuel Serapio (University of Colorado, Denver)

Russ Shackelford (Stanford University)

Eugene Spafford (Purdue University)

Elizabeth Sparrow (British Computer Society)

Manuel Trajtenberg (Tel-Aviv University)

N.V. "Tiger" Tyagarajan (GECIS)

Robert A. Walker (Kent State University)

David Waltz (Columbia University)

Tim Wedding (Government Accountability Office)

Loren Yager (US Government Accountability Office)

Yoram Yahav (Technion Institute of Management)

Andrew Yao (Tsinghua University)

Globalization and Offshoring of Software

A Report of the ACM Job Migration Task Force

Overview

1. The Big Picture

Over the past decade, low-wage countries such as India have developed vibrant, export-oriented software and IT service industries. Attracted by available talent, quality work, and most of all low cost, companies in high-wage countries, such as the United States and the United Kingdom, are increasingly offshoring software and service work to these low-wage countries. Trade (together with automation) cost many jobs in the manufacturing sector to be lost from the West and many developing nations in East Asia to increase their wealth and industrial prowess since 1970. Changes in technology, work organization, educational systems, and many other factors have caused service work—previously regarded as immune to these forces—also to become tradable. This trade in services, led by the trade in software and IT-enabled services, presents many opportunities and challenges for individuals, firms, and policymakers in both developed and developing nations.

Many people in the United States and Western Europe fear that sending software work offshore will cause wage and job suppression in the high-wage countries. Others believe that the process of getting good labor at lower prices will make the economy more productive, enabling the creation of new wealth and new jobs. Many people in the low-wage countries are excited by the economic development that their software and service industries are bringing them; while some are concerned about the side effects such as congestion, pollution, and loss of traditional cultural values. One thing that is clear is that the globalization of software is here to stay, so that policymakers, educators, and employers all need to address the realities of offshoring. This includes, for example, how to help people whose jobs are shipped to another country to get assistance with their careers, how to create innovative environments that help to create new jobs, and how to revamp educational systems for the realities of a globalized world.

"Offshoring" is the term used here. It is a term that applies best to the United States because, even though the United States does outsource work to Canada and Mexico, most of its work is sent over the seas—mostly to India, but also to China, Malaysia, the Philippines, and many other places. Germany, for example, also sends work across its borders, including to Eastern Europe, but there is no water—no shore—to cross. Some of the work that is offshored is sent to entrepreneurial firms established in these low-wage countries. Other times, multinationals headquartered in high-wage countries open subsidiaries in the low-wage countries to work on products and services for their world market. Multinationals may also open facilities in these low-wage countries in order to better serve the local market there, but that situation is not the primary interest of this study.

There are at least six kinds of work sent offshore related to software and information technology: (1) programming, software testing, and software maintenance; (2) IT research and development; (3) high-end jobs such as software architecture, product design, project management, IT consulting, and business strategy; (4) physical product manufacturing—semiconductors, computer components, computers; (5) business process outsourcing/IT Enabled Services—insurance claim processing, medical billing, accounting, bookkeeping, medical transcription, digitization of engineering drawings, desktop publishing, and high-end IT enabled services such as financial analysis and reading of X-rays; and (6) call centers and telemarketing. Our primary interest is with the first three of these categories, which are the ones most closely associated with the transfer of software work across national boundaries. However, it is almost impossible to study offshoring without at least at times considering the other three categories of work as well. This is because companies that do one of these kinds of software work may also do several other kinds of offshore work as part of their product and service line of offerings; and companies that send work offshore may send work of several kinds. Because companies and industries intermingle these categories of work, so does most statistical data that tracks this industry—and it is often impossible to disaggregate data to capture information about only the categories of work of greatest concern here. Thus we focus on the first three categories but discuss the others in passing.

The countries that send work offshore are primarily developed nations. The United States followed by the United Kingdom have been the largest offshorers, but other countries in Western Europe, Japan, Korea, Australia, and even India send work offshore. The countries that do the work fall into four categories: (1) those that have a large capacity of highly educated workers and have a low wage scale (e.g., India, China); (2) those that have special language skills (e.g., the Philippines can serve the English and Spanish customer service needs of the United States by being bilingual in these languages); (3) those that have geographic proximity ("nearsourcing"), familiarity with the work language and customs, and relatively low wages compared to the country sending the work (e.g. Canada accepting work from the United States, the Czech Republic accepting work from Germany); and (4) special high-end skills (e.g., Israeli strength in security and anti-virus software).

There are many drivers and enablers of offshoring. These include: (1) The dot-com boom years witnessed a rapid expansion of the telecommunications system, making ample, low-cost broadband available in many countries at attractive rates. This made it possible to readily transfer the data and work products of software offshoring. (2) Software platforms were stabilized, with most large companies using a few standard choices: IBM or Oracle for database management, SAP for supply chain management, and so on. This enabled offshoring suppliers to focus on acquiring only these few technologies and the people who are knowledgeable about them. (3) Companies are able to use inexpensive commodity software packages instead of customized software, leading to some of the same standardization advantages as with software platforms. (4) The pace of technological change was sufficiently rapid and software investments became obsolescent so quickly that many companies chose to outsource IT rather than invest in technology and people that would soon have to be replaced or retrained. (5) Companies felt a competitive need to offshore as their competition began to do so. (6) Influential members from industry, such as Jack Welch from General Electric, became champions of offshoring. (7) Venture capitalists pushed entrepreneurial startups to use offshoring as a means to reduce the burn rate of capital. (8) New firms emerged to serve as intermediaries, to make it easier for small and medium-sized firms to send their work offshore. (9) Work processes were digitalized, made routine, and broken into separable tasks by skill set—some of which were easy to outsource. (10) Education became more globally available with model curricula provided by the professional computing societies, low capital barriers to establishing computer laboratories in the era of personal computers and package software, national plans to build up undergraduate education as a competitive advantage, and access to Western graduate education as immigration restrictions were eased. (11) Citizens of India and China, who had gone to the United States or Western Europe for their graduate education and remained there to work, began to return home in larger numbers, creating a reverse Diaspora that provided highly educated and experienced workers and managers to these countries. (12) India has a large population familiar with the English language, the language of global business and law. (13) India has accounting and legal systems that were similar to those in the United Kingdom and the United States. (14) Global trade is becoming more prevalent, with individual countries such as India and China liberalizing their economies, the fall of Communism lowering trade barriers, and many more countries participating in international trade organizations.

At first it was believed that the only software work that would be offshored was low-level work, such as routine software maintenance and testing, routine business office processes, and call centers. Offshoring suppliers, however, have made strong efforts to move up the value chain and provide services that have higher value added because this is where there is the greatest opportunity for profit. Research and development, project integration, and knowledge process outsourcing such as reading X-rays and doing patent checking are increasingly being offshored. Today, some people believe that any kind of software or IT-enabled work can be offshored. While there is an element of truth in this belief, there are some important caveats. Some kinds of work have not been offshored. Even if it is possible to offshore a particular type of work, it does not mean that every job of that type actually will be offshored. In fact, there are a number of reasons why a company might not wish to offshore work: (1) the job process has not been made routine. (2) The job cannot be done at a distance. (3) The infrastructure is too weak in the vendor country. (4) The offshoring impacts too negatively on the client firm such as the client firm losing control over an important work element, losing all its in-house expertise in an area, or too high a loss of worker morale in the client firm. (5) Risks to privacy, data security, or intellectual property are too high. (6) There are not workers in the supplier firm with the requisite knowledge to do the job, which happens for example when the job requires application domain knowledge as well as IT knowledge. (7) Costs of opening or maintaining the offshore operation are too expensive. (8) There are cultural issues that stand between the client and vendor. (9) The company can achieve its goal in another way, such as outsourcing within its home country or consolidating business operations.

One might wonder whether IT is still a good career choice for students and workers in countries that offshore software and IT services work. Despite all the publicity in the United States about jobs being lost to India and China, the size of the IT employment market in the United States today is higher than it was at the height of the dot-com boom. Information technology appears as though it will be a growth area at least for the coming decade, and the US government projects that several IT occupations will be among the fastest growing occupations during this time. There are some things that students and workers in this field should do to prepare themselves for the globalized workplace. They should get a good education that will serve as a firm grounding for understanding the rapidly changing field of IT. They should expect to participate in life-long learning. They should hone their "soft skills" involving communication, management, and teamwork. They should become familiar with an application domain, especially in a growth field such as health care, and not just learn core technical computing skills. They should learn about the technologies and management issues that underlie the globalization of software, such as standard technology platforms, methods for re-using software, and tools and methods for distributed work.

2. The Economics of Offshoring

Much of the economic debate about offshoring centers around whether the theory of comparative advantage applies to the offshoring of software and IT services. Economists have argued on both sides of the issue. The arguments are sophisticated and nuanced, and the results often depend on whether the underlying assumptions hold in the current context. While a majority of economists are proponents of free trade, the underlying question is an empirical one and can be answered by analyzing reliable data when it becomes available.

The theory of comparative advantage states that if each country specializes in the production of goods where it has a comparative (relative) advantage, both countries can enjoy greater total consumption and well being in aggregate by trading with each other. Offshoring enables, for example, US firms to lower costs and save scarce resources for activities in which they have a relative advantage, while offshoring has led to significant employment and wage gains for Indian workers and rapid profit and revenue increases for Indian businesses.

What the theory of comparative advantage does *not* mean is that all members of society will benefit from trade. In general, imports of an "input" have economic effects that are similar to those of an increase in the supply of the input, namely, lower returns to the suppliers of the input, lower costs of production, and lower prices for consumers. If the input were a service, the wages and salaries of those producing the service would fall, but so also would costs for firms that are buyers of the service. In the exporting country, the opposite effects hold. That is, the returns to the owners or suppliers of the service or input increase and the wages of the employees at the service providers increase due to the higher demand.

Economists believe that trade generally leads to significant gains for society. These gains are not inconsistent with employment losses in specific sectors that will cause economic pain to the workers affected. To achieve an equitable result, many analysts believe that it is important to establish a safety net that provides income and training opportunities to affected workers. Components of the safety net might include extended unemployment benefits, wage insurance, and retraining.

A key assumption underlying the theory of comparative advantage is that the economy enjoys *full employment*. Thus, this theory is best thought of as a theory of the long-term, in which workers displaced by imports or offshoring find work in other sectors. By contrast, most popular discussions of the offshoring phenomenon tend to focus on questions such as "where will the new jobs be created" and "can the workers be retrained for these new jobs". In general, peering into the crystal ball to predict where and what types of new jobs will be created is both difficult and unrewarding. A dynamic economy such as that of the United States creates and destroys millions of new jobs in response to changes in tastes, and more importantly in response to innovations and advances in technology. There is no guarantee that the economy will continue to create these new jobs, but policy makers can take some comfort from the historical evidence that thus far it has managed to do so. The key to job creation is of course the ability of the economy to rapidly generate and adopt innovations—new types of goods and services, and productivity-enhancing process improvements.

In general, trade stimulates innovation and economic growth in both trading partners. Some, such as Ralph Gomory and Gregory Baumol, have argued that innovation opportunities create new possible conflicts of interest between trading partners. For example, insofar as offshoring stimulates, in countries such as China, innovation and productivity growth in goods and services where developed countries such as the United States enjoy a comparative advantage, this will cause the "terms of trade" to become less favorable over time for the United States. In other words, even if free trade is the best policy, it may well be that free trade, by stimulating innovation overseas, may impose long-term losses. However, Gomory and Baumol's analysis shows that this conflict of interest is present when the two trading partners are at similar stages of development. Since most offshoring involves countries at very different levels of development, this conflict of interest is presently unlikely.

In the IT services sector, there is a related concern. Currently, it is efficient to offshore "low-end" IT services, such as coding or maintenance, to a low-wage country while "high-end” activities, such as requirements analysis, design, and R&D, remain in the high-wage country. The concern is, however, that eventually the high-end IT activities would also move offshore. Were this to happen, the current technology leaders (United States, Germany, Japan, United Kingdom, et al.) may relinquish that leadership role. There is some anecdotal evidence that some IT process innovations are moving to low-wage, offshoring operations.

Most economists, however, argue that current technology leaders will not lose their technological leadership position. Even if production moves to other countries, history shows that in many industries the locus of production and the locus of invention are physically separated. There are two key resources required to remain at the center of innovation in software: access to talented designers, software engineers, and programmers; and proximity to a number of large and technically sophisticated users. Current technology leaders, and the United States in particular, currently dominate on both counts. More broadly, the United States has other important capabilities, including the best universities and research institutions, highly efficient capital markets, flexible labor markets, the largest consumer market, business-friendly immigration laws, and a large and deep managerial talent pool. As a result, the evolution of business in the United States has followed a consistent pattern: launch innovative businesses here, grow the business, and as products and services mature migrate lower-value-added components and intermediate services over time to lower-cost countries. Nevertheless, there are those who argue that globalization will diminish the comparative advantage of current technology leaders, which may lead to the loss of their current dominant position and create a long period of adjustment for their workers.

Data on current and future trends of offshoring leave much to be desired. First, the definitions of offshoring vary from one study to another, making it hard to compare statistics. For example, some studies count all service jobs, some count IT jobs, some include IT-enabled jobs, and some are simply not precise about what they are counting. Second, there is a question of what metric to use in measuring the extent and trends in offshoring. One might measure, for example, jobs lost in the developed country, jobs in the developing country’s IT industry, or dollar value of business outsourced. In the case of each of these metrics, however, it is either difficult to make the measurement or the metric is not directly enough relevant to the offshoring situation. For example, it is difficult to calculate dollar value of business offshored because these are internal transfer costs for multinationals, which they may not be willing to report or do not report in an appropriately disaggregated way.

Projections of future trends are more suspect than data on the current situation. One type of projection identifies types of jobs that are vulnerable to offshoring. These vulnerability projections provide at best a high upper bound on expected job loss, and for this reason they are blunt policy-making tools. It may be that routine programming jobs are vulnerable to offshoring, but it is highly unlikely that every last one of them will be lost to offshoring. Moreover, even in cases where the methodology is sound and soundly applied, projections of any kind about the future are much less likely to be accurate than data about today’s or yesterday’s situation since it is difficult to predict all the factors that will come into effect over time.

Another important issue to consider is the source of the data. Data from the United States and many other national governments tends in general to be reliable. The US government, however, collects data to handle established policy issues. If a new phenomenon arises, the existing data sets may not be well suited to studying the new policy issue. This is the case with offshoring. US data on job layoffs and on service trade are both designed for other purposes, and there is widespread belief among economists that both seriously undercount offshoring trends. Data collected and analyzed by trade associations and consulting firms may be very useful, but there is skepticism in the economic community about the quality of these data in many cases because the methods for collecting and analyzing the data are often not made available for scrutiny, the data they collect (from members of their organization) may not be a representative sample of society as a whole, and these organizations have particular objectives in mind that they hope their data will bolster.

The United States is the source of the greatest number of offshored jobs and where the phenomenon has received the greatest attention. But even for the US, it is difficult to be certain of the extent of offshoring. Federal data is not very helpful, and most of the existing data comes from consulting firms. The numbers generally indicate that 12 to 14 million jobs in the United States are vulnerable to relocation through offshoring, and that annual losses have ranged from under 200,000 to about 300,000 service jobs from the United States to offshoring. The number of IT jobs is somewhat lower than these estimates because these estimates include service jobs such as working in call centers and sometimes other IT-enabled services such as business process and knowledge process offshoring. Importantly, these estimates do not include newly created jobs. The consensus seems to be that about 20% of US companies are currently offshoring work but that the percentage is rising. The current value of offshoring contracts from the United States seems to be in the $10 to 20 billion range, with an expectation of rapid growth. It should be remembered, however, that we do not know the methods used to arrive at these numbers and how independent the data from one consulting firm’s study is from that of another.

Statistics for the entire world or for other individual countries are even harder to come by and more suspect than those for the United States. The annual dollar value of worldwide offshoring trade for recent years has been estimated to be between $1.3 billion and $32 billion, depending on whether certain exported products are counted and whether the numbers for multinational companies are included. An estimated 30% of the world’s largest 1000 firms are offshoring work. Europe has lower levels of offshoring than the United States. It is estimated that only 5% of European businesses (of all sizes) are offshoring, and at most 2 to 3% of European IT workers will lose their jobs to offshoring by 2015. The United Kingdom has the highest rate of work sent offshore of any European nation, with an estimated 61% of firms now offshoring. In Germany, only 15% of companies are now offshoring, and perhaps a total of 50,000 German jobs have been lost to offshoring so far; however, there seems to be an increase in German offshoring in the recent past. Statistics about India show a vibrant IT industry, with annual growth of 20 to 30%, the vast majority of the growth coming in the export rather than the domestic market. Data on the rest of the world are too spotty to trust.

3. Understanding Offshoring from a National Perspective

The first countries to develop software industries primarily for export rather than domestic purposes were Ireland and Israel. The big player to come in a little later was India, beginning in the mid-1970s and growing rapidly from the late 1990s. To some degree, a global division of labor is beginning to form: India serving the English-speaking world, Eastern Europe and Russia serving Western Europe, and China serving Japan. But India is also providing service to Western Europe, and China provides service to the United States. In addition, there are many smaller supplier countries. The greatest attention is given in this report to the United States and India, the two biggest players.

The United States has historically dominated and continues to dominate the software and services industry, with about 80% of global revenue. It is highly dominant in the packaged services industry, with 16 of the top 20 companies worldwide, and slightly less commanding but still dominant in the software services sector, with 11 of the top 20 companies. This dominance is due to a number of factors, including a legacy of government funding of R&D,

computer science research in the open US higher education system, early adoption by sophisticated users, the world's largest economy and market, and leading semiconductor and data storage industries that helped to spread the use of computing.

The centrality and dominance of the US industry has been a given during the past five decades. What is emerging is the globalization of the software and software services industry. This creates opportunities around the world for people and companies in both developed and developing countries to participate in this profitable industry. It also creates challenges for the former leaders, notably the United States, Western Europe, and Japan.

Software services is India's largest export. As a large developing nation, India faces many challenges, including high rates of poverty, corruption, and illiteracy; a substandard infrastructure; excess government regulation; and various other problems typical of a poor nation. These challenges are offset by a number of strengths, especially for software and services production. It has a long history of developing capable mathematicians. India is unique because of the large number of individuals with adequate English language capability, and also for the large cadre of Indian managerial and technical professionals working in North American and, to a lesser degree, in European high-technology occupations and organizations. For those who can afford it, India has a strong and highly competitive K-12 educational system emphasizing science and mathematics. Despite its democratic socialist tradition that involved large amounts of bureaucracy and state regulation, it has been a market economy and has a history of managerial education and competence. These assets have given India many advantages in establishing a software export industry.

India's software export industry began in 1974, when it began sending programmers to the United States to do work for the Burroughs Corporation. Political liberalizations related to trade in the 1970s and again in the early 1990s helped to support the development of the Indian software industry. Offering solutions to the Y2K problem helped the industry to grow substantially. The industry expanded beginning in the late 1990s, first by bringing back to India much of the software development, maintenance, and testing work it had previously done on the client's premises, then developing export businesses in business process offshoring, call centers, and research and development. India is moving up the value chain and is seeking people with considerably more skill than low-level programmers to do these higher value jobs. Software and service export firms in India are growing at 20 to 25% per year according to the best statistics available, and each of the three leading Indian software firms (Infosys, TCS, and Wipro) already employs over 40,000 people.

India is likely to continue to grow its software industry in scale, scope, and value-added. There is little reason to believe that offshoring as a process will end in the foreseeable future, but it could slow down. The enormous investment by leading software multinationals will expand the number of Indian project managers with strong managerial skills. This, together with the relocation of portions of startup firms to India, is likely to result in greater levels of entrepreneurship and lead to firms able to sell their skills on the global market. The offshoring of IT services and software for export will dominate the near future of the Indian software industry. There are several possible trajectories. Custom projects could become more complex and large, leading Indian software professionals to move from programming into systems integration and systems specification and design. The average size of projects Indian firms are undertaking has already grown from 5 person-years in 1991 to 20 person-years in 2003. As multinationals deepen their Indian operations, domain skills are developing in India and some other nations, so that managed services are likely to become more important; this will match global trends in the outsourcing of applications management and business processes.

Despite the fact that India's software production for the US market exceeds that of any other nation, it holds only a small share of the global market for all software value-added. The only part of the software value chain in which India has made substantial inroads is in applications development, where it has captured 16.4 percent of the world market. But applications development is only approximately 5 percent of the entire global software services market. This implies that there is much room for growth. In order to grow, the Indian industry will have to shift to more complex activities by securing larger projects, undertaking engineering services, integrating and managing services, or bidding on projects that include transforming a client's entire work process. India, however, will have some difficulty achieving this growth unless it strengthens its R&D capability.

Software offshoring to India is likely to grow, not only through the continued growth of indigenous Indian firms, but also because foreign software firms are increasing their employment in India in product development and particularly in software services. Competition is likely to grow between multinationals based in developed countries, such as Accenture, IBM, and Siemens Business Services, and the large Indian firms, such as HCL, Infosys, TCS, and Wipro, as the Indian companies expand their global reach and the multinationals expand their operations in low-cost countries. The Indian subsidiaries of multinationals play an important role in the development of India's software capabilities, because they are more willing to undertake high value-added activities, such as software product development, within their own subsidiary in India than they are to send the work to an Indian independent firm.

For at least the medium term, India should be able to retain its position of primacy for software offshoring from the English-language world. In the longer term, unless India makes an even greater effort to upgrade its universities and the technical capabilities of its graduates, China may become an important alternative destination.

China's software and services industry does not currently have a major impact on the world economy. The industry is highly fragmented into many small companies, few of which are large enough to take on large projects for developed nations. The hardware industry is well established in China, and in the future it may drive the software industry to a focus on embedded software. Unlike India, where the multinationals are focused mainly on serving the world market, in China multinationals are more focused on positioning themselves to serve the enormous, emerging domestic Chinese market.

Japan has the second largest software and services industry in the world, after the United States; and it is the fastest growing industry in Japan. Japan makes games software and custom software for the world market and packaged software for its domestic market. It imports a significant amount of systems and applications software from the United States; and it calls on China and India to provide custom software.

There are three typical patterns of Japanese offshoring. Most commonly, a Japanese firm will identify a need for custom software, contract with a Japanese IT company to provide the software, and the IT company will in turn contract with a Japanese subsidiary of a Chinese firm to do the programming work. This programming used to be done almost exclusively in Japan, but as the cost of locating Chinese workers in Japan has become expensive, more and more of the programming is being done in China. A second approach that is more recent is for Japanese firms to invest in China to form wholly owned subsidiaries or joint ventures with Chinese firms. A third approach is for multinational corporations to move programming and back-office functions of their Japanese subsidiaries to lower-cost locations, often in China. The Dalian software park in China is growing rapidly as a result of this emerging Japanese business. The amount of offshoring from Japan is still small, but cost pressures are likely to cause it to increase; and since Japan has such a large software industry, the opportunities for offshoring are considerable.

The European Union represents the second largest market in the world for software and IT services, after the United States. There are many differences, however, from country to country, and the European Union cannot be viewed as a unified, homogeneous market. The European software industry and employment patterns are different from those of the United States, with much more software production done in-house and embedded in physical products. This does not prevent offshoring, and certainly many leading European industrial firms are establishing offshore facilities to produce embedded software. Much of this employment is subsumed under R&D and other activities such as application-specific integrated circuit design.

About two-thirds of the work offshored from Europe is offshored by the United Kingdom. Continental European firms continue to lag UK firms in sending software work across their borders. The Germanic and Nordic nations have only recently begun to build offshore software and software service delivery capabilities, but firms with global practices such as SAP, Siemens, and others are moving rapidly to build their offshore capabilities in Eastern Europe, China, and India. The geography of European offshoring will be somewhat different from that of the United States in that Nordic and Germanic firms will use Eastern Europe and Russia in addition to India. Latin (Romance-language-speaking) Europe has been slower to begin offshoring, but now its major firms are sending work to Romania, Francophone Africa (particularly Morocco), and Latin America in addition to India. Despite these geographical differences, there is no reason to believe that the pressures to offshore software-related work will be substantially different than in the Anglophone nations. In part this is because the US-based multinationals with strong global delivery capabilities, such as Accenture, EDS, Hewlett-Packard, and IBM, are present and competitive in all European markets. European firms may continue to experience a lag due to union and government opposition to offshoring, but their cost and delivery pressures are similar to those experienced by US firms.

In Russia, software was a relatively neglected field during the Soviet era, but in the 1990s as the country transitioned to a market economy, many scientists and engineers moved from low-paid government and university positions into entrepreneurial firms and Russian subsidiaries of multinationals; and some of these people entered the software field. So far there are relatively few programmers. Wages are low. Technical skill level is high, but there is little project management experience. Software firms are typically small, not able to take on large international software integration projects. Nevertheless, the high skill level of the Russian research community, a legacy of its Soviet history, has led Intel and a few other multinationals including Boeing, Motorola, Nortel, and Sun to open R&D facilities in Russia.

4. Understanding Offshoring from a Company Perspective

Instead of examining offshoring by country, it is also possible to examine offshoring by the type of company. We will consider five types of firms. The first are large, established software firms headquartered in developed nations that make and sell packaged software. Examples include Adobe, Microsoft, and Oracle. As a general rule, the largest and most successful packaged software firms are headquartered in the United States; the notable exception is SAP in Germany.

Most large packaged software firms have global operations. In many cases, their offshore operations are for localization work for the local domestic market. However, particularly in the case of India, and also to some degree in Russia, the work is for development of their worldwide software packages. Locating in these low-wage countries enables these firms to have access to lower-cost programmers, many of whom are comparable in skill levels to the company’s workers in the developed nations. This is not the only benefit. Having operations in other time zones can speed up production by facilitating round-the-clock production.

These opportunities are encouraging major packaged software firms to expand their workforce in India and other lower-cost nations.

Offshoring will have a complicated effect on the packaged software firms. First, it might and likely will put employment pressure on developed nation software firms to decrease employment in the developed nations. On the other hand, the lower cost and faster production could allow the development of new features in old software and could contribute to the creation of new, well-priced software products, which would in turn increase income for these firms and perhaps lead to greater hiring.

Next we consider large, established software firms headquartered in developed nations that are large providers of software services. These companies may also provide packaged software, though not all of them do so. Examples include Accenture, EDS, and IBM. Software service firms have been among the fastest growing firms in the IT sector, and in general they are far larger than the packaged software firms. Firms coming from the software side (e.g., Hewlett Packard or IBM) and from the service side (e.g., Accenture) are converging. In the case of IBM, this has been through both direct hiring and its recent acquisition of the Indian service firm Daksh (with its approximately 6,000 employees). Hewlett Packard has built its global non-IT services to over 4,000 persons in the last three years, largely through in-house hiring.

Software services is in most respects a headcount and labor-cost business; these companies grow their revenues by hiring more persons. The multinational software services firms have been experiencing increasing pressure on costs due to competition from developing nation producers, particularly from the Indian service giants such as Infosys, TCS, and Wipro. This has forced the multinationals themselves to secure lower-cost offshore labor. Service firms such as Accenture, ACS, EDS, IBM, and Siemens Business Services operate globally, but only in the last five years have they found it necessary to have major operations in developing nations to decrease their labor costs. Today, the larger service firms, including Accenture and IBM, are rapidly increasing their headcount in a number of developing nations, particularly India. At the same time, these firms are holding steady on their developed nation headcount or gradually drawing it down. Given the ferocious competition in software services, there is little possibility that prices will increase substantially. This suggests that, for the large multinationals, the offshoring of services will continue to increase in both absolute numbers and percentages of their global workforce.

Next we consider firms headquartered in developed nations that have software operations but are not part of the software industry sector. This is the enormous and eclectic group of companies that provide all the non-IT goods and services in the economy. Software is now at the heart of value creation in nearly every firm, from financial firms such as Citibank, to manufacturing firms such as General Motors. Customizing, maintaining, and updating IT systems has become an increasingly significant expenditure for businesses in developed countries, and thus firms are actively trying to lower these cost. One way to lower them is to offshore the work to nations with lower labor costs.

It is difficult to estimate the amount of software work that is offshored by these companies. Businesses often do not break out this particular kind of expense, and if work is transferred to an overseas subsidiary, this is considered an internal transfer and may not be reported at all. However, it is clear who does the work. If it is not an overseas subsidiary of the company, then it is likely to be one of two other kinds of firms that provides the service: a large service firm from a developed nation (e.g., Accenture, CapGemini, IBM, and Siemens Business Services) or a firm from a developing nation (e.g. Infosys or TCS in India, Luxoft in Russia, or Softech in Mexico).

It is not certain whether offshoring will lead to a decline in the number of software service employees employed in the developed nations. In the current economic recovery, existing firm headcount throughout the IT sector in the United States appears to be stagnant. In other sectors, limited data are available. For example, in financial services it is unknown as to whether the increasing headcount in developing nations has had any impact on employment in the developed nations. The most that can be said is that non-IT firms are increasing their IT employment in developing nations to serve the global market, and this trend is underway across many different firms, including industrial firms such as General Electric and General Motors.

Next we consider software-intensive small firms, particularly startups, based in developed nations. For small startups, offshoring is often a difficult decision, although more recently a number of firms in the United States have been established with the express purpose of leveraging lower cost offshore skilled engineers. For many smaller firms, an offshore facility can be demanding on management time. This is especially true in India because hiring and retaining highly skilled individuals is difficult. The protection of intellectual property, which is typically the most important asset that a technology startup has, is problematic in India and especially China. There is substantial anecdotal evidence that, despite these challenges, under the pressure from their venture capital backers and the need to conserve funds, small startups are establishing subsidiaries abroad, particularly in India, to lower the cost and increase the speed of software development.

A pattern is emerging for US startups. They may initially use outsourcing to, say, an Indian firm as a strategy, but many soon establish a subsidiary in place of the Indian firm. They do this for a variety of reasons, including worries about intellectual property protection, control of the labor force, and management efficiency. The minimum size of an offshored operation is reportedly as few as 10 persons. If this report is accurate, then it may be possible for many more small firms to establish subsidiaries in developing nations than have done this so far. Unfortunately, data on the scale and scope of offshoring by startups are unavailable.

It is tempting to view offshoring by startups (whether to an Indian firm, say, or to their own overseas subsidiary) as an unmitigated loss of jobs for US workers. Nevertheless, the real situation is more complicated. Lowering the cost of undertaking a startup could mean that the barriers to entry are lowered, thus encouraging greater entrepreneurship. The jobs created by this entrepreneurship should be counted against those lost by offshoring. So, correctly estimating employment net effect of offshoring in the case of startups is very difficult.

Finally, we consider firms in developing nations providing software services to firms in the developed nations. The availability of capable software programmers in developing nations provided an opportunity for entrepreneurs and existing firms to offer programming services on the global market. It was in India where this practice first began in a significant way. Because telecommunications links were not so sophisticated, the Indian programmers initially were placed in the US customer's premises. This practice was profitable and gradually expanded to include remote provision of services – often to do Y2K work—when telecommunication improved and demand heated up in the late 1990s. These developments created an environment within which major corporations were willing to experiment with overseas vendors, and a sufficient number of these experiments were satisfactory. The result was that offshore vendors, particularly Indian firms, were validated as candidates for software-related projects. These projects also allowed offshore vendors, again particularly Indian firms, to grow in headcount, experience, and financial resources, so that they could undertake larger and more complicated projects.

Software services firms from a number of the developing nations have become players in the global economy. The large Indian firms (HCL, Infosys, Satyam, TCS, and Wipro) are at present the global leaders. However, in China, Mexico, and Russia there are growing software service firms that employ between 1,000 and 5,000 people. Currently, the firms from other nations are not large enough to compete with either the multinationals headquartered in developed nations or the large Indian firms. Medium-sized firms in other geographies can, however, reduce the risk for customers of having all their offshore work done in one country, where it might be interrupted by a natural disaster or by political or military problems. The larger multinationals and Indian firms are also establishing facilities in other geographies, particularly Eastern Europe and, more recently, Mexico.

Firms are leading a global restructuring of the geography of software and software services production. They are experimenting with a variety of strategies meant to utilize workers that have become available in the global economy. This is true of software product firms as well as multinational and developing-nation software service providers. The impact of firms outside the IT sector with large internal software operations transferring some of the software operations to lower-cost environments has been less remarked upon; however, should the current trend continue, this will have a substantial effect on IT employment. These firms have already relocated a significant amount of work from high-cost to lower-cost environments, and this process appears likely to continue, and possibly accelerate, as firms become more comfortable working in developing nations. The offshoring of startup employment bears particular observation because the US high-technology economy in particular is dependent upon the employment growth that small startups provide.

5. The Globalization of Research

IT research is concentrated in only a few countries. About a third of computer science papers come from the United States alone. A few additional traditional centers of concentration of IT research (Australia, Canada, France, Germany, Israel, Italy, the Netherlands, Sweden, Switzerland, and the United Kingdom) account for about another third.

This is not surprising considering the large part of world Gross Domestic Product (GDP) concentrated in these same countries. There is a correlation between Purchasing Power Parity (PPP) Adjusted Gross Domestic Product and computer science publication. However, the share of computer science paper production by scientists in the traditional centers of concentration of IT research is more than 60% greater than their share of world PPP GDP (65% vs 40%). In contrast, Brazil, China, India, Indonesia, Mexico, and Russia together account for 27% of world PPP GDP, but only 7% of computer science paper production.

IT research was even more concentrated in the past than it is today. The initial bloom of IT research occurred in a few select locations in the United States and a few other countries in the aftermath of the Second World War. This concentration has been perpetuated by the natural tendency of strength to build on strength. Particularly in the United States, this bloom was driven by ample government funding and a significant migration of scientific talent from the rest of the world. In fact, there is little doubt that government funding has played an important role in most countries. For example, on a *per capita* basis government funding is significantly larger in Sweden and Israel than in the United States. The pattern of strength in only few countries is amplified by a general migration of scientists from countries that do not support graduate education and research to countries that do.

Research-driven innovation is seen by many countries as a way to increase national wealth and standard of living. Both developed and developing countries are attempting to build up or shore up their research capabilities. This means greater competition among nations in the research area, and in particular competition for talent. Until recently, the United States had won the research talent competition, but that situation is changing. Due to strong efforts to foster research on the part of a number of national and local governments outside the traditional centers of research, IT research is slowly but steadily, and almost certainly inevitably, becoming more global. This globalization of IT research has been accompanied by a significant increase in the production of PhDs outside the traditional centers of concentration, and a reduction in the migration of researchers to these centers. In the long run, there is no obvious reason why IT research should be any more concentrated than world economic activity in general.

Globalization allows more and better people to participate in IT research. Increasing educational opportunities around the world means that more people are able to realize their research potential, thereby increasing the size of the IT researcher pool and the quality of the best researchers. A freer worldwide market in research means that potential funding for IT research can more easily be targeted to those that can most effectively and efficiently create research results. Both of these trends increase the amount of scientific advance that can be obtained from a given level of resources. There is little doubt that this is good for the field of IT and for the world as a whole; however, while we gain as a group, localities and individuals may end up suffering losses.

Globalization provides improved opportunities for people who live outside the traditional centers of concentration of IT research. It also provides improved opportunities for the best researchers, due to increased global competition for their services. It may, however, limit opportunities for other researchers in the traditional centers of concentration, for whom global competition may mean declining wages or even the loss of jobs.

6. Risks and Exposures

Businesses that make offshoring and outsourcing decisions increase their own exposures to risk, and at the same time potentially create additional risks and exposures at many other levels, all the way from individuals to nation-states. Many of these other communities of interest have scant awareness that they are being exposed. For every risk of privacy invasion into an employee database that an employer might fear, data about ordinary citizens is exposed to tens of risks. Bank records, transaction records, call center traffic, and service centers are all offshored today. Voluminous medical records are being transferred offshore, read by clinicians elsewhere, stored and manipulated in foreign repositories, and managed under much less restrictive laws about privacy and security than in most developed countries. The higher exposure to terrorist incursion, sabotage, or extortion attempts has not received wide discussion by companies employing offshore labor.

A basic principle of security is that the longer the supply chain and lines of communication, the more opportunity there is to attack them. The inherent difficulties in international data communications are compounded by jurisdictional issues regarding regulation and legal responsibility. Offshoring risks include data communications vulnerabilities, loss of control of business processes, loss of control over network perimeters, increased network complexity, clashing security policies and procedures, gaps in personnel security, and drastically diminished ability to know about and respond to security breaches.

What seems particularly lacking within many procuring companies is an overall line of authority and responsibility for primary data records as they pass through one, two, or more subsequent offshore companies that perform work on the data set or perform operational tasks for one purpose or another. Such *"hands-off"* management responsibility cannot be presumed to work in the best interests of anyone concerned with risk attenuation.

Risks turn into incidents through two basic kinds of action—accidents and intentional acts. The vast majority of incidents that can be anticipated originate with threat actors: rogue employees, hackers, criminals, organized crime syndicates, industrial espionage, unfriendly nation-states, and terrorists. Effective risk management strategies include security due diligence, business due diligence, active risk management, and third party auditing.

Commercial risk from offshoring is multi-faceted and different from security risk. Business issues are primarily operational—concerning productivity, efficiency, and quality. Business managers everywhere struggle with costs, delivery times, and product quality. Geographic and cultural spread can adversely affect the latter two even as costs seem to be reduced. Communication paths become longer and more convoluted; they are more apt to suffer distortion and error from language and cultural difference. Supply chain networks become more diverse, less centralized, and hence less controlled. Protection from manufacturing sabotage and theft becomes more difficult because of the breadth of the system. Intellectual property protection becomes more porous as the infrastructure expands on an international scale. Legal barriers and costs increase as companies cross international boundaries, due to conflicting regulations, procedures, and practices. Safety issues are exacerbated by decentralized operational logistics.

The most contentious and perhaps most challenging aspect of offshoring is its risk impact on individuals. Individuals are often pawns in this global restructuring of business. They are at risk of loss of privacy, loss of jobs, loss of property through identity theft and credit card fraud, and loss of security. Moreover, they have little say in these business decisions and little they can do to protect themselves.

Offshoring adds threats and vulnerabilities that do not exist in domestic outsourcing, and increases vulnerabilities that exist in all inter-network commerce. Multiple legal jurisdictions add new risks. Distance adds complexity and vulnerability because cyber-space is actually a complex of real-world service providers in distinct jurisdictions with varying cultures, all under cost pressures. A company acting under a business culture not easily known to clients cannot be assumed to be exercising all the same precautions that might be common practice in the client business's country. As more and more countries provide offshore services, the price pressures on providers of outsourced services increase. With increased price pressures, the temptation to skimp on security measures gets stronger.

There are a number of steps that can be taken for protection. Data that is being transmitted should be encrypted. Offshoring providers should be vetted carefully. Companies should have security and data privacy plans and be certified to meet certain standards. Service providers should not outsource work without the explicit approval of the client. Mass export of databases should not be permitted. Data should be accessed one record at a time and on a need-to-access basis. The database should be encrypted. Certain types of data should not be allowed to be exported across national boundaries.

Offshoring can also place national security at risk by threatening both military and critical infrastructure operations. For example, the United States and other countries' IT-based military systems have adopted COTS (Commercial Off-The-Shelf) product purchasing strategies, shared national and international commercial infrastructures, and Internet Protocol technologies to facilitate network-centric warfare systems. It is more difficult for the buyer to gain insight into source and application code documentation for COTS products, especially if the providing companies are offshore. Many COTS components and sometimes whole systems are developed and maintained by providing companies, which may themselves procure development and services from other nations with privacy, intellectual property rights, security, diplomatic, and defense policies possibly at odds with the original procuring country. Thus, a COTS strategy increases the possibility of a hostile nation or non-government hostile agents (terrorist/criminal) being able to compromise the system or services. Attacks can cause malfunction and destruction of critical infrastructure such as transportation, power, and financial systems, and loss of citizen confidence in their infrastructure and government.

The offshoring of homeland security technology development and management systems that send vital information such as biometrics, identification codes, tax and personal information overseas are of critical concern. Until better controls of this information are developed, this presents a risk to all nations. Further research in methods to secure this data and the development of nation-to-nation and international treatment of both the data and how compromises will be handled is vital.

Globalization is here to stay and so are its international effects. National security and social effects can never be completely mitigated, but country-specific and international strategies can be put in place. Problems cannot be solved until they are defined and accepted as valid by a sovereign entity and its citizens. Topics needing national attention include legislation, international agreements, policing, tariffs, Internet policies, and more equitable tax-structure strategies for companies investing at home. Other topics needing public attention include more formal government-commercial agreements and funded research to address data protection and communications between stakeholders involved in homeland defense and critical infrastructure.

7. Education in Light of Offshoring

Offshoring creates major changes in the demand for workers. Some countries need more workers, others fewer. Offshoring also causes the set of skills and knowledge of workers to change. Education is a tool that enables a country to provide the skilled workers that it needs, and thus it can be the centerpiece of a national policy on offshoring. Developing countries that are building up their software service export markets, such as India and China, need to prepare growing numbers of people to work in this industry. The developed countries are facing questions about how to revise their educational systems to prepare their citizens for the jobs that will remain when other jobs have moved to lower-wage countries. These developed countries also have to find ways of making their education system serve to increase the technological innovation that has historically driven productivity gains, new employment, and new wealth for nations.

The United States has a well-established and complex IT educational system. The bachelor's degree is the primary degree for people entering a computing career. While degree programs appear under many names, five majors cover most of the programs: computer science, computer engineering, software engineering, information systems, and information technology. Although there are some differences among these five types of programs, they are many similarities in providing foundational knowledge related to computer programming, the possibilities and limitations of computers, how computers and computing work in certain real world applications, various skills about communication and teamwork, and other topics.

In addition to the five traditional kinds of departments, a variety of new academic units related to computing and information technology have begun to emerge in US universities. These include schools and colleges of computing that typically include the degree programs in computer science as one component, new schools that are separate from computer science and information science programs that fill an additional need in the computing and information technology space, information schools that in almost all cases evolved from library schools, and campus-wide multidisciplinary information technology institutes aimed at fostering collaboration of faculty and students across departments. While they are not the programs intended to produce ace programmers or deep technical experts, the mix of skills and perspectives is a reasonable educational experiment to try to produce students well suited for higher-value-added jobs. There is also rapid growth in degree programs offered by for-profit universities, which provide a convenient entry to the profession for working adults.

Non-degree programs also play an important role in US IT education. They include certificate programs, non-degree courses offered by traditional colleges and for-profit organizations, training associated with specific technologies, and corporate training programs. These alternative kinds of training programs appear to be growing rapidly, but it is difficult to quantify their extent or growth. There are many different goals being sought through enrollment in these non-traditional programs: training for a specific IT career, career advancement within the IT field, move from a non-professional to professional IT job, continuing education to keep technical skills current, or gaining specific product information or usage skills. There is also training provided by corporate universities for employees, customers, and suppliers, which might include technical training, background information about the company or its industry, or core competencies such as learning skills, communication and collaboration, creative thinking and problem solving, global leadership, or career self-management.

Recent changes in Europe, under the Bologna Declaration, have the goal of unifying the European educational system along the lines of American system of separate bachelor and master degrees. The Bologna process provides a standardized sequencing of degree programs, makes it less time consuming to obtain the first undergraduate degree, and makes the system more open for students who received their baccalaureate degrees in developing nations to enter masters programs without having to repeat some of their earlier training. The Bologna initiative has stimulated new interdisciplinary and specialized studies in computing within European universities, especially those incorporating domain-specific knowledge such as bioinformatics and media-informatics, and has also created separate programs in software engineering and telecommunications. The increasing uniformity of IT education across Europe will provide additional incentive for offshoring work from higher to lower wage countries within Europe; in the long run it may lead to a leveling of IT wages across Europe.

The German model is particularly important since the German-speaking nations represent approximately a quarter of the European population. There are some major voices in Germany in opposition to the Bologna initiative. For example, the T9 initiative, by the nine largest and leading technical universities in Germany, argues that the traditional model of university education leading to a diploma after nine semesters has considerable advantages over the system that leads to separate bachelor's and master's degree. It is unclear whether this will lead to modifications in the Bologna model over time.

India, as the largest supplier of exported software services, faces a different set of educational challenges from the United States or Europe, namely to ramp up its higher education system to staff its rapidly expanding software industry. Soon after India achieved its independence in 1947, a decision was made to invest a greater amount in higher education than is typical for a developing nation, even though there was not enough money to finance primary education for all. This decision was taken in part to support the efforts to build an educated workforce for the heavy industry that India's leaders envisioned would provide an important part of its revenue base. The investment in higher education was advantageous to India when it opened up its markets and began to participate more extensively in global trade in the early 1990s. There have been many competing claims on government funds, and the central government has not been able to keep up with the increasing demand for higher education. Policies were liberalized in the early 1990s, allowing the formation of new private institutions of higher learning, resulting in the rapid development of private postsecondary education. Whereas only 15% of engineering seats in university had been at private institutions in 1960, 86% are private today. The rapid advancement of the private university system has created some problems. Quality varies widely, from clearly substandard to the highest international quality, and the government has not established, much less enforced quality standards. Some Indians also object to the high tuition and fees as being counter to the equal access goals of the nation.

Today the higher education system in India is extensive and rapidly expanding. It currently includes more than 300 universities, 15,000 colleges, and 5,000 training institutions. Nevertheless, only 6% of the college-age (18-23 year old) population is enrolled in college or university. Some of the schools, such as the Indian Institutes of Technology and the Indian Institutes of Management are world-class; but the quality falls off rapidly after the top 15 schools. Total bachelor and master degree production in the computing and electronics fields is approximately 75,000 per year. There are also some 350,000 students in other science and engineering fields at universities and polytechnics receiving degrees each year, and many of them enter the IT industry upon graduation.

Training in the latest technology, English-language skills, and other work-oriented topics are also important to the Indian software industry. This training is offered both by many independent training organizations and some of the large IT companies such as Infosys and Wipro, which run their own training operations.

China faces the same educational issue as India in building a trained workforce for its software industry, but its approach is different, through centralized planning. When the Communist Party came to power, it was committed ideologically to education and the use of science and technology for economic development. Upon the establishment of the People's Republic of China in 1949, the Western powers pursued a policy of isolating China; a by-product of this was China’s adoption of the Soviet Union’s model of comprehensive and specialized universities and a large network of research institutes. In 1978, the Chinese university model was reformed to one that more resembled that of the United States and emphasized comprehensive universities. In the 1980s, China began sending many of its brightest science and engineering students to the West, especially to the United States, for graduate education. Nevertheless, the government research institutes within China are still enormous and play an important role in graduate education. Until recently, only a very few universities undertook research; their highest priority was pedagogy.

As in the case of India, Chinese universities graduate an enormous number of students every year. In 2001, 567,000 students received their first degree, including 219,000 in engineering and 120,000 in science. The quality of these graduates varies dramatically, but the sheer volume means that China has a large reservoir of technically trained individuals.

Until 2001, Chinese universities neglected software studies as an academic discipline. At the end of the 1990s, the Chinese government recognized that it had a shortage of trained software personnel and called for improvement in Chinese software capabilities as part of its central planning efforts. In response, 51 Chinese universities established masters degrees in software engineering. These degree programs quickly attracted students. Including all the different kinds of curricula, China is now training about 100,000 people per year for the software industry. There are internal criticisms of the education, including overemphasis on theoretical education, insufficient attention to practice, and lack of familiarity with international standards.

There are many challenges to implementing an educational response to offshoring. Consider the challenges in the United States. IT work encompasses many different occupations, each with its own skill and knowledge requirements. There are five major types of undergraduate degree programs in IT, and each would require revision in order to address offshoring. There are similarly four different degree levels (associate, bachelors, masters, and doctorate) to revise. Non-degree programs, such as certificate programs, corporate training, and non-traditional universities all also play an important role in preparing the IT workforce. There are multiple career paths in IT to take into consideration, not just the traditional one from a college degree to a career in the same field. Universities are slow to make changes in their employees and their course offerings. It is hard for national bodies to predict and match supply and demand for the IT workforce, so it is hard for the higher education system to know how to set its production levels. The mission of a university is not only to prepare tomorrow's workers; there are other goals such as research, preparing tomorrow's teachers, giving students a liberal education, and teaching them to think critically that must be considered when revising a university's program to address workforce needs. Offshoring itself is rapidly changing (from bodyshopping, to call centers, to business process outsourcing, to knowledge process outsourcing and other higher value added tasks), so how is a higher education system to know what occupations to prepare its students for? These challenges mean that educational systems will have to continually adapt to serve well their students and countries in the face of increased globalization.

Although the educational needs and issues may look different from different national or individual perspectives, this study has identified six overarching principles that should apply in developing as well as developed countries wishing to participate in the global software industry.

There is a need to consider the levels of IT work that are predominant in the national or multinational economy being served by the educational institution, and which are likely to be predominant in the coming years. Software and IT work can be thought of as consisting of a spectrum from the more routine (e.g. system and computer maintenance and support, basic programming) through the more advanced (e.g. application programming that requires knowledge of IT and specific applications, whether business, science, media or otherwise, or sophisticated systems programming and IT architecture development) to the advanced strategic (development of approaches that utilize IT to advance the organization strategically and provide it with a competitive advantage). As computer science and IT curricula are developed, particularly at the national level, it is important to consider the levels of workforce preparation to which the curriculum is addressed. In nations that are current recipients of offshored work consisting of programming and routine software testing and maintenance, for example, it may be desirable to focus the curriculum more heavily on the lower levels. This may change, however, as the roles played by IT professionals in these countries evolve and the offshoring providers aim to perform higher level work. In countries that are seeing their commodity IT work being offshored, it will be desirable for the curriculum to prepare students for the middle and upper levels of IT work, where the ability to merge computer science and IT with applications and strategy are important. This is likely to lead to an increased emphasis on application knowledge and a reduced emphasis on programming skills. It should be stressed that in all cases, however, the predominance of a certain level of IT work in a certain nation or region is just a generalization; all levels will exist in all countries, and students will be needed to move into all of these levels. It is the distribution that will vary.

There is a need for CS education to evolve, whether due to globalization or not. The skills and talents needed by software and IT professionals have evolved over the past half century, independent of issues such as outsourcing and offshoring. In general, IT professionals are more likely to work in an application-specific context than previously, and conversely, less likely to work on computer-specific areas such as compiler or operating system development. They are more likely to work on large software applications in teams that include applications specialists, and depending on the organization, also to collaborate with sales and marketing staff. They are also more likely to work in an environment where they are expected to be masters of certain software platforms and interoperability standards, and know how to reuse code. Thus in general, it will be increasingly important that a computer science or IT education involves training that enables the student to work on large-scale software applications, to understand important business, scientific, or other application areas, and be familiar with the tools and platforms that are increasingly the standards in the international marketplace. It also is increasingly important that the education emphasizes teamwork and communication skills, especially as they are practiced in a geographically distributed fashion.

There is a need for education to begin to prepare students for a global economy and its possible impacts on their careers. It is increasingly likely that an IT professional will be working in a global context. This may include being part of a multinational team, or collaborating with customers or suppliers from other parts of the world. Thus, it will be increasingly important that an education in computer science and IT help prepare students for this global workplace. Education that acquaints students with different languages and cultures, whether through courses, study abroad, or other means, will be increasingly beneficial. Finally, to the extent that English is the common language of the IT industry, the ability of nations to educate their IT professionals to be fluent in English will be a major factor in determining their success in the outsourcing economy and in multinational endeavors.

Educational systems that help prepare students to be creative and innovative will create advantages for those students and their countries. As the lower tiers of software and IT work become more commoditized, creativity and innovation will become even more important, particularly in countries that experience the loss of support and programming work. The creation of new products and new businesses will continue to lead to the greatest commercial and scientific successes, and even more, become the differentiator between organizations and between nations. Historically, some educational systems are seen as fostering creativity in students more successfully than others. One crucial differentiator in fostering a creative mentality in students is the research component of the educational system, and the participation of students at all educational levels in the university's research enterprise. Another differentiator is the degree of rote learning versus more open problem solving. Nations that currently have an advanced research enterprise in their university systems may increasingly see this as their greatest competitive advantage in educating computer science and IT students for the higher tiers of the IT workforce. Nations that do not include a research component in their university systems will need to consider whether, strategically, the investment in developing this component and culture is needed to attain their goals for the IT economies in their countries.

Educational systems that not only pay attention to current business and industry needs but also provide a core foundational knowledge will create advantages for those students and their countries. To cite two national examples, the Indian educational system has been particularly good at teaching the latest technology that is needed in business and industry today. The United States has been particularly good at teaching foundational knowledge that is likely to serve a student through most of his or her career. Foundational skills help students remain current, and not become obsolescent, as the technology changes rapidly around them. Although the particulars of a new technology in the workplace may be different from what a student was taught in school, a basic understanding of computing principles and ways of addressing problems will remain current even as the particular technologies change. Of course there needs to be a balance between fundamentals and currently relevant technologies in the student's education. In order to prepare students to be productive workers when they enter the job market, it also is important that the educational system pay attention to the current needs of business and industry and select the technologies it exposes students to in order to address industry needs. This goal can be achieved through respectful interchange between people in the academic and industrial/business worlds. No IT education can possibly fulfill all of the student's educational needs for an IT career, however, and IT workers should expect to have to engage in life-long learning in order to keep up with the rapid pace of technological change and the rapid changes in the way that organizations employ information technology.

A good educational system requires the right technology, a good curriculum, and good teachers. Fortunately, personal computers are relatively inexpensive, software for them has been commoditized, and fast, inexpensive broadband communication is readily available most places in the world. Thus, the technology for training an IT workforce is within reach of much of the world. The model curricula that have been designed by the professional societies have been and should be used in many places around the world. There is probably value in developing a process by which these curricula can have greater business and industrial input and react more rapidly to changes in the way that IT gets used in the world. Although adopted around the world, the model curricula have been designed primarily for degree programs in the United States. If the professional societies truly aspire to be world bodies and develop world curricula, they should pay attention to the needs of other countries and their degree programs as well. The teacher problem may be the most difficult one to address. For example, in the United States, there are serious problems with the preparation of high school teachers who introduce students to IT, and several times in the past (in the late 1970s and again during the dot-com boom of the late 1990s) American universities had difficulty recruiting and retaining quality faculty because of the lure of industrial IT positions, and had inadequate number of students obtaining doctorates, which are required to become faculty members. In India, critics complain about the general quality of IT faculty, salaries are low, and there have been no funds to enable research either by the faculty members or their students. Inducements to improve the quality of the faculty would be helpful in India, the United States, and other countries.

8. The Politics of Offshoring

Globalization, especially in its manifestation as offshoring, is a hugely disruptive force that effects the national movement of wealth and jobs. In addition to the educational responses to offshoring discussed above, countries might adopt political responses. Developed nations might take political action to stem the loss of jobs and wealth to globalization, either through protectionism or measures to make the country more competitive. Developing nations might take political action to create an environment in which its software export industry can flourish. Our initial focus here is on the United States, which is largest global offshoring procurer.

Public policy debate about offshoring began in the United States as a result of the wide news coverage of the report in November 2002 by Forrester Research that 3.3 million US jobs would be lost by 2015 as a result of offshoring. The most common response to offshoring in the United States has been actions by the executive and legislative branches of the state and federal governments to create protectionist laws and executive decrees to control the movement of work out of the country. Bills have been introduced that limit the citizenship or visa status of workers allowed to do work for US organizations or require that call center operatives working outside the United States inform callers of that fact. There are reasons to question the legality and efficacy of this protectionist legislation. Some legal scholars believe that most proposed state laws and executive orders will be ruled unconstitutional because of the Commerce Clause of the Constitution, which leaves control of international commerce agreements in the hands of the federal rather than the state governments. Legal scholars also believe that proposed federal legislation on offshoring may break existing international agreements. There is also a risk of retaliation by other countries to protectionist American legislation.

A second policy approach has been to propose reforms to the H1-B and L-1 worker visa programs. The purpose of these programs is to help US companies find skilled workers, but critics claim that they are being misused as part of a strategy that enables companies to export jobs, especially to India.

A third approach is to ensure that US tax law provides no incentives to moving jobs overseas. These proposals would normalize tax rules between the United States and other countries so that US-based multinationals will have incentive to repatriate earnings to the United States that they earn in other countries. Tax law is hard to enact; and even if it were enacted, there would still be disparities because of costs of health care, safe workplace legislation, and environmental protection.

A fourth approach has been directed at providing support to Americans who lose their jobs through offshoring. In 1962, the US Congress passed the Trade Adjustment Assistance Act to offer job training and extend the length of time of unemployment benefits to American workers who have lost their job through trade agreements. There has been a political and legal battle over whether the Trade Adjustment Assistance Act does or should apply to software workers. Progressives want to go beyond this act and also require companies to provide three months of notification to workers whose jobs are to be eliminated because of trade, extend the term length of unemployment benefits, provide wage insurance paid for by the companies that offshore work to make up some of the drop in wages typical in the displaced worker’s next job, improve retraining and reemployment services, offer temporary health care and mortgage assistance, and allow multi-year income averaging on federal taxes.

A fifth approach is to improve the innovation base. The basic idea is that, although some jobs will undoubtedly be lost to low-wage countries, America can produce a substantial number of new jobs, including many of them that are high on the value chain, through policies that create a climate of innovation. Innovation policy generally has four elements: making it more attractive for foreign students and scientists to work in the United States, improving the educational system in the United States, attracting US citizens to the science and engineering disciplines, and increasing federal support for research and development. There have been numerous criticisms that the United States is not now doing enough to build that innovation base, and there are proposals under discussion by both Democrats and Republicans in Congress, as well as suggestions from various non-profit organizations, to create new innovation initiatives.

How do policy issues in other countries that offshore work compare to those in the United States? Australia presents an interesting case study in the politics of offshoring in that Australia offshores work but is itself a country that has benefited greatly from free trade, both in terms of its important export markets for wheat, wool, coal, wine, education, and tourism, and also for the range of products that are available to its citizens through imports.

Debates over free trade arose in Australia over offshoring in 2004. There was sharp criticism from the opposition Labor Party to the lack of policies protecting Australian jobs and workers. Interestingly, the Australian Computer Society published a policy paper that advocated free trade and resisted any protectionist measures. Instead, it called for improvements in existing government programs to help displaced workers with re-training and re-tooling, check-lists that would educate Australian companies on the cost-benefit analysis of offshoring so that they would not rush headlong into it, and changes in industrial policy to enhance Australian R&D. The sitting Howard government was pleased with the report and outlined its own policy initiatives, which included more government support for displaced workers, an effort to increase foreign direct investment in Australia’s IT industry, and various improvements in teacher training, educational programs, and educational assessment.

New Australian government data appeared this year, showing that many of the temporary visas for skilled workers are held by Indians, and many of these visa holders are doing programming work. These numbers concerned the Australian Computer Society, and they have taken harder-line positions on both the skilled temporary visa program (known as "457" visas) and on a permanent residence visa program, known as the General Skilled Migration Program. While still endorsing the basic immigration policy of the Australian government, ACS has called for adjustments in the 457 system to make it fairer. It has also called for the permanent immigration program (General Skilled Migration Program) to be substantially reduced until the market can absorb ICT graduates from Australian universities, Australian computer science enrolments begin to increase, and unemployment levels for computer workers fall to the level of other professions in Australia.

Sweden provides an example of the policy stance of a Western European country that engages in offshoring. The Swedish economy and welfare has benefited greatly from a long tradition of free trade, starting in the late 19th century. The policy includes agreements between employer and worker associations on the basic principles for wage setting and job assurance and a commitment to overall Swedish industrial competitiveness in knowledge-intensive and high-wage industries. This industrial policy caused Sweden to create one of the biggest high-technological industries in the world; and it has among the highest rates of investments in R&D and outputs in terms of scientific publications and patenting. Sweden has also become one of the most internationalized economies in the world, having a high dependence on foreign trade for its Gross Domestic Product. Part of its industrial rationalization is through offshoring to countries with lower production costs.

On several occasions, specific industrial policy measures have been taken by the Swedish government to support industries with low and decreasing international competitiveness. In the 1970s, considerable industrial support was given to the steel, clothing, and marine industries when they faced large-scale failures, but the measures turned out to be futile. As a consequence, Swedish policy has to a large extent returned to the basic policy principles of free trade, so in the current globalization trends Swedish policy is almost completely free from protectionist and direct job-protection arguments. There have, however, been a number of initiatives to improve Swedish competitiveness and counteract the negative impact of offshoring. They are all related to a new national innovation strategy advanced in the spring of 2004, which has three fundamental points: technological development and R&D as the key to Swedish competitiveness, investments in large-scale public-private partnerships to achieve centers of excellence in R&D for specifically targeted industries, and reorganization and increased funding for R&D startups and growth of small and medium-sized research-driven companies. Software is not explicitly mentioned in the plan. In Sweden, software development and production is primarily embedded in other manufacturing or service-providing value chains.

Turning now to the developing countries that export software service work, there have been significant policy issues at the national and state levels that have shaped the climate for the Indian offshoring industry. These include regulatory policy as it affects foreign direct investment, taxation, building an infrastructure, protecting intellectual policy, data protection and privacy, and education and training policy.

The regulatory history is the longest and most comprehensive of all Indian policies affecting offshoring. From the 1950s to the early 1970s, Indian economic policy focused on identifying ways for domestic companies to replace imports. Policies enacted in the 1970s that severely limited foreign ownership in companies operating in India drove out some multinationals, including IBM. Regulation in the 1980s promoted the development of the hardware industry and identified software as a promising export business; however, India had limited success in the 1970s and 1980s in building an indigenous IT industry. India was forced to liberalize its economy in 1991 in the face of severe cash problems. The new industrial policy included reduced licensing requirements in most industries, allowed foreign companies to hold majority interest in Indian companies in many industries, provided for automatic approval for hiring foreign technicians and foreign testing of technologies developed in India, and reduced restrictions on the ways in which mergers and acquisitions could take place.

Tax policy also had a shaping effect on the Indian software industry. In 1981, the Indian tax code was revised to establish tax-free zones on profits and gains for manufacturers, including software manufacturing. In 1993, the law broadened the tax-free zones to include various science and technology parks. The law was again broadened in 2005 to give tax breaks to software firms outside these parks.

Infrastructure policy also shaped India's software industry. Laws intended to build a favorable infrastructure and reduce labor regulations and other bureaucracy for the software industry were enacted primarily by individual state governments, mostly in the southern part of India. The one infrastructure issue subject to federal governance was telecommunications policy. Beginning in 1991, the telecommunications sector experienced a series of deregulations that continued until recently. Deregulation enabled the Indian software industry to have access to a completely modern telecommunications system with a capacity and cost that enabled the offshoring service companies to be internationally competitive.

China provides an interesting contrast to India. China is a policy-driven society, and one sees much more significant intervention of the state in the economic development of the software industry in China than in India. The national software strategy in India has been focused on the export service market, whereas the Chinese are interested in capturing their domestic software product and service markets as well as participating in the export market.

Until the 1980s there were mainly local rather than national companies in China. Much of the capital available to businesses was tied in one way or another to the state, and many of the decisions on capital allocation were made at the local level. Since then, internal trade barriers have been dropped, enabling companies to build scale and move into neighboring markets. In recent years, the national government has promoted economic reform through competition among provinces and growth for individual companies by access to capital through the national stock market. Consolidation and focus on the international market has not yet occurred in the Chinese software industry. As of 2002, there were over 6,000 software firms in China; only 19 of them had sales exceeding $120 million.

Chinese policy towards forming technological capabilities has changed over time. From 1978 to 1985, the focus was on central planning and state control. In the period from 1985 to 1991, the focus was on enhancing the innovation system through greater state support for both public and private R&D. Since 1992, the focus has been on enabling market-oriented reforms to improve the quality of research and the skills of the workforce, and to broaden the focus on development beyond the defense and heavy technology industries.

The government has taken a strong hand is the development of trained personnel for the software industry. This included not only new educational programs, as described above, but also concentration of highly skilled software talent in certain geographic areas, by having the government facilitate transfers of skilled software personnel to the chosen places, including providing accommodation for their spouses and children. The Chinese government has also provided incentives for overseas Chinese software workers, especially managers, to return home through such incentives as cash payments, cars, houses, and promotions.

The Chinese government supports R&D in universities, research institutes, and to some extent industry. The best known of these initiatives is the Ministry of Science and Technology's High Technology R&D Program, known more commonly as the "863 program", which has provided more than a billion dollars of government funding for basic research since 1986. Other programs to provide research support include the Development Fund on Electronic Information Industry, an R&D Fund on Industrial Technology, and a Technological Innovation Fund. Although the government has continued to support important state research institutes, such as the institutes of the Chinese Academy of Sciences, there has been an effort to make them less dependent on the state and encourage them to reach out to obtain external funding sources.

The government has also taken steps to improve the competitive business environment. China does not have a long history of controlling anti-competitive behavior in a technological sphere, and it has thus had to pass a series of acts that protect a competitive environment, making illegal certain kinds of behavior such as impugning another company's reputation, bribing, threatening, and dumping. There have been targeted tax reductions to companies that meet certain sales and export figures. Exporting firms have been given favorable terms on bank loans, export insurance, and taxes and duties.

China has one of the world's worst software piracy problems. The Chinese government has taken a series of steps to try to curb piracy. In addition to the general copyright law, China has passed several laws targeted at fighting organized crime that is manufacturing and distributed copies of pirated software. Government organizations are coordinating anti-piracy campaigns, and are being encouraged to be model citizens themselves by using no pirated software. A registry system has been established, under which owners who register their copyrighted software are given extra protections under the law. However, software piracy remains a big issue.

Politics is one of the ways (together with education, consumer boycotts, and labor action) that nations can respond to offshoring. The general movement has been to avoid protectionist legislation. Australia and Sweden have completely espoused free trade even though they risk some level of unemployment for their IT workers. In recent years, India has moved away from its protectionist and isolationist politics of the 1960s and 1970s. The United States has had a number of protectionist actions suggested, but most of these efforts have not been enacted into law, and today there are calls for policies to enhance its competitiveness rather than to protect its jobs by legal and economic barriers. China is the most protectionist of the countries studied here.

All of these countries understand that they have to make their national laws conform to some degree with global practices if they want to be players in the global marketplace. Thus China, for example, has been willing to revalue its currency despite the short-term gain from keeping it artificially low; India has eased many of its trade barriers; the United States has entered into numerous international trade agreements; and Sweden has conformed to international monetary policies.

All of the countries studied here recognize that there are certain risks of sending software work across national boundaries. These include questions of intellectual property, privacy, and data security. Europe has taken the lead in strong privacy policy, and India has seen the economic value in meeting European and US standards on privacy. China is not so far advanced in managing these risk issues as India is, but there is every reason to believe it will have to do so if it wishes to continue to attract international business. China is struggling with balancing openness of information with political control, and so far it leans in the direction of control rather than individual rights.

For the developed countries that send work offshore, a common political approach is to build new jobs and prosperity through policies that increase innovation. Sweden is increasing government support for research and development, and there are calls for this to be done in the United States. The two countries differ on parts of the innovation platform, however. Sweden currently has an abundance of highly educated workers, so it is not interested in ramping up its educational system. The United States is facing declines in foreign scientists studying and working there, as well as declining numbers of American students studying technical disciplines; so an integral part of the innovation platform for the United States is to improve the education system and attract foreign workers and students (to the degree this is compatible with national security policies).

India and China have a number of similar policies for developing their offshoring industries. Both are interested in ramping up their educational systems to supply an adequate number of skilled workers for their IT companies. Both are concerned about having adequate infrastructures (power, transportation systems, telecommunications) to provide good service to their IT companies. Both have adopted a series of policies intended to attract foreign investment. China has implemented policies to try to produce a reverse Diaspora, so that native-born scientists who have been working primarily in the United States and Europe return home to be part of the senior technical and business leadership in their IT industries; India has achieved this same effect without explicit national policies. India has more experience in developing policies to support the export software market than China, but China is advancing rapidly and has a more centralized government-planning model in place.

Authors: Alok Aggarwal, William Aspray*, Orna Berry*, Stefanie Ann Lenway, Valerie Taylor.

Chapter 1: Offshoring: The Big Picture

"*Offshoring is nothing less than a revolution in the tradability of services.*" (World Investment Report 2004, p. 148)

1. 1 Introduction

In the United States today, there are two views about the offshoring of IT and IT-enabled services. Some people, such as the television business commentator Lou Dobbs, see a crisis in our midst. More than a million blue-collar manufacturing jobs in the United States were lost in the last ten years, mainly to low-wage Asian nations. The solace in all this for American policymakers had been that another kind of job – the high-paying, white-collar jobs in the computer and other knowledge industries that had long been dominated by the United States – seemed immune to competition from low-wage countries. But then the pattern of job loss began to be repeated in the white-collar labor force as the software and IT-enabled service sectors moved jobs to Malaysia, the Philippines, China, and especially India. Dobbs and others called for protectionist measures to stop the hemorrhaging of high-paying jobs from the US economy. They believed that offshoring was not only going to do short-term harm to those who lost their jobs, but also long-term damage to the individuals and communities losing these jobs.

Others disagreed, pointing out that when this work is sent offshore, although domestic labor may lose in the short term, there are many winners in the high-wage country: consumers through lower prices; companies through higher productivity, more competitive pricing, and shorter time to market; shareholders through higher corporate earnings; company executives through higher compensation packages; and perhaps a select group of other employees whose jobs change to include more interesting tasks associated with innovation and exclude much of the drudgery of mundane tasks. Many of the supporters of offshoring believe that the individuals who lose jobs will be able to find other good jobs, especially if they are given a safety net from the state consisting of temporary benefits and retraining, and that the total number of jobs may actually increase over time through higher productivity and greater competitiveness of the companies that send work to low-wage countries.

This difference of opinion in the public debates over offshoring is also found among professional economists. Economists are generally regarded as being in favor of free trade. For example, one economist who has looked closely at the issue of offshoring is Catherine Mann of the Institute for International Economics in Washington, DC. She argues that free trade will eventually lead to greater prosperity for the nation. She points to the case of computer hardware manufacturing where many manufacturing jobs shifted from the United States to East Asia in the 1990s as having been highly beneficial to the American economy. Western innovation, coupled with global sourcing, led to price reductions in products. This led in turn to more IT investment in the Western nations, higher Western productivity growth, and ultimately enhanced growth in gross domestic product. Mann believes the offshoring of computer hardware manufacturing was one of the reasons for the robust economy in the 1990s in the United States and argues that the long-term national economic benefits from outsourcing software and services are likely to be even greater than the benefits from outsourcing hardware manufacturing. On the other hand, both Paul Samuelson of MIT and Ralph Gomory of the Sloan Foundation, working with William Baumol

• W. Aspray and O. Berry took a leadership position in the writing of Chapter 1.

of Princeton University and NYU, have done analyses that show that high-wage countries can lose through trade under certain circumstances. (Mann's argument is discussed later in this chapter, Gomory and Baumol's in Chapter 2.)

Looking at this same issue from the perspective of a low-wage country such as India, you can also see two perspectives. Offshoring work is the top growth area in the Indian economy, and it is the driver of India's international trade. Hundreds of thousands of new jobs are being created, and even entry-level positions in this field pay much more than the average wage. IT is seen as the way for India to leap from being a third-world economy in the 20th century to a world leader in the 21st century. However, this IT workforce still represents only a tiny fraction of the Indian population, and there is a backlash to all of this change in a country with rich cultural traditions. The traditional family structure is threatened as young people move to the high tech centers for work, have large disposal incomes, and otherwise follow work practices that do not fit with traditional culture. This economic growth has brought congestion, unbridled growth, and severe wage differentials to cities such as Bangalore. The benefits of offshoring are unevenly distributed with little benefit for the majority of the people in China or India who are rural, poor, uneducated, and without English language skills. Some critics complain that government funds spent on attracting and building the infrastructure for IT companies could be better spent on helping poor and rural populations with clean drinking water, better primary education, and other basic infrastructure.

Which of these pictures is correct? Is offshoring leading to long-term deterioration of Western living standards or is it the means to greater productivity and prosperity in the West? Is it the economic savior for low-wage countries such as India and China or is it the death knell for another traditional way of life? This chapter will introduce the subject of offshoring of software and services and provide a framework for understanding it and related issues from the perspective of both high-wage and low-wage nations. The following questions are addressed in this chapter; many of them will receive more detailed attention in later chapters.

- What do we mean by outsourcing, offshoring, and globalization of software?
- How did offshoring come about?
- How much work is offshored?
- Which countries send work offshore and which countries do most of this work?
- What types of work are sent off shore?
- Why are firms interested in sending work offshore?
- What are the technical, business, and other drivers and enablers of offshoring?
- Why might a firm, a profession, or a nation not want to offshore work?
- Is IT still a good career choice for people working in countries that ship IT jobs overseas?

1.2 What Do We Mean By Outsourcing, Offshoring, and Globalization of Software?

It is important to be careful about the terminology used in this study. Outsourcing means that a firm sends work to another organization to be done. Most outsourcing done by US firms, for example, is work sent out to other US firms. The client company might have parts made for them or have another company handle the cleaning of their office premises, for example. Offshore refers to where the work is done. It is a term that applies best to the

United States because, even though the United States does outsource work to Canada and Mexico, most of its work is sent over the seas, largely to India, but also to China, Malaysia, the Philippines, and many other places. Germany, for example, sends work across its borders, especially to Eastern Europe, but there is no water – no shore – to cross.

Some of the work that is offshored is sent to entrepreneurial firms established in low-wage countries. Thus a UK firm that sends work to an entrepreneurial firm in India, such as Infosys or Wipro, would be sending the work outside their own company.

At other times, multinationals headquartered in high-wage countries operate subsidiaries in the low-wage countries to work on products and services for their world market. The multinational might do this by contracting for all the services offered by an entrepreneurial firm located in the low-wage country, in which case the entrepreneurial firm is sometimes said to be a captive of the multinational, and the multinational holds great power over the entrepreneurial firm. The multinational might instead buy an entrepreneurial firm in a low-wage country outright, or it might create its own subsidiary there. These subsidiary firms, whatever their organization, represent an increasingly large share of the offshoring of software services.

Multinationals sometimes open facilities in low-wage countries in order to better serve the local market especially since the Indian and Chinese markets are expanding so rapidly, but that situation is not the primary interest of this study. We are more interested in multinationals that open operations in low-wage countries to serve the world market. Offshoring is part of a larger trend toward the globalization of software under which software products and software services are created throughout the world and sold throughout the world. The aspect of globalization that involves moving work from high-wage to low-wage countries is the most important aspect of globalization for this report but, over the coming years, other aspects of globalization are likely to become important to the professional, business, and policy communities.

More precisely, we should differentiate between captive offshoring and outsourced offshoring or offshore outsourcing as it is often called. For compactness of language, we will often use the term offshoring in this report without consideration for whether the work is done by a captive or entrepreneurial firm. Where it matters, we are careful about the distinction.

1.3 How Did Offshoring Come About?

In order to understand offshoring, it is worthwhile to place it in the historical context of globalization and multinational corporations. The import of raw goods and agricultural products from less developed nations and the export of manufactured goods by industrialized nations goes back centuries to a time when transportation across long distances became feasible. Over time, some countries placed tariffs and other protective barriers on international trade to protect their markets or industries. The first period of intensive globalization came in the nineteenth century when laissez faire economic theory drove nations to reduce or remove tariffs that limited the movement of goods. Globalization was also driven by the adoption of the gold standard by many countries in the second half of the nineteenth century. Gold stabilized the value of money and greatly enhanced trade across national borders. Globalization led to the concentration of industrialization in the industrialized countries at the expense of their agricultural bases, specialization in the manufactured products they exported, growth in population, and demand for greater import of agricultural products from agriculturally oriented countries. Globalization led to a substantial increase in wealth for the industrialized countries.

This period of globalization ended with the onset of the First World War, and then an era of protectionism ensued between the two world wars. The second wave of globalization, which continues today, began near the end of the Second World War with a meeting in Bretton Woods, New Hampshire in 1944 that led to the formation of The World Bank, The International Monetary Fund, and the reestablishment of the gold standard. The World Bank, whose original mission was the financial reconstruction of nations destroyed by the Second World War, broadened its mission to include reducing poverty through the funding of state governments to improve their educational, agricultural, and industrial systems. The International Monetary Fund was formed to oversee the global financial system. This it has achieved by making the international monetary system more stable and by helping out countries with monetary problems by supplying them with financial and technical assistance.

The period since the Second World War has been characterized by a series of international agreements to promote free trade. This period began with the General Agreement on Tariffs and Trade (GATT). Twenty-three countries participated in GATT's first round of talks in Geneva in 1948, but by the Uruguay Round of talks in 1993, the number of countries participating had increased to 123. The Uruguay Round of talks led to the formation of the World Trade Organization (WTO) as a successor to GATT. Under the WTO, there have been a number of different approaches to enhancing global free trade: reduction of tariffs, export subsidies, and other trade restrictions; formation of free-trade zones; reductions of restrictions on capital; and increased agreement among national intellectual property laws. Country membership has grown from 26 in 1993 to 148 today. The net effect of all this is to have many more countries participating in international trade and to provide conditions that enable this trade to occur more easily.

Multinational companies, which are simply companies operating in multiple countries, have played an important role in the globalization of trade. The first multinational was The Dutch East Indies Company, formed in 1602. The rise of big business in the second half of the nineteenth century, with its concomitant separation of ownership from management, created many new multinational companies. Some of these nineteenth-century multinationals were technology companies such as I.G. Farben, which started its chemical business in Germany, and General Electric, which started its electric power business in the United States. Within a few years of their founding, both of these companies were operating in many different countries around the world.

The computer industry attracted firms from the business machines, electronics, and defense industries but also included important entrepreneurial start-ups. A number of companies from the computer industries became important multinationals. These include General Electric (formed in 1895 and entered the computer industry in the 1950s), IBM (consolidated in the tabulating business in 1911), Hewlett Packard (formed in 1939 as an instrument maker and entered the computing industry in the 1960s), EDS (formed in 1962 to serve large users of computers), Microsoft (formed in 1975 to provide products in the microcomputer software industry), and Dell (formed in 1984 to provide microcomputer hardware). It is notable but not surprising that these companies all had their origins in the United States. The United States has dominated the computer industry throughout its history. In its hey-day, IBM alone held about 70% of the world market for mainframe computers, for example. The United States also had the market lead in the electronics industry (mainly because of its dominance of the radio and television industries and its later need for components for the computer industry) and the semiconductor industry, which grew as a spin-off from the invention of the transistor at the regulated US monopoly AT&T and was closely coupled in its history with the computer hardware industry.

US dominance in the computer, electronics, and semiconductor industries continued into the 1970s, but then some changes began to occur. Perhaps the most public story was the emergence of Asia as a leader in the manufacture of electronics and semiconductor devices.

In the 1970s and early 1980s, major US electronics products firms began to set up affiliates in Hong Kong, Singapore, and Scotland to use high-quality workers (with wages lower than US workers) to do labor-intensive assembly such as assembling circuit boards or assembling price-sensitive products such as computer peripherals or telephones. At first, the components were built in the United States and shipped to these assembly plants but over time the assemblers began purchasing components from local sources. Eventually, their skill levels increased and they began to provide turnkey services. One specific example is disk drive manufacture which began to migrate from the United States to Asia in the 1980s; today, very little of this manufacturing takes place in the United States.

A similar story occurred in the semiconductor industry. Beginning in the early 1970s, American (and later European) semiconductor companies such as IBM, Philips, AT&T, and Hewlett Packard began to move labor-intensive chip assembly to low-wage countries in East Asia, including Singapore, Hong Kong, Malaysia, and Thailand. These chips were then shipped back to the American or European electronics firms for assembly into final products. During the 1970s, the American semiconductor firms kept semiconductor wafer fabrication, circuit board assembly, and product-level assembly in the United States. But both computer and electronics firms opened or expanded plants in Scotland and Wales to do circuit board and product assembly for the European market in the 1980s. Scotland and Wales were selected for their educated workers, an English-speaking workforce, and government incentives to attract foreign direct investment. It also helped that wages were lower there than in the United States. More recently formed American companies such as Sun Microsystems, Silicon Graphics, and Cisco never vertically integrated their operations but instead always used contract manufacturers such as Solectron and Celestrica and chip fabricators such as Taiwan Semiconductor. These firms were located in the United States, East Asia, and Scotland.

In the 1980s in East Asia, Singapore's labor rates became too high and its companies began to offshore the most labor-intensive work to Malaysia and Indonesia which had lower wage rates. A similar phenomenon occurred in Hong Kong which offshored its labor-intensive work to China. Singapore and Hong Kong retained the work on circuit board assembly that could be automated. They also began to add backward integration services such as component and circuit design, circuit board layout and reconfiguration for better manufacturing, and forward integration services such as testing, final product assembly, packaging, shipping, and repair. With a few exceptions, the East Asian companies providing these value-added services chose not to produce products that competed directly with their American and European customers. By the end of the 1980s, East Asia had the capacity to provide circuit boards and electronics products to the entire world. At the same time, the United States retained and grew its business for higher-value, lower-volume electronics products such as large computers and communications switching equipment. This work was often done under contract to specialized contract manufacturers, such as SCI and Solectron, that were housed in the United States rather than by the large brand-name electronics product companies themselves.

As more and more of this manufacturing work was done in other countries, middle-class jobs were lost in the United States. It is hard to count the exact number of manufacturing jobs created outside the United States to serve the US market or the needs of US-based multinationals, but the number is probably in the range of a million jobs over the past decade. The labor force in the US Midwestern industrial states was especially hard hit. While this caused a public outcry and led politicians to suggest protectionist actions as mentioned earlier, some economists see a silver lining in these developments. For example, Mann argues that a combination of technological innovation in the United States and the increase of global sourcing and markets for hardware (IT, semiconductors, and electronic components and products) led to price declines. These price declines led to greater investment in IT in the United States. This, in turn, caused increasing transformation of the American workplace and an increase in the development of new products either incorporating IT or using IT in its development or manufacture. These developments, she calculates, caused half of the productivity growth in the United States during the 1990s and translated into increased wealth for the United States on the order of $250 billion in the period 1995 to 2000. Mann assumes that there can and will be a similar pattern of growth for the software industry but that the scale might be even greater for software than hardware.

While there has been angst in America over the number of good middle-class manufacturing jobs lost to Asia, there has also been a widespread belief that good jobs in the software industry would always remain in the United States. However, in the late 1990s and even more so in the past several years, there is a dawning recognition and fear that these high-paying software and service jobs will be moved out of the United States as well. Similar concerns are now beginning to be expressed in Western Europe.

A number of IT-enabled services are being offshored today. They range widely and include, for example, reading X-ray images of patients, identifying risk for insurance companies, and processing financial data, as well as testing, building, and maintaining software for customers. Software was the first service sector to be offshored to a significant degree. This is perhaps because it was easy to transport the work data and work products using simple communications equipment (a telephone and a modem) and because there was a significant wage difference for programmers between the United States (or Western Europe) and India (or China). During the late 1990s, software offshoring seems often to have been driven by labor shortages in the United States, especially associated with fixing the Y2K problem and creating new Internet products and services during the dot-com boom. When the dot-com bubble burst, offshoring continued – with cost as a major driver – and began to represent jobs transferred overseas rather than jobs supplementing an insufficient US labor market. The practice of offshoring became a political issue in the United States only after the recovery from the 2001 recession was historically weak in its creation of jobs. European concern about offshoring lagged behind US concern presumably because the United States began to offshore first and has always offshored to a greater extent than Europe.

Firms have outsourced work for centuries, sometimes even to companies that are outside their national borders. The first offshoring in the software and IT services sector began in the early 1980s: US firms sent some credit card processing to the Caribbean and established call centers there. Software centers provided software services to the PC manufacturers in Malaysia at about the same time. However, there was no substantial software offshoring industry until the 1990s. India, Singapore, Ireland, Israel, and Hungary were all early entrants in the offshoring business. Despite some differences in focus from country to country, described in a later section of this chapter, all of these countries benefited from first-mover advantages. Every several years, as a new application area became hot, the offshoring firms in these countries would turn their attention to this application, moving from business downsizing/reengineering, to Enterprise Resource Planning, to Y2K, to Euro conversion, and so on. These offshoring firms coupled this strategy with an effort to move up the value chain through industry sector specialization in order to deepen their expertise and build trusted relations with clients who would eventually turn over progressively higher level and more profitable tasks for them to do.

The story of how offshoring began in the major vendor countries, such as India and China, is told in Chapter 3. These case studies indicate that offshoring has meant several different things. In India, for example, it began with body-shopping, the process of sending trained programmers to work for a few months in another country on the client firm's premises. This was followed by a blended strategy in which some of the work was done on the client's site and some at the vendor's site in India. Then call centers opened. In the past five years, facilities began to be established to carry out IT-enabled business processes such as accounting. More recently, Indian firms have begun to move up the value chain to do IT-enabled knowledge processing such as reading X-rays, conducting patent analyses, and carrying out IT research and advanced development. The players in this story were at first Indian entrepreneurial firms. But later, multinational firms came to play an important role, sometimes through an Indian firm that did contract work for the multinational company, but also through a firm purchased outright or started up by the multinational company.

The globalization of the marketplace is helping to drive offshoring. The Indian and Chinese governments, for example, have taken many steps to ready themselves to participate in the international software market. Software is seen as attractive to low-wage countries as a way to bolster their economies more quickly than the boot-strapping strategies tried in the past by developing nations. In fact, about one-quarter of all offshored shared-service centers for European clients involve interactions with the development agencies of the vendor's country (World Investment Report 2004). These countries have used tax breaks, marketing subsidies, grants, loans, reduced bureaucracy, and other techniques to attract foreign business and foreign capital. China passed the United States in 2002 as the most preferred location for foreign direct investment. Trade policy has been liberalized in these countries, for example, by reducing or eliminating export taxes and licensing (see Chapter 8 for details). These governments have enacted policies to strengthen the public and private education and training sectors (see Chapter 7). Subsidies have been provided for research and development activities in their countries, especially for development work that is likely to have a near-to-midterm payoff in new products or services. Governments are trying harder to protect intellectual property which has been an especially serious concern to Western businesses about China (see Chapter 6). The Indian central and state governments have worked to improve basic infrastructures such as telecommunications, electric power, transportation (both roads and airports), buildings and technology parks, and other amenities such as international-class hotels, but the infrastructure started in a poor state and the government is not efficient in these efforts. Table 1 describes the state of infrastructure in Bangalore, India's leading offshoring location.

Table 1-1: Bangalore's Infrastructure for Conducting Offshoring Work

Electric power is unreliable, so most companies have backup generators.

Roads are congested and in ill repair (an hour to travel the 12 miles from center city to the outskirts where the outsourcing companies have their campuses in Electronics City and Whitefield).

Work has not yet begun on a new international airport.

There is a shortage of rooms in international quality hotels.

No mass transit exists (talking of elevated railway) so most companies hire their own buses to bring employees back and forth to work.

Telecommunications infrastructure is improving rapidly (cell phones, satellite transmission, transoceanic fiber optic cable).

Source: Fannin (2004)

1.4 How Much Work Is Offshored?

The answer to this question is that nobody has very good data on the amount of offshoring worldwide, whether one measures the number of jobs lost or created through offshoring, the number or percentage of companies offshoring work, the number of companies providing IT software services for export, or the monetary value of this work. Chapter 2 provides a detailed analysis of the problems with the data. It also provides a sample of the statistics about the extent and impact of offshoring in the United States, Europe (with separate breakouts for the United Kingdom and Germany), and India. Adding these numbers up gives some sense of the global situation. In Table 2, we provide a sample of the worldwide statistics as already totaled up by others. One can see from the McKinsey (2005) statistics that the actual number of jobs offshored is still a small fraction (less than 15%) of the number that could be offshored. Other statistics in the table make it clear that one type of offshoring –business process services – is growing very rapidly, and that there is room for considerable growth since only 30 percent of the largest 1000 corporations are currently offshoring any work of this type. It is also clear that India is the major provider of these services. We do not have good numbers for the amount of software service work (software maintenance, testing, programming) being done independent of work for call centers or business process outsourcing. Nor can we tell exactly how much of the offshoring work is being done by independent firms and how much by subsidiaries of multinationals, although it is clear that the latter are a large part of the total. The numbers do, however, give a general sense of the scale of offshoring activity worldwide. Additional information about the size of the Indian and Chinese shares of the world offshoring and software markets is given in Chapter 3.

Table 1-2: The Extent of Offshoring Worldwide

Source	Data Reported	Statistic
McKinsey & Co. (2005)	Amount of onshore outsourcing worldwide as of 2001	$227 billion
	Amount of offshore outsourcing worldwide as of 2001	$10 billion
	Amount of captive offshoring worldwide as of 2001	$22 billion
	Number of IT services jobs globally that could be done anywhere in the world as of 2003	2.8 million
	Number of service jobs worldwide that could be done anywhere in the world	160 million
	Number of actual IT service jobs in offshore operations in low-wage countries as of 2003	371,000

Evalueserve (2004)	IT offshore revenue worldwide, April 2003-March 2004	$17 billion (almost half from India, almost one-quarter from Ireland; includes IT products shipped from Ireland)
UN Conference on Trade and Development (2004) (as quoted on TurkishPress.com)	Percentage of world's largest 1000 companies offshoring business process outsourcing	30
	Value growth in offshore business process outsourcing worldwide (projected)	$1.3 billion in 2002 to $24 billion in 2007
Scholl (2003) (as quoted in World Investment Report 2004)	Market value for offshoring of IT services (not including captive production for multinationals)	$1.3 billion
McKinsey & Co. (2003) (as quoted in World Investment Report 2004)	Market value for offshoring of IT services, including captive production for multinationals	$32 billion

1.5 Which Countries Send Work Offshore and Which Countries Do Most of This Work?

Countries that send software and IT-enabled service work offshore are primarily high-wage countries that have advanced service industries. These are also the countries that have the largest amount of IT work. According to Datamonitor (May 2005), the global data processing and outsourced market had a value of $246 billion in 2004 with North America accounting for 43.6%, Europe 29.4%, Asia-Pacific for 17.8%, and the rest of the world 9.1%. The country that started the offshoring trend and that sends the most work offshore is the United States. The United Kingdom, Germany, France, and other Western European countries come next. Although Japan has an advanced economy, it does not offshore as much work as the United States or the Western European countries. In an interesting turn of events, Indian offshore companies have begun to open facilities in China (where wage rates are lower than in India and a huge local market is opening) and Eastern Europe (to take advantage of proximity to the Western European market –nearsourcing). The extent of this phenomenon is limited and recent, and it is not clear whether it is a strategy for Indian firms based primarily on obtaining more contracts or on taking advantage of lower-wage labor.

Which countries do the offshoring work is a more interesting story. There are quite a few countries that have tried to develop this business, and these countries vary considerably in their skill sets, labor costs, cultural fit with the countries seeking to have work done, levels of technical and business expertise, and type of work that they offshore. The four countries that have the most established offshoring industries (accounting for 71% of the market in 2001) in order of market share are Ireland, India, Canada, and Israel (McKinsey & Co. 2003 as quoted in World Investment Report 2004). The public stories make one think that offshoring work is all done in low-wage countries such as India and China. In fact, the majority of offshoring services have historically been provided by developed nations, and Ireland still leads with a 25% share. However, as Arora and Gambardelli (2005) point out, the value added in Indian offshoring is higher than in Ireland because so much of the Irish work involves localizing US software products for the European market. Moreover, the growth rate of the national software export industry is much higher in India than in Ireland so the relative position is changing rapidly. Canada and Ireland do have lower wages than the United States, perhaps 10 to 20 percent lower, but there are not the extreme wage differentials as there are between the United States and India or China. So this is not yet a north-south or developed/undeveloped nation issue although the trend is in that direction (World Investment Report 2004).

An assessment by the consulting firm A.T. Kearney of the most desirable future locations for offshore work placed India at the top of the list, followed by China, Malaysia, the Czech Republic, and Singapore (A.T. Kearney 2004 as quoted in the World Investment Report 2004). The expected rapid growth in offshoring activity occurring in low-wage countries will make the public perception of who does offshore work progressively more accurate. The Kearney report listed Brazil as the leading offshore source in South America; South Africa in Africa; Hungary, Poland and Romania in Central and Eastern Europe; and Canada and New Zealand among developed nations. Ireland, Portugal, Spain, and the United Kingdom were listed as the preferred destinations for offshore work within Western Europe.

Countries doing offshore work fall into four categories as shown in Table 3. First are those countries that take advantage of their large capacity of highly trained/educated workers and low-cost wage scale. One example is China which has established businesses providing offshore work on embedded software and IT-enabled financial services. Another example is Malaysia which is building up business at the lower end of the offshoring market in call centers and IT-enabled back-office business processing services. The principal example is India which is the fastest growing destination for offshore work and is involved in almost every aspect of the industry from call centers to business process outsourcing, to software maintenance and testing, to software research.

The second category consists of countries that have competitive advantage through their language skills to serve a special part of the market. While it is useful in any kind of offshoring work for vendor and client to be able to speak the same language, it is essential that workers in call centers, for example, be able to speak fluently in the language of their customers. Thus China, which has relatively few people who speak English fluently, is unlikely to become a major provider of call centers to the United Kingdom or the United States. The Philippines, Mexico, Costa Rica, Chile, and Morocco have taken advantage of their bilingual skills in English and Spanish to open up call center businesses serving the United States. South Africa is the leading offshoring nation in Africa because of its English-language skills. Some countries from Francophone Africa (Mauritius, Morocco, Senegal, Tunisia, and Madagascar) have recently started to provide call center and telemarketing service to France. India, of course, has been able to build up its call center business in part because of its English-language skills.

The third category consists of countries that take advantage of their geographic proximity to a country that offshores work, so-called nearsourcing. The nearsourcing countries not only are located nearby, making it easier for executives from the client firms to visit the vendors, but there is often a shared language and culture as well. These countries generally do not have extremely low wages, but their wages are typically lower than in the country that is offshoring the work. Canada is a major nearsource destination for the United States, providing many high-end services. Poland, the Czech Republic, Hungary, and increasingly the Ukraine, Belarus, Romania, and Latvia are building nearsourcing businesses to serve Western Europe, especially Germany. In a poll of 500 top European companies in 2003, the German consulting firm Roland Berger found that 50% of European firms were planning to offshore to other parts of Europe and only 37% were planning to offshore to Asia (Gumbel 2004). China is trying to establish a nearsource business for Japan and Korea. (One could call the second category linguistic nearsourcing and this third category geographical nearsourcing. Doing so suggests that there are other kinds of affinities between nations that might make them want to do business with one another such as a common heritage or legal system as exists between the United Kingdom and countries in its former empire.)

The fourth category consists of countries that have special high-end skills. Like the nearsourcing countries, the wage rates might not be as low as in India or China, but they are lower than those in the United States or Western Europe. Israel provides offshoring in the form of research and development for multinational corporations and niche software products and services, especially in the security and anti-virus software markets. Ireland's offshore business is mainly in the area of packaged software and product development; it hosts many multinationals who are building software products and providing IT services for the European market. It also has a number of small Irish-owned companies operating mainly in niche markets. China is beginning to develop high-end skills in the Linux operating system, bioinformatics, and anti-virus software. Australia exports high-end, IT-enabled financial services. India is beginning to develop research and development laboratories for various European and American-based multinational corporations. Also, one should not neglect the United States which exports the highest amount of IT products and services of any nation, mostly to Europe, and mostly in the form of packaged software and consulting services.

Table 1-3: Nations that Do Offshoring Work

Strategy	**Principal Examples**	**Others**
Cost and Capacity	China India	Malaysia
Language Skills	Philippines Mexico Costa Rica India	South Africa Tunisia Morocco Senegal Madagascar Mauritius
Nearsourcing	Canada Poland Czech Republic Hungary Slovakia	Ukraine Belarus Romania Latvia China
Special High-End Skills	Israel Ireland Australia United States	China India Russia

1.6 What Types of Work Are Sent Offshore?

Various kinds of work involving the use of information technology are being offshored. Types that are of primary interest in this study include:

- programming, software testing, and software maintenance,

- IT research and development, and
- high-end jobs such as software architect, product designer, project manager, IT consultant, and business strategist (the extent to which these jobs have been offshored is an open question).

Because the focus of this study is on offshoring of software and services, we are not primarily interested in the following kinds of IT-related work, even though they are frequently offshored:

- physical product manufacturing – semiconductors, computer components, computers,
- business process outsourcing/IT enabled services/knowledge process outsourcing (e.g. insurance claims, medical billing, accounting, bookkeeping, medical transcription, digitization of engineering drawings, desktop publishing, and high-end IT enabled services such as financial analysis for Wall Street and reading of X-rays), and
- call centers and telemarketing.

A detailed list of the various kinds of IT and IT-enabled services that are being offshored can be found in the World Investment Report 2004 (p. 150). These include various types of audiovisual and cultural services, business services, computer-related services, higher education and training services, financial services, health services, Internet-related services, professional services, and animation. Many of these fall outside the principal focus of this study. In Table 4, we identify skill levels required for various kinds of IT and IT-enabled services also taken from the World Investment Report 2004.

Table 1-4: Skills Categorization of Traded IT and IT-Enabled Services

Skill Level	Definition	Examples	Requires	Comments
low	Low entry barriers in terms of skills, scale, technology	Data entry Call centers	general formal education working knowledge of relevant language basic computer skills	few economies of scale little agglomeration
medium	Complex services that require more advanced skills	financial and accounting services standardized programming work routine data analysis back-office services such as ticketing	specialized training required (perhaps in training schools)	may offer economies of scale may have agglomeration effects

high	Most creative and skill-intensive work	R&D Design services Architectural drawings software design Animation Medical testing Technology systems design	Advanced skills at high levels of specialization, often with strong educational institutions	stringent entry requirements involve agglomerated economies with different skills, enterprises, and institutions interacting with each other to share work, stimulate knowledge flows and allow specialized skills to be fully utilized

Based on Box IV.2 in World Investment Report 2004

Jobs that are at the greatest risk of being offshored are also often those most at risk of being automated, in which case labor would be replaced by technology instead of by foreign labor. For example, although it has not happened to an extensive degree yet, software automation tools might help to automate low-end software development.

The situation is far from static. We described earlier how India first offered body-shopping, then software services, only later IT-enabled services, and most recently research and development. There has been a similar change in the pattern of offshoring by firms in high-wage countries. In the 1980s and 1990s, the typical pattern was for an IT manager to hire an outsourcing firm to carry out some task that was not critical to the mission of the client firm. It tended to be an application development that was highly structured, required relatively little interaction and project management from the client, had clear deliverables, well understood bidding procedures, and transparent risk to both the client and vendor. Often the vendor was located near the client. More recently, the pattern has changed. The outsource firm is hired not by the IT manager but by a higher-level executive such as the CFO, CIO, or perhaps even the CEO. The task is more likely to be mission-critical to the client. The applications are wide ranging, but they often include tasks that are less well structured than in previous times; ones that require greater amounts of client contact and project management and where deliverables, costs, and risk are less clear. The vendor is as likely to be located in another country as nearby.

But what are the characteristics of work favorable to performance offshore? John Sargent and Carol Ann Meares of the US Department of Commerce have provided an excellent and detailed answer to this question that is adapted slightly in Table 5.

1.7 Why Are Firms Interested In Sending Work Offshore?

The public perception is that companies in the United States, Western Europe, and Japan send work to India, China, and other low-wage countries principally because of the lower labor cost. There is some truth to this perception. Companies want to maximize their profits, and, in many cases, the lower cost of qualified labor in these countries is the principal reason for making the offshoring decision. Sometimes companies begin offshoring for cost reasons but continue for quality of work reasons. Sometimes something else drives the initial decision to offshore, for example, the lack of enough qualified workers in the

United States during the Y2K era. This section shows that the situation is complex. There are at least nine reasons, low-cost labor among them, why companies send work offshore, and often more than one reason is in effect in a company's decision to offshore. Here is a summary of those reasons. Chapter 4 gives examples of the ways in which particular companies of various types use offshoring as a strategic tool.

Table 1-5: Characteristics of Work Favorable to Performance Offshore Through 2004

- high wage differential with similar occupation/level in destination country
- high labor intensity
- clearly defined requirements, little nuance
- repetitive tasks
- rule-based decision-making and problem solving
- documented or easily transferred content and process knowledge
- discrete, separable; low degree of interaction across different services, applications
- low degree of personal interaction with end users, clients
- stable applications with minimum of "firefighting"
- long projected useful life to amortize offshore set-up costs
- low-to-medium business criticality
- less time-sensitive, longer transition periods
- projects involving simple and standard hardware and software
- digital, Internet-enabled
- low setup barriers
- low-to-medium technical complexity
- not-multidisciplinary
- projects in business areas in which offshoring is a broadly accepted concept
- tightly defined work processes
- stable process

Source: Sargent and Meares (2004). Note: as the Indian companies, for example, move up the value chain, the characteristics of work subject to being offshored may change.

1. *Reduced Costs and Increased Margins.* In the modern, investor-driven, globalized marketplace, there has been a compression of resources, both time and money, that companies, new and old, have with which to make a new business model profitable. One response to this compression has been to reduce costs. Labor costs are a major portion of service and other knowledge-intensive businesses so it is natural to want to reduce these costs. When a new software engineer costs $45,000 annually in the United States and only $5,000 per year in India, even with many additional overhead costs associated with offshoring, most firms anticipate substantial savings in sending work to the Indian software engineer over doing the work in-house in the United States. In this way, the companies can make their new business start-up funds last longer or increase their profit margins. While the focus in the public perception is on the low salaries, costs are also sometimes reduced because the offshore vendor has scale benefits in doing the work. (Another response to this compression, to address the time issue, is given in point 5.)

2. *Access to Skills.* The United States has the strongest postsecondary system in the world. It trains many highly qualified workers from both home and abroad, and it also imports workers who are educated or trained in other countries. But the United States does not

have a monopoly on highly talented, educated, and experienced workers. As China, India, Russia, and Eastern Europe have joined the world market, there is now an excess of educated workers in certain countries such as India, Ireland, Russia, and some Eastern European countries at a time when the US math and science educational system is slowing down its production. In 1999, for example, China graduated three times as many engineers as the United States. In particular, we are seeing strong pools of talent outside of the United States in the IT, telecommunications, engineering, and health care domains.

Thus another reason for companies to send work offshore is the size and quality of the available labor pool. The applicant pools available to the offshoring companies in the leading offshoring countries in many cases have been larger and stronger than the applicant pools available in the United States and Europe. In the late 1990s, many US firms turned to Indian vendors because they had available programmers with the knowledge of legacy systems to make Y2K fixes. Similarly, during the dot-com boom in 1999 and 2000, many US firms turned to offshore vendors to find enough people who knew the Java programming language. There was an abundance of such people in India, for example, not only because of the large labor pool but also because of the tendency of the Indian higher education system to react quickly to the marketplace and teach skills that are in current demand.

To take advantage of this labor pool, many of the best offshoring vendors spend substantial money on the hiring process, going through a lengthy and rigorous screening process to identify employees who have a higher average quality than those available for the client firms to hire directly. NASSCOM, the Indian software and services trade association, has expressed concern recently about the uneven quality of the Indian educational system, contending that while there are still large numbers of graduates, not all of them have the quality education that gives India this competitive edge in offering this access to skills.

3. *Experience.* Companies from the United States and Western Europe sometimes choose to send work offshore because other countries have greater experience in a particular field than they do. This experience can be of four types:

   A. Experience with a particular technology. For example, China already has the largest number of mobile phones in the world and India may be the second in this regard by 2012; these countries have skipped a level by not putting the infrastructure in landlines but investing more in the wireless domain. Hence, it makes good business sense to do R&D on wireless in India, China, and other emerging wireless markets. A similar situation pertains to Linux which is a part of the Chinese government's national technology policy. While India and China are not yet the world leaders in these fields, they have a growing number of scientists and engineers with knowledge of these fields, and the overall level of knowledge in the country is growing rapidly.

   B. Experience with a particular scientific domain. There are, for example, several countries that provide offshore services with strong labor pools in the biomedical disciplines.

   C. Experience with particular management issues. For example, several of these countries have strong experience managing projects that operate multiple shifts per day.

   D. Experience with cultural and marketing issues in emerging countries.

4. *Time Shifting.* Offshoring enables companies to offer multiple-shift services that may not have been offered prior to offshoring. For example, US hospitals are using US-trained Indian physicians to read X-rays in India in time to deliver the results to the US doctors

the next working day. This move can increase patient service at a reasonable cost. Offshoring medical services can also provide rural areas with access to affordable medical services. Some IT companies have several offshore sites, located strategically by time zone, that enable them to provide round-the-clock services such as help desks and network monitoring, while requiring none of their workers to have to work the graveyard shift.

5. *Time To Market.* Some companies offshore work in order to reduce the time to bring a product to market. The types of work offshored for this reason include R&D, production, and other parts of the supply chain. One reason that time to market can be reduced is that companies can take advantage of time shifting. A design team in the United States can work regular business hours and then turn the work over to their team in China, which is just beginning its regular work day, to either continue the design work or do code checking. Then the Chinese team can turn the work over to their Indian colleagues for the next shift who work on it and turn it back to the US team to start the process all over again. Another way to take advantage of offshoring to reduce the time to market is to divide the work into self-contained tasks that can be worked on in parallel in several locations. Yet another strategy for achieving faster time to market is to compartmentalize the work into a set of tasks that require different skill sets and parcel the work out to the teams around the world that would be most effective or productive at doing a particular part of the work. With synchronization points, this modularized work process can be used effectively to create one single larger product developed on a distributed basis in a timely manner.

6. *Market Access.* Companies sometimes find it strategically attractive to have a market presence in countries in which they would like to sell their products. As Balasubramaniyan, general manager at Wipro Technologies, describes this issue: "Offshoring also helps a company be closer to its global customers, thereby providing appropriate offerings to its regional market and ensuring speedier problem resolution. Developers and support personnel in the relevant geographies have a better understanding of customers' needs, regulatory compliances and regional preferences, and can better implement the product or provide the service." (Balasubramaniyan and Guyer 2004).

7. *Ability to Send Overflow Work.* Many small IT companies, especially those in IT services, are usually faced with "feast or famine" situations, that is, during any given period of time, either they do not have enough work or they have too much work. These small companies cannot afford to keep a very large workforce on their payrolls because they cannot afford the payroll in lean times, and therefore they have to work with a minimum workforce. However, this causes problems for the company when it lands a large project that needs to be completed in a short period of time. These companies can benefit by sending work to large offshore providers who can supply very capable professionals with the right domain expertise at the right cost. Larger companies face this same problem. Companies are unlikely to want to hire extra staff for a project that might only have a six-month or one-year duration because of the cost of hiring and the morale problems of having to lay these workers off at the end of the project. The use of offshore workers enables a company to ramp up and down quickly without these problems.

8. *Extending Venture Capital Money.* After the dot-com and the telecom busts in 2001, many startups, especially in the IT, telecom, and biotech areas, have found it difficult to raise venture capital. Those that have been able to raise such funding – as well as those who are working on a "shoestring" fund provided by family and friends – are left with little choice but to make the funding stretch as far as possible. Lower-cost locations such as Israel and India become very attractive for them, and so it is not surprising that by March 31, 2005, more than 170 startups already had established their R&D centers in

India. Often, the venture capital firms themselves are pressuring the companies to use offshoring to keep costs down.

9. *Other Business Reasons.* Using offshore workers can have other business advantages. Given the low cost of labor, a number of the better offshoring vendors have expanded the ranks of their middle managers who have time to mentor and enhance the skills of the lower level employees and identify and implement process improvements that make the work effort more effective. The vendor might have access to tools that are not available to the client either because they are proprietary or because they would be too expensive for the client to buy but not too expensive for the vendor who can use them for many different clients. Clients who are not in the IT business may have more time to focus on their core business and maximize their overall profits if they offshore their IT tasks. Some companies have found that because the offshore vendors are eager to retain their business, there is a stronger focus on continuous business improvements and customer service than if the work had been done in-house. Public sector companies, who may be regulated against large cost overruns and have rigid work rules that make hiring new employees difficult, may find that offshoring provides them with new flexibilities.

1.8 What Are the Technical, Business, and Other Drivers and Enablers of Offshoring?

Offshoring has been made possible by a collection of technological, business, work process, policy, educational, and other changes over the past 15 years. The technological changes are the ones that are most often mentioned in the discussions about the growth of offshoring, but they are by no means the only ones.

(1) *Telecommunications infrastructure.* Since the late 1990s, there has been a dramatic increase in the telecommunications infrastructure. As part of the dot-com boom, various telecommunications carriers competed to increase satellite and optical fiber networks to the point where there was a glut in the market after the dot-com boom ended and prices plummeted. India now has readily available low-cost, high-bandwidth communication and access to all the major telecommunications applications such as email, fax, videoconferencing, and cell phone. Telecommunications capacity between India and the United States grew from practically nothing in 1999 to 11,000 GBS in 2001. The cost of a one-minute telephone call from India to the United States dropped more than 80% within several years after January 2000.

(2) *Changes in information technology.* A number of changes in information technology also changed the opportunities for offshoring. Low-cost computing power became readily available. Software platforms became standardized: IBM and Oracle provided the standard for database management, SAP for supply chain management, PeopleSoft for human resource management, and Siebel for customer relations. Offshoring vendors could invest in the purchase of a small number of standardized software platforms and train their employees in their use rather than having to deal with possibly hundreds of proprietary software systems. Workers could learn standardized skills that were then portable. Training and skill certification became simplified. A similar effect was created by using commoditized, inexpensive applications software packages. Standardization of data formats and networking protocols made it easier to move large data sets from client to vendor. Interoperability standards such as MDA, UML, CWM, CORBA, and OMA were established during the 1990s, making it easier to modularize software.

(3) *Pace of innovation.* The technological changes mentioned in (1) and (2) can be considered enablers. One study (Bartel et al. 2005) discusses technology as a driver of

offshoring. It found that a high level of IT use in an industry is not a predictor of greater outsourcing. However, an increase in the pace of information technology change does increase outsourcing. The explanation is that firms are more willing to gain access to the latest technology through their outsource vendor than by sinking fixed costs into a technology that is likely to change with great rapidity. One would describe the dot-com era as an era of rapid IT change, hence driving companies to outsource.

(4) *The downsized corporation.* Since the 1970s, businesses in the United States began to move away from vertical integration of the corporation, shedding activities that were not regarded as core competencies, through eras of reengineering and downsizing. During the 1980s and 1990s, more and more activities were pared from the list of core competencies and subject to outsourcing. As IT systems became more standardized, they were seen less as core activities. And as corporations focused more on core competencies, there was big growth in outsourcing of functions outside the core.

(5) *Other business drivers.* There have also been some business drivers of offshoring. When rival firms began offshoring, many companies felt that they had to offshore in order to remain competitive. Companies looked for ways to cut expenses to deal with the economic downturn that began in 2000. Venture capitalists began pushing startups to incorporate offshoring into their business plan so that the burn rate on start-up funds was lessened. Several high-profile business leaders, such as Jack Welch from General Electric and Carly Fiorina from Hewlett Packard, became evangelists for offshoring. As experience with offshoring mounted, some of the early mistakes were understood and some of the early problems with bureaucracy and infrastructure were fixed. It became more acceptable and less risky to offshore; offshoring was no longer restricted to the early adopters such as Texas Instruments or General Electric. Business leaders began to recognize the value of reengineering, both in cost savings and improved performance, that was often undertaken when work was transferred from client to vendor.

(6) *Intermediaries.* The offshoring business created new specialty occupations and firms. Some of them did part of their work on the client's site and offshored the rest; some did all the work offshore on their own premises. Some served as brokers, placing the client's work with one or more of a number of offshore firms. Others served as consultants, helping companies to make the decision about whether to offshore, what work to offshore, and how to make contact and close a deal with an appropriate offshoring vendor. These consulting firms and brokers aggressively marketed the advantages – particularly the labor cost advantages – of offshoring. The presence of these specialty firms made it possible for smaller companies to offshore work by helping them with the management of offshored projects in a cost-efficient manner. Another group of firms emerged to provide support services to the offshore vendors: transportation services, catering services, access to specialty knowledge workers, and the like.

(7) *Changes to the work process.* Changes to the work process have enabled offshoring. Certain kinds of knowledge work have been digitized and business processes have been reengineered, making them suitable for offshoring. The value chain has been divided into separable work processes some of which can be routinized and made subject to offshoring even when not all aspects of the process are amenable to offshoring. This kind of fragmentation of labor process is much more easily done with software and services than with manufacturing. There is also more personal acceptance of having old ways of doing business transactions replaced by using the Internet or proprietary networks to acquire services so there is less resistance to service at a distance. All of these reasons add up to the fact that progressively larger amounts of work can be offshored each year.

(8) *Higher education system.* In the past, one of the great advantages of the United States has been its higher education system. However, some of the developing countries

are using higher education as an effective means to create a skilled workforce, and the numbers are impressive in comparison to the United States. Model curricula, established by professional organizations such as the ACM and the IEEE, have been adopted in many different countries, and the computing machinery needed for classroom instruction is inexpensive in these days of personal computing.

In India, for example, national policy since the Second World War has placed a surprising amount of limited resources into developing the post-secondary educational system rather than in supporting the primary or secondary systems. There are 160 universities and 500 institutes today in India offering computing degrees of one kind or another, and the number is growing rapidly. This is not yet as large as the number of colleges and universities awarding computing degrees in the United States where about 200 universities offer IT-related doctoral degrees and about 2000 colleges and universities offer four-year degrees. However, the number of technical degrees awarded in India as opposed to the number of degree-granting institutions tells another story. India is awarding a much higher percentage of its degrees in technical fields than the United States is. Each year, India awards approximately 290,000 engineering degrees which includes 120,000 information technology degrees, while the United States awards a total of approximately 75,000 computing degrees at the bachelor's, master's, and doctoral levels. India has also rapidly built up a set of institutions for training people for jobs in IT skills training and certification. To cite just one example, the offshoring firm Wipro has established Wipro University with 70 full-time instructors. It trains 2500 workers per year in areas directly pertinent to Wipro's offshoring work.

The United States still holds some significant advantages over India in the higher educational system. Although India has a much larger population than the United States, only a small fraction of its population attends college (7% as of 1997). The Indian system is strongest in IT skills training and undergraduate degrees. University research in India is very modest, and India produces only 300 master's degrees and 25 doctorates each year in the computing disciplines, compared to 10,000 master's degrees and 800 doctorates in the United States. For many years, the United States has been considered the place of choice for advanced degrees for people throughout the world, but this seems to be changing. Because of visa tightening and attitudes towards the United States in the post-9/11 era, the number of foreign students applying to graduate school in the United States has plummeted. The United States also has decreasing numbers of domestic students studying IT (or science and engineering subjects more generally).

(9) *Free-market world economy.* The development of a world economy since the Second World War has provided the opportunity for creating a global software market. International agreements such as GATT and increasing national participation in international organizations such as the World Trade Organization, the collapse of communism, and the liberalization of the economies of India and China have all contributed to making the software market global and in making India and China major participants in this market.

(10) *Immigration.* Immigration has played a role in the growth of offshoring. A large number of Indian and Chinese citizens came to the United States to study and many of them stayed on to work. In concentrated high-tech regions of the United States, most notably in Silicon Valley, communities of Indian high-tech entrepreneurs emerged and bonded with other Indians in the high-tech community, and similarly for the Chinese. In many cases, these technical entrepreneurs were the ones who started offshoring companies or who were the go-betweens to ease the difficulties of doing business across so many miles and such different cultures. US immigration policy, especially the H1-B and L-1 visa programs, have enabled Indians and other foreigners to gain valuable experience and contacts in the United States before returning to their home countries. Recently, there has been a reverse diaspora of engineers, and China and India are both recruiting technical

workers to return permanently to live and work in their native countries. China has been providing all-expense-paid trips to China, holding job fairs in Silicon Valley, and recruiting faculty members online to spend their sabbaticals working in China. India has been providing salaries, benefits, and stock options that make living in India attractive to Indian high-tech workers who had been working in the United States.

(11) *Other factors.* Other factors have also played a role in driving or enabling offshoring. The fact that English is the language of education and business has helped make India more attractive to US firms. That India's accounting and legal systems are compatible with the British and American systems has also been an attraction. An aging population in the United States means that the country will need to reach outside its national boundaries for its workforce of the future. The McKinsey Global Institute projects a US need for 16 million additional workers from overseas over the coming decades in order to maintain the present ratio of workers to retirees. Evalueserve predicts a 5.6M worker shortfall by 2010, including a shortage of 970K IT workers (assuming no work is offshored and not counting immigrants). This shortage would lead to higher prices, being less competitive, and loss in Gross Domestic Product. US temporary visa policy (for H1-B and L-1 visas) has been conducive to building the offshore vendor presence onsite in the United States and in building networks of people between India and the United States especially in Silicon Valley. For the offshoring of research, international projects such as the International Space Station and Human Genome project have built ties, involved many countries in the international research community, and made internationalization of the R&D process seem more familiar and feasible. The following case (Table 6) of the Indian state of Andhra Pradesh and its capitol city of Hyderabad illustrates actions taken by governments interested in building up an offshoring industry.

Table 1-6: Government Action to Build an Offshoring Industry: Andhra Pradesh

In the 1990s, the Indian state of Andhra Pradesh and its capitol city of Hyderabad developed a public policy to create an IT-enabled services offshoring industry in their locale. They created a government agency with the double entendre acronym APFirst (Agency for Promoting and Facilitating Investment in Remote Services and Technology) for this purpose. The government provided free right-of-way land for laying fiber optic cable and donated a 55,000 square-foot office building with reliable electric power service to encourage IT- enabled services firms to locate there. In 1999, the government created a new incentive policy that provided 25% discounts on power bills to IT firms, exempted software from sales taxes, and provided a rebate on the cost of land by up to 20,000 rupees per job created. In 2001, the Indian School of Business was enticed to relocate to the city. The state created the Indian Institute of Information Technology to provide IT education and the Information Technology Enabled Service Training Institute to offer courses in English and other subjects of value to the ITES offshoring firms. The state also declared the ITES industry to be an essential service, thus prohibiting its workers from labor actions (just as in other critical industries such as water and police).

Sources: Atkinson (2004), Dossani and Kenney (August 13, 2004), Balatchandirane (undated "…Hyderabad…")

There are some reasons why companies might not want to offshore. These have been grouped in Table 7 into eight categories: (1) the job process is not routinized sufficiently to offshore the work; (2) the job cannot be done at a distance; (3) the infrastructure in the vendor country is too weak for the work to be carried out there; (4) offshoring the work negatively impacts the client firm's workplace; (5) there are risks to privacy, security, and intellectual property of the client company from offshoring the work; (6) there are not workers in the offshore company with the requisite knowledge; (7) the cost of opening or maintaining the offshore operation is prohibitive; and (8) miscellaneous other reasons. Although each specific reason is placed in only one category, a number of the reasons could fit in more than one category. Note that there is a certain parallelism between work that firms might offshore (Table 3) and work they are unlikely to offshore (Table 7).

Table 1-7: Reasons a Firm Might Not Offshore Work

Category	Specific Reason
Job process is not routinized.	*Uncertainty about the nature of work; uncertain specifications in some jobs. *Project has a highly iterative development process. *Applications involve complex processes that require frequent intervention to fix algorithms or data. *High-skill work such as research, process design, or business analysis. *The work involves system analysis.
Job cannot be done at a distance.	*Face-to-face interaction is required for the job. *It is too difficult to coordinate the non-standardized parts of a project if they are geographically distributed.
The infrastructure is too weak in the vendor country.	*Telecommunications, transportation, or specialty vendors are not adequate.
The offshoring impacts negatively on the client firm's workplace.	*The company loses control of the work process. *The company loses in-house expertise needed to maintain, improve, or replace the offshored product or service. *Worker morale in the client organization deteriorates because of potential loss of job, loss of wage power, or deskilling of job.
There are risks to the client company in offshoring the work.	*The work requires security clearance. *Giving the vendor's employees VPN access to the clients information systems makes security difficult. *Data privacy and security are hard to control at the vendor site. *It is difficult to ensure that the vendor will protect the client's intellectual property. *The vendor may not be able or motivated to follow the privacy and security mandates in legislation from other countries such as HIPAA, Gramm-Leach-Bliley Act, Sarbanes-Oxley Act, California State Bill 1386, and European Union Data Protection Directive. *The vendor may not be able or motivated to meet professional qualifications required to do certain kinds of work such as being an accountant certified as required by the client's country. *Legal recourse to privacy, security, or intellectual property problems is non-existent or unenforceable in the vendor country's legal system.

There are not workers in the offshore company with the requisite knowledge.	*Application domain knowledge is required to do the job. *The work crosses multiple disciplinary boundaries. *The work depends on craft or proprietary knowledge held only by the client company's staff. *The work involves business as well as technical expertise.
Cost of opening or maintaining the offshore operation is prohibitive.	*The client needs to implement new bureaucratic structures such as explicit authority relations, operating procedures, and incentive systems. *There is an extra cost for evaluating vendors, managing contracts, improving security, travel, and severance pay for laid off workers. *Alternatives to offshoring such as downsizing, consolidation, and reorganization are more cost-effective.
Other reasons	*Cultural issues exist between the vendor and client countries (social behavior, attitudes towards authority, language issues). *Gain occurs from being located near to other companies doing similar work (agglomerated economy), e.g., jobs in complex functions that need to be located near one another to thrive, adapt, and innovate such as in activities in corporate centers or less routine consulting practices.

There are also reasons that professions or countries might want offshoring not to occur. If low-level programming jobs are shipped overseas, then there might not be a viable career ladder for IT workers to climb in order to attain the higher-end IT occupations that people hope will remain in the high-wage countries. Salaries of IT workers in the client (high-wage) countries might be pushed down by offshoring. The ingredients for innovation (including labor, capital, knowledge, facilities, and technology) are threatened at home since innovation is widely regarded as the driver of higher productivity and standard of living for a nation. The locus of entrepreneurship begins to move offshore.

1.9 Is IT Still a Good Career Choice for People Working in Countries That Ship IT Jobs Overseas?

Almost every day one can find stories in the US press about people losing their IT jobs because their positions were sent to a low-wage country. Many of these stories quote talented young people who are choosing careers in other fields because they believe there are no longer opportunities in IT. There are fears that it will not only be low-level programming jobs that are sent to low-wage countries but also jobs that require higher skill levels and are more highly compensated. If the world really is flat, as Thomas Friedman proclaims, and a job can as easily be done in Bangalore or Beijing as in Boston, then even if the job remains in Boston, eventually the wages will fall in order to remain competitive with wages in other parts of the world. One study has shown that if you are one of those who loses a job to trade, the chances are that you will be paid less in your next job (Kletzer 2001).

All of this sounds bleak, but consider some interesting statistics on jobs as shown in Table 8 and on salaries as shown in Table 9. They are both based on data from the US Bureau of Labor Statistics, one of the most reliable sources available. There is some lag in collecting and analyzing data so the most recent data is only from May 2004. Note what David Patterson, a computer scientist from Berkeley who is president of the ACM, has to say about these numbers:

"Moreover, most of us believe things have gotten much better in the year since the survey was completed. Does anyone besides me know that U.S. IT employment [in 2004] was 17% higher than in 1999—5% higher than the bubble in 2000 and showing an 8% growth in the most recent year—and that the compound annual growth rate of IT wages has been about 4% since 1999 while inflation has been just 2% per year?" (Patterson 2005)

How could it be that, at the same time jobs are being shipped overseas, the number of IT jobs in the United States is growing rapidly and is even higher than at the height of the dot-com boom? There are several possible explanations, but we do not have adequate data to identify the one at play. One possible explanation is that the very companies that are sending jobs overseas are prospering from the lower costs of overseas labor which is enabling them to grow and create new jobs in the United States and elsewhere. Another possible explanation is unrelated to offshoring except that the background factors that make it possible are the same background factors that make offshoring possible, namely, many industries are being reorganized to make them more productive through the use of IT. Catherine Mann, the economist from the Institute for International Economics mentioned earlier in this chapter, has conducted a study of Bureau of Economic Analysis data for the years 1989-2000. (More specifically, her data is taken from BEA Digital Economy 2002, Table A.4.4) She has found a strong correlation for industry sectors between high productivity growth and high investment in IT (Mann 2004). She has also identified a number of sectors that still have low IT intensity and thus are poised to take off as IT is introduced. These include health care, retail trade, construction, and certain services. As IT becomes more pervasive in society, there are more jobs involving either pure IT skills or combinations of IT skills and skills associated with a particular domain such as finance or health care. Most of the forecasts suggest that perhaps 2 to 3% of US IT jobs will be lost annually to offshoring on average over the next decade. With the expanded use of IT in society, it is very possible that the total number of IT jobs will grow at more than a 3% rate over the decade. Thus it is not surprising that the US Bureau of Labor Statistics forecasts that three IT occupations will be among the ten fastest growing occupations over the coming decade (BLS 2002).

Even if the IT job market is a growth area over the next decade, some types of jobs are likely to fall off, probably including routine programming jobs. As explained in Section 1.8, there are many reasons that companies do not send work offshore so there are likely to be jobs in almost every IT occupation to be found somewhere in the United States; but perhaps in some of these specific occupations there will be fewer jobs that there are today. It is very unlikely that the United States will be completely devoid of even these most at-risk, routine programming jobs ten years from now.

There are no fail-safe recipes for having a successful IT career, but there are many things people can do to make themselves more attractive to employers. They can get a good foundational education and keep up with current technology. They can improve soft skills such as oral and written communication and teamwork skills. They can get management training and experience. They can learn the processes of a domain in which IT is likely to be increasingly important in the future such as in the health disciplines. They can be prepared to work on tasks that are less routine and that require regular discretionary judgment or that require regular interaction with others (e.g., with customers or domain specialists within the company). They can seek out jobs that involve knowledge of trade secrets or fundamental processes of the company or that are involved with national defense. They can learn about other cultures, the technologies for doing work in a geographically distributed fashion, and other things about managing distributed work so that they can take advantage of offshoring instead of being a victim of it. They can gain a wide array of experiences so that they can be employed flexibly by a company and so that they gain an overview of the way IT is being used in the company and its industry sector.

There are also some things that American (or British or German or Japanese) society can do to assure that there continue to be good IT jobs for their workers. They can nourish the innovation base that creates these jobs. This can be achieved by adequately funding research and development, improving the educational system at all levels, making sure that there continue to be opportunities for foreign scientists and technologists to study and work in the country because of their important role in driving innovation, and developing and enforcing rules for fair competition in the international marketplace. These issues are all discussed in the policy chapter (Chapter 8).

Table 1-8: IT Employment in the United States (US Bureau of Labor Statistics)

	Employment								
					May	**Nov.**	**May**	**Change, May 2003 to May 2004**	
Occupations	***1999***	***2000***	***2001***	***2002***	***2003***	***2003***	***2004***	***#***	***%***
Computer and Information Scientists, Research	26,280	25,800	25,620	24,410	23210	23,770	24,720	1,510	6.50%
Computer Programmers	528,600	530,730	501,550	457,320	431640	403,220	412,090	-19,550	-4.50%
Computer Software Engineers, Applications	287,600	374,640	361,690	356,760	392140	410,580	425,890	33,750	8.60%
Computer Software Engineers, Systems Software	209,030	264,610	261,520	255,040	285760	292,520	318,020	32,260	11.30%
Computer Support Specialists	462,840	522,570	493,240	478,560	482990	480,520	488,540	5,550	1.10%
Computer Systems Analysts	428,210	463,300	448,270	467,750	474780	485,720	489,130	14,350	3.00%
Database Administrators	101,460	108,000	104,250	102,090	100890	97,540	96,960	-3,930	-3.90%
Network and Computer Systems Administrators	204,680	234,040	227,840	232,560	237980	244,610	259,320	21,340	9.00%
Network Systems and Data Communications Analysts	98,330	119,220	126,060	133,460	148030	156,270	169,200	21,170	14.30%
Computer and Information Systems Managers	280,820	283,480	267,310	264,790	266020	257,860	267,390	1,370	0.50%
Computer Specialists, All Other							130,420	130,420	
TOTAL (The "Change" columns do not include "Computer Specialists, All Other")	**2,627,850**	**2,926,390**	**2,817,350**	**2,772,740**	**2,843,440**	**2,852,610**	**3,081,680**	**107,820**	**3.80%**
Computer Hardware Engineers	60,420	63,680	67,590	67,180	72,550	70,110	74,760	2,210	3.00%
TOTAL, including Computer Hardware Engineers ("Change" columns do not include residual "Computer Specialists, All Other")	**2,688,270**	**2,990,070**	**2,884,940**	**2,839,920**	**2,915,990**	**2,922,720**	**3,156,440**	**110,030**	**3.80%**

Table 1- 9: IT Mean Annual Wages (source: US Bureau of Labor Statistics)

	1999	2000	2001	2002	May-03	Nov-03	May-04	CAGR (1999-May 2004)	May 2003 - May 2004
Computer and Information Scientists, Research	$67,180	$73,430	$76,970	$80,510	$84,530	$85,240	$88,020	5.60%	4.10%
Computer Programmers	$54,960	$60,970	$62,890	$63,690	$64,510	$65,170	$65,910	3.70%	2.20%
Computer Software Engineers, Applications	$65,780	$70,300	$72,370	$73,800	$75,750	$76,260	$77,330	3.30%	2.10%
Computer Software Engineers, Systems Software	$66,230	$70,890	$74,490	$75,840	$78,400	$79,790	$82,160	4.40%	4.80%
Computer Support Specialists	$39,410	$39,680	$41,920	$42,320	$42,640	$43,140	$43,620	2.10%	2.30%
Computer Systems Analysts	$57,920	$61,210	$63,710	$64,890	$66,180	$67,040	$68,370	3.40%	3.30%
Database Administrators	$52,550	$55,810	$58,420	$59,080	$61,440	$62,100	$63,460	3.80%	3.30%
Network and Computer Systems Administrators	$50,090	$53,690	$56,440	$57,620	$59,140	$60,100	$61,470	4.20%	3.90%
Network Systems and Data Communications Analysts	$55,710	$57,890	$60,300	$61,390	$62,060	$62,220	$63,410	2.60%	2.20%
Computer and Information Systems Managers	$74,430	$80,250	$83,890	$90,440	$95,230	$95,960	$98,260	5.70%	3.20%
Computer Hardware Engineers	$66,960	$70,100	$74,310	$76,150	$79,350	$82,040	$84,010	4.60%	5.90%
								3.90%	3.40%
								3.80%	3.30%
11					24,720	5.60%	4.10%	3.60%	3.00%
					412,090	3.70%	2.20%		
CAGR	2%				425,890	3.30%	2.10%		
1999	$100.00				318,020	4.40%	4.80%		
2000	$102.00				488,540	2.10%	2.30%		
2001	$104.04				489,130	3.40%	3.30%		
2002	$106.12				96,960	3.80%	3.30%		
2003	$108.24				259,320	4.20%	3.90%		
2004	$110.41				169,200	2.60%	2.20%		
					267,390	5.70%	3.20%		
					74,760	4.60%	5.90%		

1.10 Bibliography

Aggarwal, A. 2004. Moving up the value chain, from BPO to KPO. Evalueserve (Oct.). *ACM Job Migration Task Force Meeting* (Oct.) Chicago, IL.

Aggarwal, A. and Pandey, A. 2004. Offshoring of IT services –present and future. *Eavlueserve Business Research* (July).

Agrawal, V., Farrell, D., and Remes, J.K. 2003. Offshoring and Beyond. *The McKinsey Quarterly*, No. 4.

Aspray, W. 2004. (Offshore) Outsourcing overview. *ACM Job Migration Task Force Meeting* (Oct.) Chicago, IL.

Atkinson, R. 2004. Understanding the Offshoring Challenge. *Progressive Policy Institute* (May).

Balasubramaniyan, M. and Guyer, L. 2004. Face Off: Do offshoring's benefits outweigh its drawbacks? *Network World* (July 5) 42.

Balatchandirane, G. *Education and Training* [source unclear].

Balatchandirane, G. *Development of IT Industry in Bangalore and Hyderabad IT Clusters and the Impact on the Local Economy* [source unclear].

Bardhan, A.D., Jaffee, D., and Kroll, C. 2004. *Globalization and a High-Tech Economy: California, the United States and Beyond*. Springer.

Bardhan, A.D. and Kroll, C. 2003. The New Wave of Outsourcing. Research Report 1103, *Fisher Center for Real Estate & Urban Economics, University of California, Berkeley.* http://repositories.cdlib.org/iber/fcreue/reports/1103.

Bartel, A., Lach, S., and Sicherman, N. 2005. Outsourcing and Technological Change. *National Bureau of Economic Research* (Feb.).

Bivens, J. 2004. Will the New International Division of White-Collar Work Make the U.S. Rich? *ACM Job Migration Task Force Meeting* (Dec.) Washington, DC. www.epinet.org.

Booz Allen Hamilton 2004. Outsourcing Globally: Trends and Implications of Offshoring for Australia.

Dossani, R. 2005. IT Services Offshoring to India: India's Position in the Supply Chain. *ACM Job Migration Task Force Meeting* (March) Palo Alto, CA.

Dossani, R. and Kenney, M. 2004. Thoughts for the ACM Working Group. *ACM Job Migration Task Force Meeting* (Oct.) Chicago, IL.

Dossani, R. and Kenney, M. 2004. Offshoring: Determinants of the Location and Value of Services. *Sloan Workshop Series in Industry Studies* (Aug.).

Dossani, R. and Kenney, M. 2005. Moving Service Offshore: A Case Study of an U.S. High-Technology Firm. (Feb.).

Drezner, D.W. 2004. The Outsourcing Bogeyman. *Foreign Affairs 83*, 3 (May/June) 22-34.

Fallon, A.J. 1993. Foreign Outsourcing of the U.S. Electronics Industry. Executive Research Project 521. *The Industrial College of the Armed Forces. National Defense University*. Fort McNair, Washington, DC.

Fannin, R. 2004. India's Outsourcing Boom. *Chief Executive* (May) 28-32.

Friedman, T. 2005. *The World is Flat*. Farrar, Strauss, Giroux.

Hagel, J. III 2004. Offshoring Goes on the Offensive. *The McKinsey Quarterly 2*.

Haveman, J.D. and Schatz, H.J. 2004. Services Offshoring: Background and Implications for California. *Public Policy Institute of California* (Aug.).

Heeks, R.B. 1999. Software Strategies in Developing Countries. *Communications of the ACM 42* (June) 15-20.

Hira, R. 2003. Utilizing Immigration Regulations as a Competitive Advantage: An Additional Explanation for India's Success in Exporting Information Technology Services. *Center for Science, Policy, and Outcomes, Columbia University* (March).

Hira, R. 2004. Offshoring of High Skilled Jobs: Emerging Global IT Business Model. *ACM Job Migration Task Force Meeting* (Dec.) Washington, DC.

Huws, U., Dahlmann, S., and Flecker, J. 2004. Outsourcing of ICT and Related Services in the EU. *European Foundation for the Improvement of Living and Working Conditions*. Dublin, Ireland. www.eurofound.eu.int.

Kletzer, L. 2001. Job Loss from Imports: Measuring the Cost. *Institute for International Economics* Washington, DC.

Kletzer, L. 2004. Trade-Related Job Loss and Wage Insurance: A Synthetic Review. *Review of International Economics 12*, 5 (Nov.).

Koehler, E. and Hagigh, S. 2004. Offshore Outsourcing and America's Competitive Edge: Losing out in the High Technology R&D and Service Sectors. Office of Senator Joseph I. Lieberman (May).

Krishna, S., Sahay, S., and Walsham, G. 2004. Managing Cross-Cultural Issues in Global Software Outsourcing. *Communications of the ACM 47,* 4 (April) 62-66.

Mann, C.L. 2003. Globalization of IT Services and White Collar Jobs: The Next Wave of Productivity Growth. International Economics Policy Briefs, No. PB03-11. *Institute for International Economics* (Dec.).

Mann, C. 2004. Global Sourcing and Factor Markets: The Information Technology Example. *ACM Job Migration Task Force Meeting* (Dec.) Washington, DC.

Mann, C. 2004. What Global Sourcing Means for U.S. IT Workers and for the U.S. Economy. *Virtual Machines 2,* 5 (July/Aug.).

Marcus, A. 2004. Insights on Outsourcing. *Interactions* (July/Aug.) 12–17.

McKinsey and Company. 2005. The Emerging Global Labor Market (June).

NASSCOM-Evaluserve. 2004. Information Security Environment in India. *Business Research*.

Patterson, D.A. 2005. Restoring the Popularity of Computer Science. President's Letter. C*ommunications of the ACM* (Sept.) 25-28.

Ramer, R. 2001. The Security Challenges of Offshore Development. *SANS Institute.*

Sargent, J.F. and Meares, C.A. 2004. Workforce Globalization in the U.S. IT Services & Software Sector, Office of Technology Policy, U.S. Department of Commerce. *ACM Job Migration Task Force Meeting* (Dec.) Washington, DC.

Slaughter, S. and Ang, S. 1996. Employment Outsourcing in Information Systems. *Communications of the ACM 39,* 7 (July) 47-54.

Sturgeon, T.J. 1999. Network-Led Development and the Rise of Turn-key Production Networks: Technological Change and the Outsourcing of Electronics Manufacturing. In G. Gereffi, F. Palpacuer, and A. Parisotto, Eds. *Global Production and Local Jobs*. International Institute for Labor Studies. Geneva, Switzerland.

United Nations Conference on Trade and Development. 2004. The Offshoring of Corporate Service Functions: The Next Global Shift? *World Investment Report* (chapter 4). United Nations, New York, NY and Geneva, Switzerland.

U.S. Bureau of Labor Statistics.2002. Fastest Growing Occupations, 2002-2012. Labor Review Table 3 (Feb.) http://www.bls.gov/emp/emptab3.htm.

Wagstyl, S. 2004. Budapest, the Next Bangalore? New EU Members Join the Outsourcing Race. *The Financial Times* (Sept. 21 as reprinted in YaleGlobal Online.

Wessel, D. 2004. The Barbell Effect. *Wall Street Journal* (April 2) A1.

Authors: Ashish Arora, William Aspray, Burt Barnow*, Vijay Gurbaxani

Chapter 2: The Economics of Offshoring

This chapter provides background material on the economics of offshoring. The first section deals with the economic theory applicable to offshoring, including discussions of why firms engage in offshoring and what economic theory indicates the consequences may be for individuals, firms, and nations. The second section covers the extent of offshoring; it first cautions the reader about the difficulties in tracking offshoring activities, and then provides estimates of current, recent, and projected offshoring activity in the United States, Europe, India, and other countries. The third section draws general conclusions about the economics of offshoring and identifies data that it would be useful to collect in order to better understand offshoring.

2.1 The Economics of Offshoring: Rationale and Potential Impacts

From a long-term view, offshoring is a response to two developments: technical change, especially in IT itself, and international differences in population and economic growth. Advances in IT have made it possible to trade in what were previously untradable (or difficult to trade) services such as software development, support, and maintenance. In particular, as discussed in Chapter 1, the development of low-cost and high bandwidth communications links that connect most corners of the globe have facilitated a massive increase in the potential to move information around the world with virtually no time lag and at low prices. This has allowed service providers in countries such as India and the Philippines and manufacturers in China to coordinate and communicate with their customers instantaneously. This ability to communicate has made a whole new set of sourcing opportunities feasible that were previously unattractive due to the high costs. More rapid population growth combined with increases in education levels outside the developed countries has meant that countries such as India, Brazil, China, and the Philippines have large numbers of young and talented workers who face limited opportunities for productive employment and therefore have received relatively low wages in the local economy. The combination of these developments makes for fruitful opportunities for gainful trade, sparked by the sustained growth in demand for IT talent since the 1990s in the United States and other developed countries.

Several additional factors make it easier for some countries than others to provide offshore services. Even relatively low-skilled service jobs generally require literacy, for example, help desk workers need to be able to look up reference material when needed. Thus, countries with more educated workers are more likely to be able to handle offshored jobs. Speaking the same language as the client nation is also beneficial for jobs requiring communication with the client country; thus, India has an advantage over China for receiving offshored work from the United States.

Some of the confusion and disagreement about the extent of offshoring stems from a lack of agreement about whether goods are included as well as services, lack of precision when applying the terms offshoring and outsourcing, and disagreements about whether direct foreign investments are included in offshoring. For a discussion of some of these issues, see Bhagwati et al.(2004).

In a free market economy, offshoring decisions are made primarily by private firms seeking to maximize profits. The decision to offshore the production of goods or services to another country can be implemented in one of two ways. A firm may choose to source the good or service from a foreign provider that could be either an unaffiliated firm or a captive

* Burt Barnow took a leadership position in the writing of Chapter 2.

organization such as a subsidiary. (A captive organization is one which has its operating decisions dictated by another organization. This might be, for example, because the captive organization is owned by the captor organization or because there are strong economic incentives for them to follow the dictates of the captor.) A firm's choice to produce a good or service itself or to outsource it to an unaffiliated firm is often referred to as the "make versus buy" decision and can apply both to domestic and offshore situations. It is worth pointing out that the degree of outsourcing of IT services to specialists has been increasing significantly in developed countries over the last decade, initially to domestic providers and recently to both domestic and offshore providers.

Firms consider any offshoring that they undertake to be in the best interests of their stockholders. The theory of comparative advantage indicates that, if each country specializes in the production of goods where it has a comparative (relative) advantage, both countries can enjoy greater total consumption and well being in aggregate by trading with each other. In our context, if providers in countries such as India have a relative advantage in the provision of software services, for instance, then it would be beneficial for US firms that utilize these services in their operations to source the services from Indian providers and focus their scarce resources on activities in which they have a relative advantage. Note that we do not say whether these are captive or outsourced providers since that decision will depend on a variety of factors such as whether the service creates valuable intellectual property. Likewise, the gains from trade are generally beneficial to the service provider's host country. In countries such as India, employees at software firms have seen significant increases in their incomes even as the number of employees such as software engineers increases rapidly. Similarly, revenues and profits at these firms are growing rapidly.

Services can also flow from developed countries to developing countries. For example, companies based in developed countries such as ABN Amro, ING Bank, Prudential, and Citibank are capturing significant market share in developing countries in numerous service industries such as banking and insurance, and displacing workers in less efficient domestic companies in these countries. In these sectors, the know-how possessed by these firms provides them with comparative advantage. As Chapter 4 discusses, some of the IT service firms headquartered in developed countries such as IBM Global Services and Accenture, are adding workers from developing countries in order to take advantage of low wages, talent, and location enabling them to compete directly with Indian software service firms such as Infosys, Wipro, and TCS in the global software services industry.

What the theory of comparative advantage does not mean is that all members of society will benefit from trade. In general, imports of an input have economic effects that are similar to those of an increase in the supply of the input, namely, lower returns to the suppliers of the input, lower costs of production, and lower prices for consumers. If the input were a service, the wages and salaries of those producing the service would fall, but so would the costs for firms that are buyers of the service. In the exporting country, the opposite effects hold. That is, the returns to the owners or suppliers of the service or input increase and the wages of the employees at the service providers increase due to the higher demand. However, there are costs as well. In the short run, assuming lead time to develop and scale service capacity, providers will often transfer capacity from a domestic market to service the export market, raising costs to the domestic consumers of these services.

There have been relatively few studies estimating the economic impact of outsourcing and most of those that exist have been based on European data and focus more on the outsourcing of intermediate goods rather than services. Several studies identify cost saving as the primary motive for outsourcing of intermediate goods, for example, Egger et al. (2003). For the United States, Feenstra and Hanson (2001) construct industry-by-industry estimates of outsourcing (of intermediate products) between 1972 and 1992 and find that outsourcing contributed substantially to an increase in domestic demand for high-skilled, non-production workers and their wages.

European studies, such as Gorg and Hanley (2004), have used plant-level data for the electronics industry in Ireland for the period from 1990 to 1995 to show that offshoring of services had a positive, though not highly robust, effect on productivity growth[1]. Likewise, Girma and Gorg (2003) find a positive impact of outsourcing of industrial services[1] on productivity in the UK manufacturing industries during 1980-1992, although they are unable to distinguish between international and domestic outsourcing.

The studies, however, did not consider offshoring of services. Recent work by Mann (2003) provides a back-of-the-envelope estimate that the first wave of offshoring, which focused on global sourcing of computer hardware, led to a reduction in IT hardware costs of 10 to 30 percent in the 1990s and an annual increase in productivity of 0.3 percentage points during 1995-2002, or $230 billion in additional Gross Domestic Product (GDP). This fall in IT costs would be reflected in higher profits for producers and lower prices for consumers. IT production workers lose, while firms and consumers gain. She goes on to argue that, since a larger share of IT costs accrue to labor-intensive tasks such as software development and systems implementation, the productivity impacts of offshoring these tasks can be expected to be significantly higher.

Economists believe that trade generally leads to significant gains to society. These gains are not inconsistent with employment losses in specific sectors that will cause economic pain to the workers affected. To achieve an equitable result, many analysts believe that it is important to establish a safety net that provides income and training opportunities to affected workers. (See, for example, Atkinson (2004); Bivens (2004); Kletzer (2004); and Mann (2004).) Components of the safety net should include unemployment insurance, wage insurance, and retraining. This topic is discussed in more detail in Chapter 8.

A key assumption underlying the theory of comparative advantage is that the economy enjoys full employment. Thus, this theory is best thought of as a theory of the long-term where workers displaced by imports or offshoring find work in other sectors. By contrast, most popular discussions of the offshoring phenomenon tend to focus on questions such as "where will the new jobs be created" and "can the workers be retrained for these new jobs"? In general, peering into the crystal ball to predict where and what types of new jobs will be created is both difficult and unrewarding. A dynamic economy, such as that of the United States, creates and destroys millions of new jobs in response to changes in tastes, and more importantly, innovations and advances in technology. The US economy creates and destroys more than 30 million jobs each year. In 1999, 32.9 million jobs were lost and 35.5

---

[1] The authors find that international outsourcing generally had a positive effect on productivity, of which the effect on the level of productivity can be attributed to outsourcing of material inputs. Similarly, for international outsourcing of materials inputs, Egger, Pfaffermayr, and Wolfmayr-Schnitzer (2001) find outsourcing of material inputs by Austrian manufacturing firms to the Eastern transition economies increases domestic growth in total factor productivity, more so in capital-intensive industries than in labor-intensive ones. Egger and Egger (2003) find that a 1 percent increase in outsourcing of intermediate inputs to the Eastern countries relative to gross production induces a shift in relative employment by about 0.1 percent in favor of high-skilled labor. Egger and Egger (2001) find that outsourcing of intermediate products by EU manufacturing firms reduces productivity of low-skilled workers in the short-run and increases it in the long run, an effect which the authors attribute to imperfections in the EU labor and goods markets.
[1] This study defines "industrial" services as "activities such as processing of inputs which are then sent back to the establishment for final assembly or sales, maintenance of production machinery, engineering or drafting services, etc." (p. 5). They do not include "non-industrial" services such as accounting, consulting, cleaning, or transportation services.

million new jobs were created for a gain of 2.6 million jobs. In 2003, there was a net loss of 100,000 jobs even though 30.2 million new jobs were created (BLS Business Employment Dynamics). There is no guarantee that the economy will continue to create these new jobs, but we can take some comfort from the historical evidence that thus far it has managed to do so. The key to job creation is of course the ability of the economy to rapidly generate and adopt innovations, that is, new types of goods and services, and productivity-enhancing process improvements.

Innovation is indeed an engine of economic growth, and perhaps the most important source of productivity growth in developed economies. When there is rapid technological innovation, as in the case of IT, there is a significant spillover effect to users of the technology when the price paid for the technology is lower than the value received. This can result in significant productivity and economic growth in the user sectors as well. Given that IT is a general-purpose technology, the users are many and varied.

In general, trade stimulates innovation and economic growth in both trading partners. However, Gomory and Baumol (2000) and Samuelson (2004) argue that innovation opportunities create new possible conflicts of interest between trading partners. For instance, insofar as offshoring stimulates innovation and productivity growth in countries such as India, and more likely, Brazil, China, and Israel, in goods and services for which developed countries such as the United States or Germany enjoy a comparative advantage, this will cause the terms of trade to become less favorable for the developed nation. Simply put, the comparative advantage of the developed nation becomes less valuable over time. As a result, offshoring may impose permanent losses in the developed nation. In other words, even if free trade is the best policy, it may well be that free trade, by stimulating innovation overseas, may impose long-term losses. However, Gomory and Baumol's analysis shows that this conflict of interest is present when the two trading partners are at similar stages of development. Since most offshoring involves countries at very different levels of development, this conflict of interest is presently unlikely.

In the IT services sector, there is a related concern in the developed nations, particularly in the United States. Currently, it is efficient to offshore low-end IT services such as coding or maintenance, with high-end activities such as requirements analysis, design, and research and development remaining in the developed country. However, the concern is that eventually the "labs will follow the mills", and high-end IT activities will also move offshore. Were this to happen, the developed country might cease to be the technology leader. There is some anecdotal evidence that some process innovations are moving offshore. For example, in laptops, it used to be the case that contract manufacturers made product to the design specifications of US vendors. Today, many of these companies have moved upstream to design the product. Intel is designing processors at its R&D facility in India. Likewise, software services firms have moved upstream to provide increasingly sophisticated software solutions from more traditional applications, and to business process services such as accounts payable, human resources, and even medical applications. Thus, in addition to the static, resource allocation efficiency from free trade, one must also look at the impact on the fundamental capabilities that underlie innovation.

These concerns reflect possible scenarios, perhaps even plausible scenarios. However, it is not clear how likely they are. There are offsetting forces as well. In parallel with offshoring, the inflow of skilled and trained workers into the United States has grown. Though perhaps these inflows substitute for native-born workers in the short run, in the longer run, they create all-around benefits by raising innovation. Moreover, it could be argued that even a loss of technical leadership in one area could be beneficial by allowing scarce talent and resources to be allocated to more promising areas such as nano-technology, bioinformatics, or genomics. The post-9/11 trend of a reduced rate of immigration should be of concern to the United States given that many other developed countries are seeing increases in immigration of qualified professionals.

Arora and Gambardella (2005) suggest that the scenarios that result in a loss of US technological leadership are very unlikely. In many industries, the locus of production and the locus of invention are physically separated. This is particularly true when the body of knowledge underlying the invention process has a strong scientific basis. Building on earlier work by Lamoreaux and Sokoloff (1996; 1997), Sutthiphisal (2003) studied the location of production and invention in three different industries during the Second Industrial Revolution, namely, textiles, shoes, and the electric industry. He finds that, in general, the locus of invention did not shift with the locus of production as the latter moved to other locations. Moreover, he found that the link between location of production and invention is weaker in the more science-based electric industry. Using data from a century later, Mariani (2001) studied the location of R&D and production facilities by the Japanese multinationals in Europe. She found that in low- and medium-R&D industries, R&D labs are more likely to be located close to production facilities than in more R&D-intensive industries. Chapter 5 discusses some of the current patterns in the globalization of research.

Can the United States specialize and keep its comparative advantage in the higher end? The starting point for this discussion is to note that there are two key resources required to remain the center of innovation in software: access to talented designers, software engineers, and programmers along with proximity to a number of large and technically sophisticated users. The United States dominates on both counts. Recall that in the 1990s, there was considerable concern about Japan's software factories (e.g., Cusumano 1991), but there has not been a single successful Japanese software product that has developed a global market (if one excludes the software that is a key component of gaming devices which is not sold separately). To the extent that students are misreading the tea leaves and moving away from studying computer science, the United States in particular could face a longer-term problem in having access to talented software professionals. This topic is discussed in Chapters 7 and 8.

The size and the openness of its culture and economy have given the advantage to the United States over Japan and Western Europe in attracting talent from around the world. The United States has been and continues to be a large producer of IT human capital for the world, especially at the graduate level, and some of the students who study remain to work in the country after graduation. The country has also been a magnet for technical workers trained elsewhere. The United States as a destination for study and work has abated somewhat in the past several years partly because of the harsher governmental regulations in support of national defense.

Another global advantage of the United States is that most lead users are US-based. New software applications depend largely on knowledge about demand and about the applications domain. This is especially true for the substantial fraction of software used in running businesses and business processes. Proximity to business activities is crucial for innovations in such areas. Indeed, the development of new commercial applications or solutions is a very special comparative advantage of the United States. On a more limited basis, this benefit also accrues to other developed countries such as Germany where the software giant, SAP, is based and dominates the market for enterprise software. In general though, US industry is the largest user of IT in the workplace.

Globalization may reinforce this lead because we find that innovative companies from Israel, Ireland, and even India are likely to move their operations to the United States to be closer to their users. Sometimes, venture capitalists push for such a move as well. Other intermediating institutions, such as legal services and thick and well functioning labor markets, are also important sources of advantage enjoyed by the United States that are not likely to be eroded soon.

There are counter-tendencies as well. In so far as these professionals (be they Indian, Irish, Israeli or Chinese) have a preference for staying in their home country where the cost of scientists and engineers is lower, the cost of R&D activities that are human-capital-intensive and relatively less intensive in physical infrastructure will also be lower offshore.

More broadly, the United States has several distinct capabilities – the best universities and research institutions, highly efficient capital markets, flexible labor markets, the largest consumer market, business-friendly immigration laws, and a large and deep managerial talent pool. As a result, the evolution of business in the United States has followed a consistent pattern: launch innovative businesses here, grow the business, and as products and services mature, migrate lower-value-added components and intermediate services over time to lower-cost countries. As more countries and regions enter global trade with highly skilled and capable labor pools, this increases the amount of competition that US companies and workers face. This competition produces an increased premium on the innovation and productivity of the US workforce.

To continue growing the wealth of the United States and its individual workers, labor productivity must grow at a rate that equals or exceeds the growth of wages. Labor productivity can increase in a variety of ways but generally occurs through an increase in worker skills combined with increased innovation in products and processes. Essentially, growth requires capital investment in technologies that increase productivity and a focus on innovation that results in new or transformed existing marketable products and in more efficient processes.

In summary, economists have argued on both sides of the offshoring and free trade issue. The arguments are sophisticated and nuanced, and the results often depend on whether the underlying assumptions hold in the current context. While a majority of economists are proponents of free trade, the underlying question is an empirical one and can be answered by analyzing reliable data. As someone once said, "The difference between theory and practice is greater in practice than in theory." Unfortunately, there is a lack of data to help understand the phenomenon, and more importantly, there are no data collection processes underway that would help in conducting a statistical analysis of the empirical evidence.

It is important to distinguish among effects at the country, firm, and worker levels. Because it is voluntary, offshoring benefits the firms that undertake it. Workers, on the other hand, sometimes lose substantially from offshoring because they cannot instantly (and may never) transfer their skills to other jobs that pay as well. At the country level, the benefits of trade often outweigh the costs, but we have seen that this is not always the case.

2.2 Data on the Current State of Offshoring and Projections for the Future

"…there are currently no reliable statistical indicators of the extent or nature of global outsourcing." (Huws et. al. 2004)

The report that triggered public concern about the impact that offshoring would have on US lives was produced by Forrester Research in 2002, indicating that 3.3 million US service jobs would be lost to offshoring by 2015. This report was followed by many additional studies, each with its own numbers, produced by private consulting firms, federal agencies, and economists from academia and think tanks. These numbers ranged quite widely, in some cases differing by a factor of ten. How are we to know which numbers are correct? This section discusses some of the general issues concerning data about offshoring. It then considers what the existing data tells us about the current state of offshoring and about projections of future offshoring activity. The greatest emphasis is on the United States (the leading sending country), then on India (the increasingly dominant recipient country), but data are provided about all the countries actively involved in offshoring to the degree that we could identify data. Worldwide data was given in Chapter 1 and is not repeated here.

What Are the General Issues We Should Consider in Evaluating the Accuracy of Data About Offshoring?

There are three basic points to consider in evaluating offshoring data. First, there is a question of the definition of offshoring. Some reports include all service jobs, some include a subset of the service jobs that pertain to professional and technical services (following a category used by the Bureau of Labor Statistics (BLS) in the U.S. Department of Labor), some include all IT jobs, some include only software jobs, some include IT-enabled service jobs, some include other jobs with other criteria, and some reports are not precise in defining what they are counting. Obviously, the numbers will vary considerably based upon the definition used.

Second, it is not clear what should be considered a good measure of the extent of offshoring. Many people count jobs or workers. In addition to the issue raised in the prior paragraph about what kinds of jobs one has in mind, there are other considerations. Suppose one wants to count the number of jobs lost in the United States or Western Europe to offshoring. How does one know which jobs to count? Business decisions by companies are complex and, while the press sometimes reports horror stories of employees being asked to train IT workers from a low-wage country and afterwards being replaced by them, it is rarely clear-cut whether a job has been lost directly because of offshoring. A company might cut back on the number of workers in one location and add workers in another location, or cut back on people in one occupation and replace them with workers in another occupation. And this might be because of some good business reason other than labor arbitrage that is taking advantage of the wage differentials in the two countries to save on labor costs. It might be, for example, that one product line is declining and resources are needed elsewhere in the company, or the company needs fewer workers in a particular field because of automation of some aspects of the work or rationalization of the work process, or because the company has a global strategy that it is trying to achieve and part of that strategy involves building market presence in specific geographic locations.

One might instead want to count the number of jobs created in a low-wage country to do offshoring for a high-wage country. There is, however, no necessary correlation, for instance, between the number of Indian jobs created and American jobs lost. A company might decide to hire more Indian workers to work on a project than the number of American workers displaced because the cost of the Indian workers is so low and better results might occur by dedicating a larger labor effort to it. An American worker and an Indian worker might not have the same productivity rate because of educational level, work process, infrastructure, technical tools available to support the work, or many other reasons. The literature gives examples where American workers are clearly more productive than the Indian workers, and other examples that show the opposite. In particular, work processes often are reengineered before being implemented in India, and the reengineered process sometimes leads to significant increases in productivity. Also, in some lower level jobs (for example, working in a call center), Indian companies are on average able to recruit workers to do these tasks who are much more highly educated than the average American holding that job. There is also confusion in the statistics about whether to count only the jobs newly created that are focused on doing software work for export versus counting all new and existing jobs with this focus.

One might want to focus on the monetary value of the business rather than on the number of workers who perform the work. This, too, is difficult to measure. One of the problems is that a significant portion of the work that is done for multinational corporations is done by their subsidiaries in countries such as India. The work that is conducted is then regarded as an internal operation of the multinational, and this may make it difficult to identify the monetary value of the work performed offshore or even to know when to consider something as offshoring and when to regard it simply as a product or service developed by a multinational through several of its divisions located in different countries. This is a serious issue in measuring offshoring because balance-of-payments data tells us that intrafirm trade represents 71% of all business, technical, and professional services imported into the United States and, moreover, in the period 1997-2002, it was increasing faster than imports from companies not affiliated with a multinational (UNCTAD 2004).

Another issue is that offshoring of complex products or services often occurs by dividing up the labor and having some of it done within the client company, some done by one or more vendors, and some purchased as components. In these cases, it is often difficult to value fairly the portion of the product or service that has been outsourced. A recent European study addressed these issues:

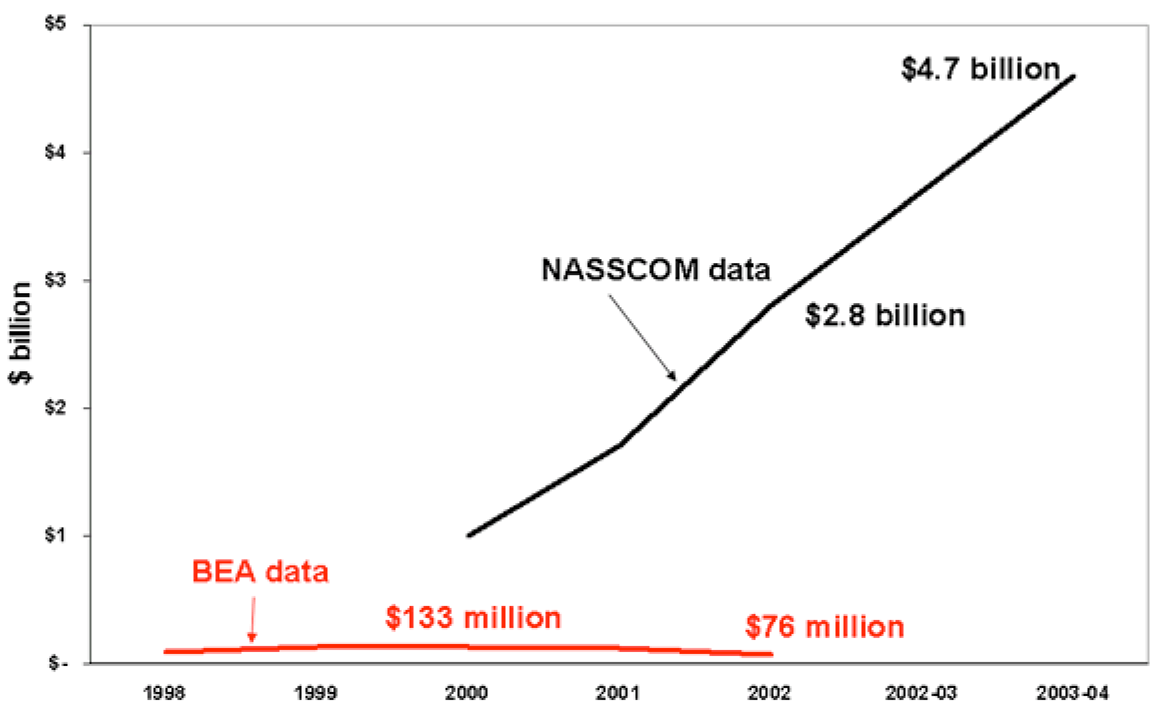
> In its legal sense "outsourcing" refers to a business activity, involving the production of either goods or services, purchased by an organization from an external supplier rather than internally. It is, in other words, "subcontracting." However, in the current context of rapid organizational change, determining what is "internal" and "external" is increasingly difficult. Mergers, demergers, strategic alliances, public-private partnerships, and a variety of different forms of organizational disaggregation – including those resulting from business process re-engineering – are increasingly common. If a company is restructured on the basis of separate cost or profit centers, for instance, should transactions between them be regarded as 'outsourcing' or merely as internal accounting flows?" (Huws et. al. 2004, p. 3)

If one wants to focus on the long-term impact of offshoring, the appropriate metric might be jobs lost or created, or the monetary value of offshoring business over time rather than at any specific point in time such as today. This kind of data tends to be of two types. One type analyzes the nature of work to determine the number of jobs that might be vulnerable to offshoring without making any claims that all or any particular portion of these jobs would be transferred from the high-wage to a low-wage country. The other type analyzes the number of jobs that will actually be sent overseas (or the monetary value of actual offshoring business) by a certain date. Even in cases where the methodology is sound and soundly applied, projections about the future are much less likely to be accurate than data about today's or yesterday's situation since it is difficult to predict all the factors that will come into play over time.

These two types of analyses introduce additional data issues. Vulnerability analyses are less prone to errors because they require fewer assumptions than the other types of analyses. To conduct a vulnerability analysis, all that is required is to identify industries whose work could be transferred offshore and count the number of workers and their occupations in the identified industries. To some extent, the list of vulnerable industries is subject to change as new technologies and price changes can affect the list of industries that are vulnerable to offshoring. A more important problem with vulnerability analyses is that they tend to produce very large numbers that may bear little relationship to the actual amount of offshoring that will take place. For example, all manufacturing, mining, and agricultural activities could be replaced by offshore activities. Thus, other than pointing out which industries and occupations are immune from offshoring, assessments of the number of jobs vulnerable to offshoring provide a very high upper bound that may be of little practical value. As described in the following, projections of how much offshoring will occur, while more useful in theory, are plagued by additional problems.

In addition to issues with the definition of offshoring and what constitutes a good measure of it, there is an issue concerning the source of the statistics. There are four major categories of data providers: government agencies, trade associations, consulting firms, and universities and think tanks. At least in the United States and Western Europe, the national governments provide data that is among the most trustworthy. For example, the US government collects large and often fairly complete data sets, taking advantage of its ability to compel business organizations and individuals to report certain kinds of data under penalty of law. Most of these federal agencies employ well-trained and experienced economists and demographers who typically use appropriate methodologies and open their methods and assumptions to scrutiny. In the United States and a number of other countries, the data-collecting and reporting agencies have been relatively unbiased – not subject, for example, to political whims but instead trying honestly to determine what the data tells us. Some analysts have argued, however, that US government data and reports may indeed be either inferior to data from other sources or biased. For example, the Economic Policy Institute (2004) has noted that the Bureau of Economic Analysis (BEA) data on US imports of software from India shows much lower levels and a different trend (flat or declining compared to a rapid increase) than data provided by NASSCOM, the Indian trade association (see Figure 1). Business Week Online (2005) points out how the tone in US Department of Commerce reports on the effects of offshoring changed markedly when one of their reports was updated with the authorship shifted from career staff to political appointees.

Figure 2-1. U.S. Software imports from India



Source: Bureau of Economic Analysis and the Indian National Association of Software and Service Companies (NASSCOM).

Projections, however, require more than simply collecting and analyzing data. Models must be developed to extrapolate trends, and decisions must be made on turning points and when new forces will affect trends. Thus, it is not surprising that projections related to offshoring, and other labor market variables as well, are subject to error, particularly when projecting over longer periods of time. Even federal agencies are often far off the mark with projections especially if these projections extend far into the future. The BLS periodically assesses the accuracy of its projections. The most recent BLS review of its general occupational projections shows that although BLS does reasonably well in projecting overall employment in broad occupational groupings, the projections do not do as well in dealing with specific occupations (Alpert and Auyer 2003). In projecting employment growth from 1988 to 2000, the BLS projected an increase of 15.3 percent, but employment grew by 21.7 percent over the period. The most serious problems in projecting occupational employment patterns resulted from problems in anticipating changes in staffing patterns. Examples of particularly large errors include the category of gas station attendant, which was projected to grow from 308,000 to 331,000, but actually fell to 140,000, and travel agents, whose ranks were expected to grow by 54 percent but whose numbers declined by 6.2 percent (Wessel 2004). An earlier outside review of the BLS occupational projections found that BLS tended to underpredict the growth of occupations requiring a college education (Bishop and Carter 1991).

Even when government agencies do a good job of collecting data and making projections, they generally collect data that helps them assess issues that have occurred in the past so when a new phenomenon arises (such as offshoring), it is not clear that the data that federal agencies have been collecting and the analyses they have been performing will answer the policy questions that now arise. This is generally true for both the federal data from most countries and for the data collected by pan-national organizations such as the United Nations, the International Monetary Fund, and the Organization for Economic Cooperation and Development (OECD).

The data provided from the other sources is potentially more problematic. Trade associations, such as the Information Technology Association of America (ITAA) and the National Association of Software and Service Companies (NASSCOM), the trade association for the software industry in India, have access to large data sets from their members. However, the members of these organizations are not necessarily representative of the totality of producers or consumers of information technology so the data from these organizations may not accurately represent the full story of what is going on. Moreover, these organizations are partisan to their members, and they may craft their data studies or reporting of these studies in ways that are favorable to the interests of their membership.

The consulting firms have a strong interest in increasing their business based on their statistics. It is in their interest to provide numbers that demonstrate to potential clients that there is a problem that needs fixing. Most of the consulting firms keep proprietary the method by which they produce their projections so it is hard to evaluate what their numbers mean. In fact, many economists are skeptical of the methods these firms use. Much of the alarmist data about the impact of offshoring on job loss in the United States and Europe has been generated by the consulting firms. All of this discussion indicates that it is difficult to get accurate data about the amount of offshoring currently going on and that is likely to take place in the future.

What Does the Data Tell Us About the Size and Impact of Offshoring in the United States?

Although the Forrester Research numbers are the most widely quoted, it would be preferable to be able to use other sources because Forrester is an interested party and the firm is not forthcoming about its methodology. One would like to use US federal data, if possible, for quality and objectivity. The most relevant federal data source is the Bureau of Labor Statistics Mass Layoff Statistics (MLS) series. Unfortunately, the MLS has serious shortcomings for this purpose in that it both undercounts and overcounts layoffs. It counts only relatively large layoffs (at least 50 employees within a five-week period) and only layoffs at companies that employ at least 50 employees; thus it undercounts by not counting all small businesses and by not counting companies that lay off people for offshoring purposes in smaller numbers or over a longer period of time. The MLS also overcounts in that its numbers include people who are laid off for many reasons, including a number not relevant to our interest such as bankruptcy, financial difficulties of the company, movement to other locations within the United States, or change of company ownership. BLS reports that these latter reasons are more common than layoffs for outsourcing, both domestic or across national boundaries.

For the IT industries (by which the BLS means the communications equipment, communication services, computer hardware, and software and computer services), MLS only identified 7,923 people affected by movement of their jobs during the period January through September 2004. Of these job relocations in the first three quarters of 2004, 70% of the jobs were moved within the United States and 80% were moved within the same company. When the jobs were moved contractually to another company, 40% of the jobs were moved outside the United States. These numbers appear unreasonably low.

A study by Bronfenbrenner and Luce (2004) used online media tracking and corporate research to identify offshoring job losses in the United States. This study found that the MLS grossly underreported job loss due to offshoring. It estimated that 206,000 jobs were shifted overseas in 2002 and 406,000 were moved in 2004. The authors argue that their method, while imperfect, probably undercounts job migration because not all losses are reported in the media and their search tools did not fully capture job losses that are reported only in the local media, a common place for such losses to be reported.

[2]Even if the MLS data does not provide exact numbers, it might serve as a representative sample from which one could learn about trends (for example, the year in which losses peak in a particular field of IT). If this sample is indeed representative, computer hardware, software and computer services, and communications equipment had their peak losses in 2001, while communications services had its peak losses in 2002. The Bronfenbrenner and Luce study discovered that the largest job losses came from the midwestern states in the United States, and that there have been rapid increases in job movements in IT, call centers, and white-collar jobs to India.

Another potential source of federal data on offshoring comes from the US Department of Commerce's Bureau of Economic Analysis (BEA). However, some economists believe that the BEA numbers seriously underreport software imports to the United States. For example, BEA reports the United States imported $76 million in software from India in 2002, whereas the Indian software trade industry association NASSCOM reports Indian software exports to the United States at $2,800 million that same year (see Figure 1). A small part of this difference can be attributed to differences in definitions but not nearly the entire amount. The US Government Accountability Office (GAO) noted the shortcomings of the BEA data on offshoring as follows: "In addition to the lack of quarterly survey data for unaffiliated transactions and lack of quarterly product detail for affiliated services, there are reliability issues related to the mandatory filing requirements and survey coverage." (Government Accountability Office 2003, p.62).

---

[2] This study defines "industrial" services as "activities such as processing of inputs which are then sent back to the establishment for final assembly or sales, maintenance of production machinery, engineering or drafting services, etc." (p. 5). They do not include "non-industrial" services such as accounting, consulting, cleaning, or transportation services.

The BEA data nevertheless show some trends. Imports of business, professional, and technical services into the United States increased by 77% to $38 billion between 1997 and 2002. US investments in developing countries that offshore services were small compared to investments in developed countries, and most services created abroad are sold to non-US markets.

Turning to trade association data about offshoring and the United States, the Information Technology Association of America (ITAA) is the principal provider. ITAA is an organization that represents 350 US-based Internet, software, service, and telecommunications companies. It reports that 372,000 software and services jobs were lost between 2000 and 2003, with only 104,000 lost to offshoring. ITAA estimated that 90,000 new software and service jobs were created in the United States in 2004 due to increased economic activity.

The largest amount of data (that is also the most suspect data) comes from the consulting firms. Table 1 provides information about the impact of offshoring on the United States based on reports and projections from consultants. The numbers generally indicate that 12 to 14 million IT and IT-enabled jobs in the United States are vulnerable to relocation through offshoring. Annual losses range from under 200,000 to about 300,000 for service jobs lost from the United States due to offshoring. The number of IT jobs lost is somewhat lower than these estimates because the estimates include service jobs such as working in call centers and possibly in other IT-enabled services such as business process and knowledge process outsourcing. The numbers from the American Electronics Association might seem to be contradictory to the other data, but it should be remembered these are net losses in the industry so they include losses not only to offshoring but for other reasons such as company downsizing or bankruptcy, and these losses are offset by newly created jobs. The consensus seems to be that about 20% of US companies are currently offshoring work but that the percentage will rise considerably over the coming years. Bednarzik (2005) concludes that "employment trends by industry and occupation suggest that offshoring in the information technology sector occurs, but not to a great extent." These numbers also do not take into consideration jobs that are created by offshoring.

The current value of offshore contracts from the United States seems to be in the $10 to 20 billion range, and most analysts believe there will be rapid growth in these numbers over the coming few years. It should be remembered, however, that we do not know the methods used to arrive at these numbers and how independent the data from one consulting firm is from that of another. We do not know, however, of any body of extant raw data that serves this analysis well.[BSB1]

Table 2-1: The Impact of Offshoring on the United States

Source	**Data reported**	**Statistic**
I. Current or Recent Offshoring		
Forrester (2004)	US service jobs lost in 2003	315,000
Forrester (2004)	US service jobs lost by end of 2005	830,000
Goldman Sachs (2004)	US jobs lost in past three years	300,000 to 400,000

Dossani (2005)[BSB2]	Software workers in the United States	1,200,000 software engineers; 500,000 programmers
Evalueserve (2004)	IT jobs offshored year ended March 2004	212,000 (60% to India)
Evalueserve (2004)	Call center jobs offshored year ended March 2004	136,000 (90% to India)
Gartner (2004)	Fortune 500 companies expected to offshore some IT work by end of 2004	40%
Gartner (2003)	IT industry and employment	500,000 jobs by end of 2004
Meta Group (2004 Annual IT Staffing and Compensation Guide)	US companies using offshore labor in software	19%
American Electronics Association (2003 Cyberstates report) [Seeley 2003]	Jobs lost in 2002 in the US software services sector	30,000 (compared to 146,000 the year before)
American Electronics Association (2003)	Jobs lost in 2002 in the US software industry	150,000
American Electronics Association (2003)	Jobs gained in 2002 in US in high-tech R&D	7,000
Washington Alliance of Technology Workers (CBSNEWS.com, 2005)	Jobs lost in the US IT sector March 2001 to April 2004	403,300
Washington Alliance of Technology Workers (CBSNEWS.com, 2005)	Percentage of IT sector jobs in San Francisco area lost March 2001 to April 2004	49%
United Nations Conference on Trade and Development (World Investment Report 2004)	Average percentage annual growth in US imports of computer and data processing services, 1992-2002	31%
Bajpai et al. (2004)	Percentage of companies that have offshored work (survey is mostly but not exclusively of US companies)	25%
Bajpai et al. (2004)	Percentage of companies that have already or plan to offshore work	79%
IDC	Value of offshore contracts from US in 2005	$17.6 billion

ITAA[BSB3]	Value of offshore contracts from US in 2003	$10 billion
II. Estimates of Workers Vulnerable to Offshoring		
Bardhan and Kroll (2003)	US workers in service jobs vulnerable to offshoring	14,000,000
Progressive Policy Institute (2004)	US IT jobs vulnerable to offshoring	12,000,000
III. Projections of Offshoring		
Wired magazine (Pink 2004)	Service jobs leaving the United States each year for the foreseeable future	200,000
Prism (2004) meta-analysis	Percentage of IT jobs lost from US over next five years	7% to 8%
ITAA[BSB4]	Value of offshore contracts from US in 2008	$31 billion
Deloitte Research (2003 report cited in GAO 2004)	Financial services jobs that may move offshore	850,000 (15% of industry employment)
Forrester (2004) report cited in GAO (2004)	U.S. service jobs lost by 2015	3,300,000
Goldman Sachs (2003 report cited in GAO 2004)	Services and manufacturing jobs lost over coming decade	Up to 6 million jobs
Evalueserve (2003)	All jobs lost 2003-2010	1.3 million worst case
Evalueserve (2004A)	Total jobs offshored in IT and non-IT business process operations (BPO) in 2010	775,000 IT jobs 1,414,000 non-IT BPO jobs
Evalueserve (2004B)	Growth of value of knowledge process offshoring (KPO) from 2003-2010	From $1.29 billion in 2003 to $17.0 billion in 2010 (46% annual growth rate)
Shaw quoted in McDougall (2005)	IT jobs moving offshore in 30 years	30% of IT jobs offshore within 25-30 years
Gartner quoted in McDougall (2005)	Percent of U.S. IT jobs offshored in 2005 and 2015	Will increase from 5% in 2005 to 30% in 2015

Two studies estimated the number of jobs in the United States that are vulnerable to offshoring, and they found 12 to 14 million jobs could be offshored (Bardhan and Kroll 2003; Progressive Policy Institute 2004). Both studies note that their figures represent an upper bound on offshoring activity that could occur not a projection of what will take place. Thus, these studies are useful not so much for the numbers they provide as for identifying sectors and occupations subject to offshoring. Bardhan and Kroll, for example, include in their 14 million jobs vulnerable to offshoring office support, business and financial support, computer and mathematics professionals, paralegals and legal assistants, diagnostic support service jobs, and medical transcriptionists.

A number of studies provide projections of offshoring activity in the United States. It is difficult to make comparisons among the studies for several reasons. The major obstacle is that the studies measure different sectors of the economy (e.g., IT, services, manufacturing, business processing operations, knowledge process offshoring), use different measures of the extent of offshoring (e.g., jobs lost, percent of jobs lost, value of jobs or business lost), and different start and end points. Few of the studies provide details on how they developed their projections which makes it difficult to assess the reasonableness of the assumptions and the soundness of the methodology. The Evalueserve studies provide more details on their methods so one can assess the assumptions and methods better than for most other studies. For example, a critical assumption in Evalueserve's work is that there will be a large shortage of labor in the United States and that a significant part of the solution will be from offshoring. Since Evalueserve has described its assumptions and methods in some detail, other analysts can make their own assessment of how reasonable these assumptions and methods are.

All the projections indicate that offshoring of service jobs in the United States in general and of IT jobs specifically will continue to grow, but there is some disagreement about how rapidly the growth will take place. Some of the studies project absolute numbers of workers lost over a given number of years such as Forrester's projection of 3.3 million service workers by the year 2015. The problem with these projections is that most of them do not give a baseline for understanding the significance of the job losses. They often do not tell you the size of the population from which these projected losses will be taken. In fact, it is a difficult task to count the number of IT or service workers in the United States. Here is one part of a lengthy analysis of this issue from a Computing Research Association study done in 2000 about the IT workforce.

> Commerce used the narrow definition of the Bureau of Labor Statistics classifications: computer scientists and engineers, systems analysts, and computer programmers. The Information Technology Association of America (ITAA) used a broader definition: any skilled worker who performs any function related to information technology, which itself is defined as the "study, design, development, implementation, support or management of computer-based information systems, particularly software applications and computer hardware." (Freeman and Aspray 2000)

Not surprisingly, different definitions lead to different numbers. The Bureau of Labor Statistics counted a little more than 2 million workers in 1997 and about 3 million today. Between 2000 and 2004, the ITAA has counted between 10 and 11 million IT workers. Service workers account for a very significant portion of the American labor force, amounting to many tens of millions of workers. Some significant fraction of these service workers are enabled by information technology, but it is hard to count how many and to what extent.

Some of the other studies project in terms of the percentage of the jobs lost. These vary significantly in the percentages they quote and the length of time over which this job loss takes place. But perhaps more importantly, it is hard in some cases to know what a given percentage projection means or to compare across these projections by different organizations since their meanings are often different from one another. When a study says that 25% of the US IT jobs will be lost by a given year, does it mean that the IT workforce in the United States will be a quarter smaller than it is today? Does it mean that there will be three IT jobs in the United States at that date in the future for every IT job in another country doing work for a US firm? Are the numbers calculated on a base of the number of IT jobs today or at that time in the future? Would it matter if there were a sizable number of IT jobs in other countries servicing the US economy if the number of IT jobs that remained in the United States continued to grow?

Some of the projections are for specific slices of the offshoring market. For example, Evalueserve (2004B) has projected a high rate of growth—46 percent annual compound rate of growth—in what they term knowledge process offshoring (KPO). Evalueserve distinguishes KPO from other business process operations (BPO) by the high level of knowledge intensiveness required. Examples of opportunities in KPO include intellectual property research; equity, financial, and insurance research; data search, integration, and management; analytics; and research and information services in human resources (Evalueserve 2004B, p. 4). What happens in the KPO slice that is developing from a small base, making it easier to have high growth percentages, may well not be true for other segments of the offshoring industry.

How do we put all this in perspective? Looking only at the number of jobs lost to offshoring is a narrow and one-sided way of looking at the situation. If one wants to know how many jobs there will be for IT workers in the United States in the future, one needs to look not only at all the ways in which jobs are lost (including not only those moved offshore but those lost through companies downsizing or going out of business) but also look at the number of new jobs that are created in the IT occupations.

It is useful to consider what has happened over the past five years and compare that situation with some of the projections just mentioned about IT job growth. The reports discussed earlier in this section indicate that the United States has lost several hundreds of thousands of jobs to offshoring since the height of the dot-com boom. Does that mean that we have fewer jobs today in the United States in the IT field than we did then? The last section of Chapter 1 contains an analysis of recent US Bureau of Labor Statistics numbers (see Table 8). It shows that the number of US IT workers is actually higher today than in 1999, at the height of the dot-com boom, despite the hundreds of thousands of jobs lost to offshoring. People who study the overall US labor market will not be surprised to learn that the situation is not as dire as it is made out to be by those who dwell on the offshoring losses. This is because history shows tremendous and continuing churn in the American labor market with massive numbers of jobs lost and jobs created each year, but with a fairly consistent pattern that the number of jobs created is larger than the number of jobs lost. These patterns do not hold true for all occupations of course, we have significantly fewer telephone operators than we once had, for example, but the Bureau of Labor Statistics in its ten-year forecasts continue to believe that the IT occupations will experience overall sustained growth and, in fact, several IT occupations will be among the fastest growing occupations in the next decade. The ITAA study mentioned previously also suggests that the number of IT jobs created in the United States in the future will be robust.

One can similarly ask about the effect of offshoring not on jobs but on wages for US IT workers. The same Bureau of Labor Statistics data just cited indicates that, since the height of the dot-com boom and throughout the dot-com crash, even through a recession in the US economy, IT wages have continued to rise at about twice the percentage of inflation. Wages did not rise at the same rate in all IT occupations. High-skill jobs rose at the highest rates, for example, computer science research salaries rose at 5.6% per year and computer systems manager salaries at 5.7% per year. Wages for low-skills jobs rose less rapidly. For instance, computer support personnel wages rose at only 2.1% per year, fairly close to the rate of inflation during this time. Even the much talked about programmer, whose job is expected to be particularly vulnerable to offshoring, had wages rise by a healthy 3.7% per year.

What will happen in the future is hard to predict. If the United States remains innovative in the IT field and if this innovation continues to have an important positive influence on the US economy as was the case throughout the 1990s, then it is likely that the United States will continue to create large numbers of jobs for IT workers. If the country does not continue to promote innovation and it cedes large portions of its IT industry to other countries, then the future is likely to be much bleaker for American IT workers.

What Does the Data Tell Us About the Size and Impact of Offshoring in Countries Other Than the United States That Offshore Work?

EUROPE OVERALL

The European Union is the largest offshorer of IT software and services after the United States. In one project of the European Commission's Information Society Technologies Programme, known as the STILE project, there was an effort to cull data on the IT-producing sector in Europe. The study group tried to use the accepted classification scheme, Nomenclature Generale des Activites Economiques dans les Communautes Europeenes (NACE) (General Industrial Classification of Economic Activities within the European Communities). They found that this was not particularly useful because IT activities are in many cases bundled with non-IT activities in the classification codes, and it was impossible to separate out services from products. More generally, there seems to be very little data, if any, collected by government organizations that provides information about the state of offshoring in Europe. As one major survey of the literature on European offshoring summarizes:

> It is important to emphasize, along with the OECD (van Welsum, 2004) that there are currently no reliable statistical indicators of the extent or nature of global outsourcing. It is not possible, either through the trade statistics or the EU occupational and employment statistics, to track statistics of imports and exports of business services to identify with any accuracy which components of these services represent jobs.
>
> For evidence we must therefore look to the results of market research, one-off surveys and case studies or anecdotal evidence. It must be emphasized that these vary in their reliability and their conclusions. They may be coloured, either positively or negatively, by the specific interests of the agencies who commissioned them, depending on their point of view. In between, lie many analyses which strain for objectivity but are hampered by the lack of solid empirical evidence….
>
> An even greater confusion exists in the EU [than in the United States] where there are notably few academic, systematically led investigations in the area of European and offshore outsourcing. Estimates of the impact on Europe are vague, especially in relation to outsourcing to smaller Asian countries and eastern European states. (Huws et. al. 2004, p. 10)

Table 2 provides an overview of some of the consultant data on the extent and impact of offshoring in Europe. The amount of offshoring is clearly at substantially lower levels than in the United States. These reports indicate that only about 5% of European businesses are currently offshoring, and not quite a third of European companies are even planning for offshoring. Huws et. al. (2004) point out that most studies agree that 2 to 3% of all EU service employment will be lost to offshoring by 2015 but notes that this loss is likely to be less than the number of new jobs created so that the European service industry is likely to expand its employment over time.

It is true today that Europe overall is not losing IT service jobs. Even at the country level, this is mostly true, and where there are national losses, in every country other than Denmark, any losses in computer jobs have been more than offset by growth in business service jobs (Eurostat, Community Labour Force Survey). Other than the United Kingdom, Western Europe has a decided preference for selecting Eastern European firms to do their offshore work (Pierre Audoin Consultants (2003), quoted in Huws et. al. 2004). Nevertheless, there is a sizable amount of work sent from Germany as well as from the United Kingdom to India. Eurostat data (Community Labour Force Survey) shows that the EU countries that are growing most rapidly in IT business activities are the new member states such as Hungary which had been behind the rest of the EU in percentage of IT activities. These data are consistent with, but not proof of, these countries becoming prime destinations for European offshoring.

Table 2-2: The Extent and Impact of Offshoring on Europe

Forrester (August 2004 as quoted in Gumbel 2004 and Knapp 2004)	Jobs lost by Europe to offshoring by 2015	1.2 million, including 150,000 IT jobs
Deloitte Research (quoted in Matlack et al. 2004)	Financial-services and high-tech jobs that will migrate from Europe to low-wage countries by 2008	800,000
Heidrick and Struggles/PeopleSoft (2004) as reported in van Breek (2004)	CEOs of European companies who reported offshoring work to low-cost labor markets as a key business issue	31%
European Commission 2000 (as quoted in Huws et al. 2004)	European companies offshoring	5.3%
Forrester Research (as quoted in Huws et al. 2004)	Value of offshore spending in western Europe in 2004 and 2009	1.1 billion, 3.6 billion Euros
Gartner (as quoted in Huws et al. 2004)	European business expected to include offshoring in their business plans by end of 2005	30%
Huws et al. (2004)	EU service employment lost to offshoring by 2015	2% to 3%

UNITED KINGDOM

The United Kingdom is the largest offshorer in Europe by a considerable margin, and this trend is likely to continue at least for the next few years. Forrester Research estimates that the United Kingdom will be responsible for three-quarters of all European offshoring in five years (Huws et. al. 2004). 61% of UK companies send IT work across national boundaries compared to only 15% in Germany, the second largest offshorer in Europe (Roland Berger 2004). Amicus (2004) claims that a thousand UK jobs are being lost to offshoring each week and projects a loss of 200,000 UK IT jobs by 2008 with a significant number of these positions in IT support.[BSB5] Management Consultancies Association predicts 25% growth in offshoring of call centers between 2003 and 2008 (Huws et. al. 2004). The Communications Workers Union (2004) predicts almost 200,000 call center jobs moved from the United Kingdom to low-cost countries between 2004 and 2006.

According to the consulting firm Evalueserve (2004), the United Kingdom will face a shortage of 714,000 workers by 2010 due to the aging of the workforce. IT is one of the fields projected to have the greatest shortages. Evalueserve estimates that 342,000 of these 714,000 jobs can be filled by immigrants and notes that the remainder will need to be filled in other ways if the country is to avoid a decline in GDP due to an insufficient labor pool. Evalueserve claims that, by the end of 2002, 31,100 jobs in the service sector in the United Kingdom had been moved offshore, and the company projects that 272,000 more jobs will move offshore in the period 2003-2010. Focusing more narrowly on IT and software development jobs only, Evalueserve claims that 18,000 jobs had been moved offshore by the end of 2002 and 84,000 more would be moved between 2003 and 2010.

GERMANY

In Germany, there are no federal statistics that help to track the number of jobs offshored (Bartsch 2004). For various reasons, it is expected that offshoring will not be as significant in Germany as in the United States: few people in low-wage countries speak German, Germany has fewer low-skill jobs than the United States of the sort that have been offshored, stricter layoff regulations make it more costly in Germany than in the United States to lay off workers and relocate the work overseas, and there has been less political fallout over jobless recovery after the last recession than in the United States. Germany historically does not have such strong labor rebounds after a recession as the United States. After the most recent recession, job recovery was close to the historical norms in Germany, while in the United States the recovery led to an unprecedented small number of jobs created.

Using an analysis of German foreign direct investment in Central and Eastern Europe by the Oesteuropa-Institut, together with employment trends in German foreign affiliates and correction factors for the German foreign affiliates numbers (because they underreport activities by small and medium-sized companies), Elga Bartsch arrived at an estimate on behalf of the consulting firm Morgan Stanley that the number of jobs (of all kinds) offshored to Central and Eastern Europe over the past decade is approximately 600,000. She also considered an alternate source, the European Restructuring Monitor (ERM), which "compiles information on major corporate restructuring announcements from daily press runs of the major national newspapers in the European Union and classifies them by country, industry, and reason for the restructuring" (Bartsch 2004). The ERM found that 117,000 jobs losses were announced in Germany from January 2002 into mid-2004, and that 3% were lost to relocation of production facilities and another 0.3% to outsourcing. In another study commissioned by the Deutsche Bank, it was estimated that 50,000 German IT-related jobs had been relocated outside Germany up until the time of the publication of the study (Huws and Flecker 2004).

In a McKinsey study (Farrell 2004), Germany shows only a $0.80 return on each dollar invested in offshoring, compared to $1.14 return on the dollar invested in offshoring for the United States. There are multiple reasons for this: German companies have higher management costs because of language and cultural issues; offshoring work is frequently contracted to Eastern Europe where the wages and infrastructure costs are higher than in India; Germany is not able to capture much in high-tech exports through offshoring because of the dominance of US firms in these export markets; Germany gains practically nothing from repatriated earnings (i.e., from offshoring providers abroad that German companies have invested in); and most important of all, as many as 60% of German workers have difficulty being re-employed when they lose their jobs through offshoring which is a major drag on the German economy.

What Does the Data Tell Us About the Size and Impact of Offshoring in India?

By far, the most complete data about the Indian software industry is provided by the Indian trade association, NASSCOM. Table 3 provides a snapshot of the offshore industry based on the NASSCOM Strategic Review 2005. You can see that the industry is vibrant with growth in the 20 to 30 percent range each year. IT software and services are still the largest export, far ahead of hardware and ITES/BPO, but the IT-enabled services are growing more rapidly than any other sector of the Indian offshoring industry. The United States, followed distantly by the United Kingdom, is the destination of most of this work.[3] About 60% of the ITES/BPO work is conducted by multinationals with this percentage edging higher over time. The export trade is growing much more rapidly than the domestic IT/ITES market in India, from 58% to 78% by revenue from 1996 to 2003 (RIS 2004 as quoted in UNCTAD 2004). The software and service industry is becoming increasingly important to India's economy, growing from 3% to 21% of India's total exports between 1996 and 2003 (RIS 2004 as quoted in UNCTAD 2004). Although there are more than 3000 software and service exporters in India, 25 of these firms collect more than 60% of the revenue (Prism 2004).

Table 2-3: The Extent and Impact of Offshoring in India

Indian national economic output attributable to the IT-ITES industry in 1997-98	1.2%
Indian national economic output attributable to the IT-ITES industry in 2003-04	3.5%
Indian IT industry revenue in IT services and software in 2003-04	60%
Indian IT industry in hardware in 2003-04	22%
Indian IT industry in ITES/BPO in 2003-04	18%
Growth in Indian IT and ITES exports	$9.9 billion in 2002-03 $$13.3 billion in 2003-04
IT and ITES export from India to the United States in 2003-04	69%
IT and ITES export from India to Europe in 2003-04	22% (mostly to the United Kingdom)
India IT services and software revenue in 2003-04	$12.8 billion (29.6% increase over previous year)
Jobs added to Indian IT services and software sector in 2003-04	98,000 (more to domestic companies than multinationals)
Growth in Indian IT services revenue	$1.9 billion in 2002-03 $2.5 billion in 2003-04
Growth in Indian offshore product development exports (includes exports of software products made by Indian companies)	$560 million in 2002-03 $710 million in 2003-04 (mostly produced by multinational captives)
Multinational companies that opened captive centers in India since early 2001	230

[3] Joseph and Parayil (2004 as quoted in UNCTAD 2004) claims 80%. Table 3 gives 69% for IT and ITES combined.

Value of research conducted by Indian captives of multinationals in 2003-04	$800 million to $1 billion
Value of research conducted by Indian captives of multinationals in 2008 (projected)	$11 billion
Call center seats	96,000 in 2003; 158,000 in 2004

Source: NASSCOM Strategic Review 2005

What Does the Data Tell Us About the Size and Impact of Offshoring in Countries Other Than India That Do Software Work for Export?

Quantitative information about software exports especially those related to offshoring is difficult to locate for most countries. Table 4 provides a smattering of data that we have been able to locate although we cannot attest to its correctness.

Table 2-4: Nations Other than India with Offshoring Industries

Country	**Statistic**	**Source**
Australia	$21B commercial service exports in 2003 (22% computer and communications)	World Development Index database
	call center seats: 135,000 in 2003, 146,000 in 2004	www.bpoindria.org/knowledgeBase/
Barbados	$1.1B commercial service exports in 2003 (16% computer and communications)	World Development Index database
Belarus	$1.5B commercial service exports in 2003 (24% computer and communications)	World Development Index database
Brazil	$9.6B commercial service exports in 2003 (50% computer and communications)	World Development Index database
Canada	HRDC estimates 500,000 Canadians work in call centers	Prism (2004)
Cape Verde Islands	$211M commercial service exports in 2003 (9% computer and communications)	World Development Index database
China	8,000 software and service providers, _ of whom have fewer than 50 employees and only five have more than 2,000 employees. (Yuan 2005)	McKinsey (January 2005)

	$1.5B in 2003	Prism (2004)
	Call center seats: 38,000 in 2003; 54,000 in 2004	www.bpoindria.org/knowledgeBase/
Czech Republic	$7.8B commercial service exports in 2003 (24% computer and communications)	World Development Index database
Dominican Republic	$3.4B commercial service exports in 2003 (5% computer and communications)	World Development Index database
Ghana	$612M commercial service exports in 2003 (11% computer and communications)	World Development Index database
Guatemala	$954M commercial service exports in 2003 (19% computer and communications)	World Development Index database
Hong Kong	Call center seats: 10,000 in 2003; 10,700 in 2004	www.bpoindria.org/knowledgeBase/
Hungary	$7.9B commercial service exports in 2003 (41% computer and communications)	World Development Index database
Ireland	leads the global market in offshore IT services with 25% of market	World Investment Report 2004
	$3.8B in 2000, 8.5B Euros in 2003	Prism
	60% of EU software is developed or localized in Ireland; software industry is 11% of GDP	
	55% of Ireland's 28,000 IT professionals are employed by multinationals and account for 90% of Irish software exports	
	$38B commercial service exports in 2003 (61% computer and communications)	World Development Index database
Israel	$1.9B value in offshoring exports in 2002	Prism (2004)

Latvia	$1.5B commercial service exports in 2003 (19% in computer and communications)	World Development Index database
Madagascar	$202M commercial service exports in 2003 (32% computer and communications)	World Development Index database
Malaysia	call centers growing at between 100 and 200% per year since 2000	World Investment Report 2004
	$14B commercial service exports in 2003 (33% computer and communications)	World Development Index database
Mauritius	$1.3B commercial service exports in 2003 (17% computer and communications)	World Development Index database
Mexico	$13B commercial service exports in 2003 (7% computer and communications)	World Development Index database
Morocco	$5.1B commercial service exports in 2003 (18% computer and communications)	World Development Index database
	Call center seats in all North Africa in 2005 (Morocco has largest share): 3,900	Datamonitor
New Zealand	Call center seats: 12,000 in 2003; 13,500 in 2004	www.bpoindria.org/knowledgeBase/
Philippines	27,000 people in call center jobs in 2003 and growing rapidly	World Investment Report 2004
	$250 software, or $1B including BPO (2003)	Prism (2004)
	Call center seats: 20,000 in 2003; 40,000 in 2004	www.bpoindria.org/knowledgeBase/
Poland	number of jobs in BPO will increase from 3,000 in 2004 to 200,000 in 2008	McKinsey & Co. (as quoted in Wagstyl 2004)
Romania	$3B commercial service exports in 2003 (42% computer and communications)	World Development Index database

Russia	$150 – 200M value of offshoring exportsin 2003	Prism (2004)
Senegal	$3890M commercial service exports in 2002 (40% computer and communications)	World Development Index database
Singapore	Call center seats: 10,000 in 2003; 10,100 in 2004	www.bpoindria.org/knowledgeBase/
Slovak Republic	$3.3B commercial service exports in 2003 (28% computer and communications)	World Development Index database
South Africa	number of call centers to expand from 494 in 2004 to 939 in 2008); serving the English but also the German populations.	Datamonitor (as quoted in Chatterjee 2004)
	Employees working in call centers in 2005	New York Times (Feb 2, 2005)
	$6.4B commercial service export in 2003 (9% computer and communications)	World Development Index database
Thailand	Call center seats: 11,000 in 2003; 13,000 in 2004	www.bpoindria.org/knowledgeBase/
Tunisia	$2.8B commercial service exports in 2003 (16% computer and communications)	World Development Index database
Ukraine	$5B commercial service exports in 2003 (11% computer and communications)	World Development Index database

2.3 Conclusions

Even in the face of offshoring, economists generally continue to believe in the theory of comparative advantage, that if each country specializes in the production of goods where it has comparative advantage and trade is not restricted, both countries can enjoy greater total consumption and well being by trading with one another. Some economists, notably Gomory and Baumol, have pointed out that it is possible for a country to lose under free trade. In the short-term, the question is one of jobs and wages. Are the jobs lost to offshoring in developed countries compensated for by new job creation in these countries which might come, for example, from the lower cost of development and production, faster development time, higher quality, or round-the-clock service associated with using an offshore workforce to supplement or supplant the domestic workforce? Similar questions can be asked about wage rates. The analysis by Mann of hardware offshoring to Asia in the 1990s suggests by analogy that it is entirely possible for a developed nation to be much better off through offshoring of its software work. Recent Bureau of Labor Statistics shows that IT jobs and wages have generally increased in the United States from the height of the dot-com boom until late 2003, a period during which there was active offshoring. However, lack of data limits what we can say about the impact of offshoring.

Leaving aside for the moment the question of whether offshoring has hurt aggregate jobs or wages, there are at least two ways in which offshoring might harm a developed country. Offshoring clearly can do harm to individuals who lose their jobs through offhsoring and to local communities that lose large numbers of jobs or particular businesses through this type of trade. The general sense among economists is that the only solution to this is a political one of providing a safety net to workers. This might include wage insurance, extended unemployment benefits, retraining, and perhaps others benefits. However, the costs of providing this safety net are great. The other way that offshoring can harm a developed country in the long run is to erode the country's capability to innovate. As a developed country loses its edge in innovation, it becomes less able to remain competitive. Enabling a country to remain innovative is a matter of education, research funding, and immigration policy. These issues are discussed in Chapters 7 and 8.

What does the available data tell us about the extent and trajectories of offshoring? First, considering the United States which has seen the largest amount of offshoring and is subject to the greatest amount of loss through offshoring, we know that there are perhaps 12 to 14 million jobs vulnerable to offshoring. However, this number represents a high upper bound on potential job losses, and nobody believes that all these jobs will be lost. So far, annual job losses have probably been no more than 2 to 3% of the IT workforce in the United States. Moreover, there are questions about the reliability of these numbers because of the definitions and other methodological issues. The meaningfulness is also at question because these job losses have to be placed in perspective with the much higher level of job loss and creation that occurs every year in the United States and, in particular, with the jobs that are created directly or indirectly because of companies sending work offshore. The data simply does not exist that would enable a full analysis of the impact of offshoring on the US IT workforce. Anecdotal information, together with data, suggest that the United States will continue to increase the amount of work it offshores at double-digit percentage rates at least for the next few years. Programming and related technical work continues to be the work most likely to be offshored, but IT-enabled services are rapidly taking a greater share. There is also rapid growth, from a small base, in the offshoring of higher-value activities such as knowledge processing and research.

Data about countries other than the United States or worldwide data are much harder to come by than data for the United States. There are reports of offshoring industries or sectors of these industries that have grown in India, China, and a few other countries by 20, 30, or higher percentages per year with projections that these growth rates will continue for varying lengths of time into the future. It is difficult to evaluate these projections but it seems likely that there will be continued rapid growth at least for the next few years. Whether these growth rates will be 10, 20, 30, or 40 percent per year is beyond our ability to project based on existing data. It appears that India will continue to be the primary destination of offshoring, with China growing rapidly. However, Chinese software activities are devoted to a significant extent on the emerging domestic market not the export market. There appears to be some promise of growth for the main nearsourcing countries such as Canada and those in Eastern Europe despite the fact that their wage rates are higher than those in the low-wage Asian countries. There are at least limited opportunities for offshoring work by companies located in Africa, Latin America, and low-wage Asian countries other than India and China. Data, together with anecdotal evidence, suggests that Western Europe is beginning to increase the amount of work it offshores. The United Kingdom has been by far the largest offshorer in Europe, and this is likely to continue to be true for the next few years. And Germany, in particular, has begun to increase the amount of work being offshored in the past year or two. Japan is set to increase the amount of work offshored especially to China.

There are numerous problems with the current state of data. Definitions used in reporting offshoring's growth and impact are inconsistent with one another. All of the obvious metrics that could be used to measure offshoring have limitations. Government statistical organizations, such as the US Bureau of Labor Statistics and the Bureau of Economic Analysis, provide the greatest promise in providing good data because of their highly trained staffs and long traditions of quality, reliability, and objectivity. Governments collect data, however, in connection with existing policy issues, and the offshoring phenomena is sufficiently different that existing government data sources turn out to be not very useful. Trade organizations and consulting firms are not disinterested parties, and these organizations are often unwilling to make public the methods and assumptions by which they arrive at their results so it is not surprising that there is some skepticism in the economic community about the credibility of their results. For many parts of the world, little or no data is being gathered.

A professional society such as ACM itself is not in a good position to collect data. However, it can encourage the principal data gatherers – governments, trade associations, and consultants – to improve their offshoring data practices. We need clear definitions, careful choice of metrics, data that separates the impact of offshoring on job loss from other causes of job loss such as business cycles and technological change, and data that measures the various aspects of offshoring (jobs created, gains in wealth to companies and nations, impact on wage rates, etc.) not just job loss. Thus, we recommend that the following steps be taken:

Standard definitions of offshoring and related terms should be developed. A good starting place is the diagram developed by the US General Accountability Office (Figure 2) that provides a complete description of all outsourcing and offshoring activities. These definitions should be used by all countries participating in the global software market, not just the United States.

The US Department of Labor should gather data on layoffs that is more suited to measuring offshoring than the current Mass Layoffs Statistics data. Ideally, such data should be collected on a regular basis, but even a one-time special effort would be useful. Other countries should collect similar data.

The United States should improve the collection of data on imports and exports of services by country, following the guidelines recommended by the General Accounting Office (2004). Other countries should follow similar practices, and practices should be consistent from country to country.

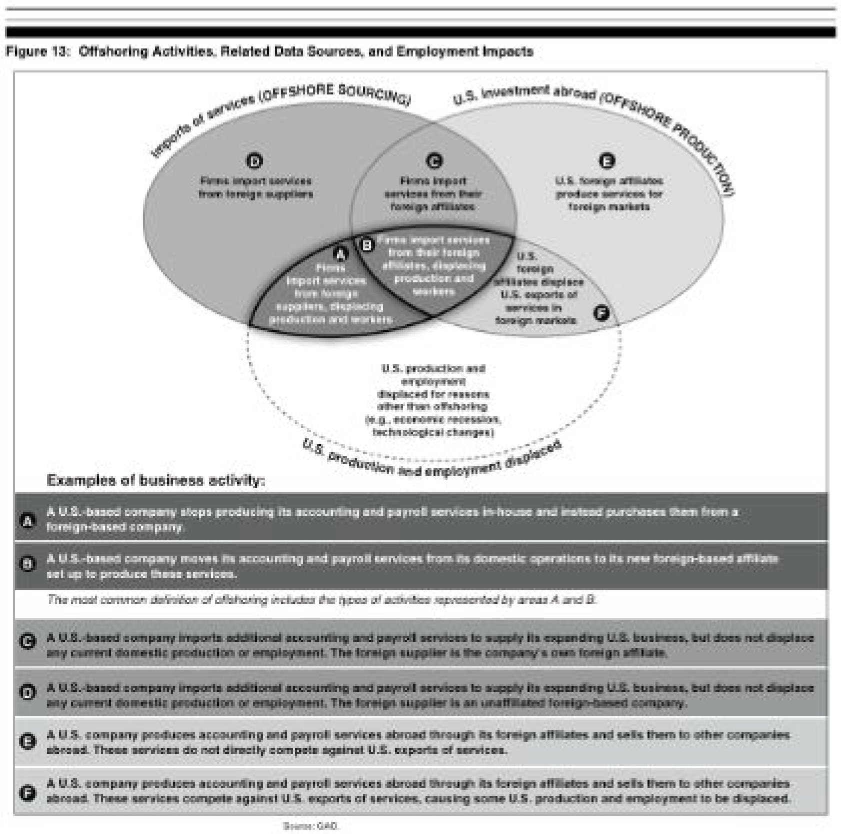
Data on direct investment abroad by source country and multinational company operations should be improved also following the recommendations of the GAO (2004).

R&D and design activities in low-wage countries should be tracked especially in affiliates of multinational firms.

All organizations, private as well as public, that are creating statistical information about offshoring should be transparent about their methods and assumptions.

Developing better current data and adopting standardized definitions should help to improve projections of offshoring. We are not sanguine, however, about the likelihood of developing good projections any time soon. In the United States, the BLS has been modestly successful in developing ten-year occupational projections, but projecting the size and effects of offshoring appears to be more difficult.

Figure 2-2



2.4 Bibliography

Alpert, A. and Auyer, J. 2003. Evaluating the 1988-2000 Employment Projections. *Monthly Labor Review* (Oct.) 13-37.

Amicus MSF. 2004. Back to the Future as Call Centres Go Same Way as Manufacturing. London, UK.

Associated Press 2005. 400K+ High-Tech Jobs Lost. (Sept. 15) Seattle, WA. (As reproduced on *CBSNEWS.com* April 4, 2005.)

Atkinson, R. 2004. Understanding the Offshoring Challenge. *Progressive Policy Institute* (May).

Bajpai, N., Sacks, J.D., Arora, R., and Khurana, H. 2004. Global Services Sourcing: Issues of Cost and Quality. Center on Globalization and Sustainable Development. *Working Paper No. 16. Columbia University, New York, NY.*

Bardhan, A.D. and Kroll, C.A. 2003. The New Wave of Outsourcing. *Fisher Center for Real Estate and Urban Economics, University of California*, Berkeley, CA. (Fall).

Bartsch, E. 2004. Germany: Offshoring – More a Myth Than a Matter? *Morgan Stanley Global Economic Forum* (Aug.). www.morganstanley.com/GEFdata/digests/20040804-wed.html and www.morganstanley.com/GEFdata/digests/20040805-thu.html.

Bednarzik, R.W. 2005. Restructuring Information Technology: Is Offshoring a Concern? *Monthly Labor Review* (Aug.) 11-21.

Bhagwati, P. and Sriniviasan, T.N. 2004. The Muddle Over Outsourcing. *Journal of Economic Perspectives, 18*, 4, 93-114.

Bishop, J.H. and Carter, S.D. 1991. How Accurate Are Recent BLS Occupational Projections? *Monthly Labor Review* (Oct.) 37-43.

BIVENS, J., 2004. Will the New International Division of White-Collar Work Make the U.S. Rich? *ACM Job Migration Task Force Meeting* (Dec.) Washington, DC. www.epinet.org.

Bronfenbrenner, K. and Luce, S. 2004. The Changing Nature of Corporate Global Restructuring: The Impact of Production Shifts on Jobs in the US, China, and Around the Globe. *Corporate Restructuring and Global Capital Mobility* (Oct.).

Business Week Online. 2005. Just the Bright Side, Thanks. (Oct. 17). http://www.businessweek.com/magazine/content/05_42/c3955025.htm#ZZZ24WZQGEE.

Chatterjee, S. 2004. South Africa Seen as India's Rival in Outsourcing. *Indo-Asian News Service* (Nov. 21). (As appeared in Yahoo! India News, Nov. 28, 2004.)

Communications Workers Union. 2004. The Threat of Outsourcing UK Call Centre Jobs Offshore – the Current Situation and Future Developments. London, UK.

Cusumano, M. 1991. *Japan's Software Factories*. Oxford University Press.

Dossani, R. 2005. IT Services Offshoring to India: India's Position in the Supply Chain. *ACM Job Migration Task Force Meeting* (March) Palo Alto, CA.

Egger, H. and Egger, P. 2001. International Outsourcing and the Productivity of Low-skilled Labor in the EU. *WIFO (Australian Institute of Economic Research).* Working Paper 152. <http://publikationen.wifo.ac.at/pls/wifosite/wifosite.wifo_search.frameset?p_filename=WIFOWORKINGPAPERS/PRIVATE539 7/WP152.PDF>.

Egger, H. and Egger, P. 2003. Outsourcing and Skill-Specific Employment in a Small Economy: Austria after the Fall of the Iron Curtain. *Oxford Economic Papers 55,* 4, 625-643.

Egger, P., Pfaffermayr, M., and Wolfmayr-Schnitzer, Y. 2001. The International Fragmentation of Austrian Manufacturing: The Effects of Outsourcing on Productivity and Wages. *North American Journal of Economics and Finance 12*, 257-272.

Economic Policy Institute. 2004. Offshoring Frequently Asked Questions. (June). http://www.epi.org/content.cfm/issueguide_offshoring_faq.

Evalueserve. 2003. The Impact of Global Sourcing on the US Economy. (Oct. 9).

Evalueserve. 2003. Impact of Global Sourcing on the UK Economy 2003-2010.

Evalueserve. 2004. The Next Big Opportunity—Moving up the Value Chain from BPO to KPO. (July 13).

Evalueserve. 2004. Offshoring of IT Services—Present and Future. (July 13).

Farrell, D. 2004. Can Germany Win from Offshoring? *McKinsey Global Institute* (July).

Feenstra, R.C. and Hanson, G.H. 2001. Global Production Sharing and Rising Inequality: A Survey of Trade and Wages. *National Bureau of Economic Research*. Working Paper 8372.

Fielding, R. 2003. Enlarged EU to Attract Offshoring. *vnunet.com* (Oct. 3).

Freeman, P. and Aspray, W. 1999. The Supply of Informatic Technology Workers in the United States. *Computing Research Association.* Washington, DC.

Goldman Sachs. 2004. Offshoring by the Numbers (May). (As quoted in the Center for American Progress.) http://www.americanprogress.org/site/pp.asp?c=biJRJ8OVF&b=81289.

Gomory, R. E. and Baumol, W.J. 2000. *Global Trade and Conflicting National Interests*. MIT Press, Cambridge MA.

Gorg, H. and Hanley, A. 2004. International Outsourcing and Productivity: Evidence from Plant Level Data. *University of Nottingham.*

Gumbel, P. 2004. Au Revoir, Les Jobs,. *Time Europe* (Online edition, Oct. 3).

Huws, U. and Flecker, J. 2004. Asian Emergence: The World's Back Office? *Institute for Employment Studies*. Report 409. Brighton, UK.

Huws, U., Dahlmann, S., and Flecker, J. 2004. Outsourcing of ICT and Related Services in the EU. *European Foundation for the Improvement of Living and Working Conditions*. Dublin, Ireland. Available at www.eurofound.eu.int.

Kletzer, L. 2004. Trade-Related Job Loss and Wage Insurance: A Synthetic Review. *Review of International Economics 12,* 5 (Nov.).

Knapp, P. 2004. 1.2 Million European Jobs to Flee Offshore. *Brainbox.com.au* (Aug. 24).

Lamoreaux, N. and Sokoloff, K. 1996. Long-Term Change in the Organization of Inventive Activity. *Proceedings of the National Academy of Science 93*, 12686-12692.

Lamoreaux, N. and Sokoloff, K. 1997. Location and Technological Change in the American Glass Industry During the Late Nineteenth and Early Twentieth Centuries. *National Bureau of Economic Research.* Working Paper 5938. Cambridge MA.

Mariani, M. 2001. Next to Production or to Technological Clusters? The Economics and Management of R&D Location. *Journal of Management and Governance 6,* 2, 131-152.

Mann, C.L. 2003. Globalization of IT Services and White Collar Jobs: The Next Wave of Productivity Growth. *Institute of International Economics.* International Economics Policy Briefs 3-11 (Dec.).

Mann, C.L. 2004. What Global Sourcing Means for U.S. IT Workers and for the U.S. Economy. *Virtual Machines 2,* 5 (July/August).

Matlack, C., Kripalani, M., Fairlamb, D., Reed, S., Edmondson, G., and Reinhardt, A. Job Exports: Europe's Turn. *BusinessWeek Online* (April 19).

McCarthy, J.C. 2004. Near-Term Growth of Offshoring Accelerating. *Forrester Research* (May). http://www.forrester.com/Research/Document/Excerpt/0,7211,34426,00.html.

McDougall, P. 2004. Offshore Outsourcing Revenue Soaring at 20%-A-Year Pace. *Informationweek.com* (Oct. 16). http:www.Informationweek.com/story/ShowArticle.jhtml?articleID=50500438.

McDougal, P. 2005. Exclusive: Gartner Predicts Increase in Offshore Outsourcing by 2015. *CRN* (March). www.crn.com/sections/breakingnews/breakingnews.jhtml?articled=160400729.

McKinsey & Co. 2003. India Information Technology/Business Process Offshoring Case Summary. www.mckinsey.com/knowledge/mgi/newhorizons/reports/IT_BPO.asp.

McKinsey & Co. 2005. Can Germany Win From Offshoring? www.mckinsey.com/mgi/publications/germanoffshoring.asp.

Meta Group. 2004. Annual IT Staffing and Compensation Guide.

NASSCOM. 2004. Strategic Review 2004: The IT Industry in India (Feb.) New Delhi, India.

Pink, D.H. 2004. The New Face of the Silicon Age. *Wired* (Feb. 12).

Prism Economics and Analysis. 2004. Trends in the Offshoring of IT Jobs. *Software Human Resources Council*. Ottawa, Canada.

RIS. 2004. *European Foundation for the Improvement of Living and Working Conditions*. (Full citation in bibliography of World Investment Report 2004.)

Roland Berger Strategy Consultants. 2004. Global Footprint Design: Mastering the Rules of International Value Creation. Munich, Germany.

Samuelson, P. 2004. Where Ricardo and Mill Rebut and Confirm Arguments of Mainstream Economists Supporting Globalization. *Journal of Economic Perspectives 18*, 3, 135-136.

Sasaki, T. 2004. Upgrading of IT Based Services: Trends, Challenges, and Policy Implications. *The UNCTAD-ASEAN Seminar on Service FDI and Competitiveness in Asia*. Kyoto, Japan. (March).

Scholl, R.S., Sinha, D., Datar, R., and Chohan, S. 2003. India Will Generate $13.8 Billion from Offshore BPO Exports in 2007. *Gartner Dataquest Report* (June) Stamford, CT.

Seeley, R. 2003. Report: 150,000 U.S. Software Jobs Lost Last Year. *ADTmag.com* (Dec. 2).

Sutthiphisal, D. 2004. The Geography of Invention in High- and Low-Technology Industries: Evidence from the Second Industrial Revolution. *UCLA*, Department of Economics. Working paper.

TurkishPress.com. 2004. World on Brink of Surge in Offshore Provision of Services: U.N. (Sept. 22).

United Nations Conference on Trade and Development. 2004. The Offshoring of Corporate Service Functions: The Next Global Shift? World Investment Report 2004 (Chapter 4). *United Nations*, New York, NY and Geneva, Switzerland.

U.S. Government Accountabillity Office. 2004. International Trade: Current Government Data Provide Limited Insight into Offshoring of Services. GAO-04-932, (Sept.).

Van Breek, Y. 2005. Offshoring a Top Priority for European CEOs. *The Conference Board*. 2005. (Online publicity for The Conference Board, Report 1353-04-RR. CEO Challenge 2004.)

Wagstyl, S. 2004. Budapest, the Next Bangalore? New EU Members Join the Outsourcing Race. *The Financial Times* (Sept. 21). (As reprinted in YaleGlobal Online.)

Yuan, L. 2005. Chinese Companies Vie for a Role in U.S. IT Outsourcing. *Wall Street Journal Online* (April 5).

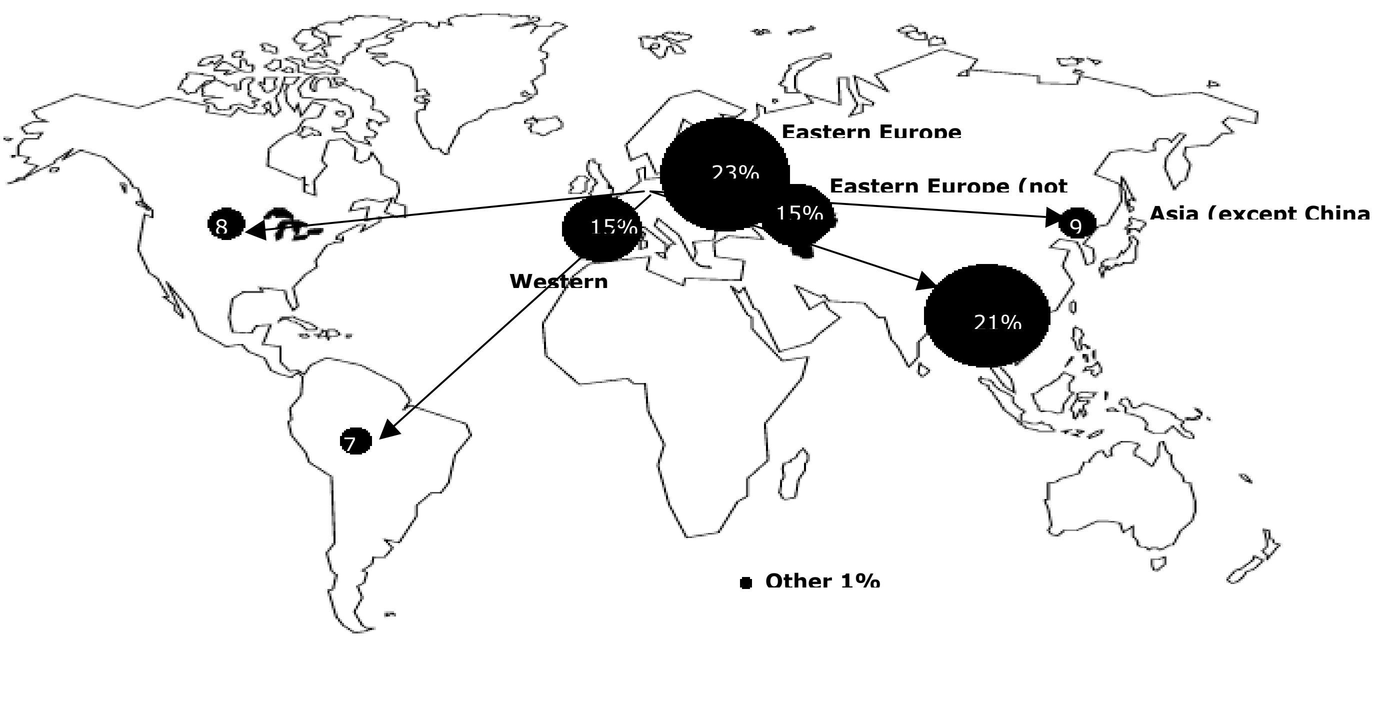
Authors: Govindasamy Balatchandirane, Michael Blasgen*, Arndt Bode, Charles H. House, Martin Kenney*, Vivek Mansingh, Goran Marklund, Bankim Shah, Takashi Umezawa

Chapter 3: The Country Perspective

3.1 Introduction

This chapter examines the development and current status of the largest and most dynamic nations in the evolving global software market with particular attention given to offshoring. The focus is on software services and to a lesser extent on software products. In particular, the chapter examines three pairs of regions that have special offshoring relationships with one another: the United States and India, Japan and China, and Western Europe and Eastern Europe/Russia. The selection of these three pairs is not meant to argue that there are not other linkages, for example, between Western Europe and India; there are. Western Europe is not monolithic in its offshoring patterns; it has different geographical patterns, largely based on language capabilities. For example, the United Kingdom sends its offshore work primarily to India, whereas Germany has strong relationships with both Eastern Europe/Russia and India (see Figure 1). Thus the portrayal here of national/regional pairs of offshoring partners, while representing some important aspects of the global software industry, is clearly a simplification of an extremely complicated map of offshoring.

Figure 3-1. Outsourcing from Germany



Source: Compilation from various newspaper articles by Martin Wildemann 2005:19

The decision to focus on only these regions and nations means that we omit some countries that are active in the global trade in software. In particular, we touch only briefly on Ireland and Israel who were among the earliest countries to enter the global market.

*M. Blasgen and M. Kenney took a leadership position in the writing of Chapter 3.

Although their software export markets are significant, they are relatively small and are not expected to grow much especially in comparison, for instance, to India or China. Ireland and Israel also do not appear to have a major effect on the global division of software labor.

We also omit many nations that have smaller software services export businesses such as the Philippines and Mexico. Mexico, which in 2003 is estimated to have exported $30 million of software and software services (Singh 2003), is discussed in Chapter 4 through an examination of one of its leading software export firms, Softtek. Mexico's limited amount of software services exports is typical of many developing nations. Rather than listing all of the nations and the size of their industries (see some data on this topic in Chapter 2), this chapter focuses on the most important ones, but suggests that they are not unusual, just indicative of the larger pattern of globalization.

Offshoring has a long history and continues to evolve. National IT industries and international supplier-customer relationships are part of a co-evolutionary process involving many parties. Factors include government support, education, infrastructure, telecommunications policy, finance, and even national perceptions. These factors interact and gradually produce an environment more or less favorable to accepting relocated work. This is exemplified in the case of China and its manufacturing sector where a sophisticated manufacturing support infrastructure evolved over the past two decades to facilitate the manufacturing of goods for export. In the case of India, higher educational institutions, infrastructure, labor force, and government policies have evolved in a way that encourage and support the production of IT services for the global economy. Each of the nations and international relationships examined in this section is a product of similar co-evolution.

For firms, the decision of whether and where to offshore a certain business function involves a complex calculation that balances a variety of concerns that include labor force availability, government policy, factor costs, various kinds of risk, and comfort level with the location. For each of these nations, this chapter examines both their past experiences with offshoring and their current situation. We also consider their prospects for future growth.

3.2 The History of Software Offshoring

The origins of software offshoring are difficult to determine because large multinationals such as IBM have long had overseas R&D facilities that were conducting software development for the company's global operations at the same time that they were undertaking localization work for their domestic markets. The nations that first emerged as software development sites for the global economy, that is, not for the domestic market, were Israel and Ireland. Notice the distinction made here between undertaking software development for the domestic market, which includes localization and even some development based on unique features of the local market such as different accounting or legal systems, as opposed to producing for the external market. Production for the local market can displace jobs for workers in high-wage countries. However, it is unremarkable that localization would be undertaken in the local market where knowledge of the language and the specifics of the business culture and legal environment are the greatest. With respect to job loss, there is far greater concern about the displacement of labor by a nation producing for another nation's market than for its own.

The United States is the overwhelming leader in the world software industry as the home to such firms as Accenture, IBM, Microsoft, and Oracle. The only firms that rival these giants are SAP (headquartered in Germany) in packaged software and Siemens Business Systems (Germany) and Cap Gemini (France) in software services. Siemens Business Systems is losing money and may be sold.

Let us turn briefly to the small economies, Ireland and Israel, which pioneered software and software services production for the global economy. The Israeli IT industry first emerged in the late 1960s through an excellent educational system, military research, a strong relationship to the United States based on geopolitics, and investment by multinationals (de Fontenay and Carmel 2004). In the 1980s, Israelis began to found new technology firms, many of which specialized in packaged software especially for security. These Israeli firms often had cutting-edge technologies and, as part of their life cycle, very soon established operations in the United States. The most successful of them listed their stock on NASDAQ. Many of these firms were successful, but because of the small size of the Israeli software industry their success is unlikely to lead to a massive relocation of employment from the developed nations to Israel. The total Israeli employment in IT services, including software, was 92,000 in 2000 or approximately 4 percent of the total Israeli workforce (de Fontenay and Carmel 2004, 43). The Israeli Export and International Cooperation Institute (2005) reports Israel as having 13,000 software professionals in 2002, down from an all-time high of 14,500 in 2000. Whichever number is correct, Israel has a much smaller software workforce than larger nations, though it is unusually large in terms of the percentage of its own population. Even if Israel were to double its IT services employment to an unheard of 8 percent of its workforce – amounting to some 200,000 employees – it would still be less than one-third the size of India's 697,000 employees in software and software-related services. Israel's niche in the global software industry is as a center of entrepreneurship at the highest technological level. It draws upon the technical expertise of a highly trained workforce, and its startups almost immediately enter the US market by forming an offshore office.

Another early location for software offshoring was Ireland. In the 1990s, both Irish indigenous firms and multinationals rapidly increased their software-related activities in Ireland. For the multinationals, Ireland was a convenient low-cost, English-speaking nation that had strong European language skills. The multinationals adopted Ireland as an offshore platform for Europe. In 2000, the total number of employees in the Irish software and computer services firms, counting both indigenous and multinational firms, was 30,000 (Arora et. al. 2004). It is difficult to fully reconcile the various statistics as O'Riain (2004) believes that in 1999 there were over 50,000 employed in the software industry. The larger number may be misleading because O'Riain finds that the multinational firms that make up approximately two-thirds of total software industry employment include among their activities disk reproduction, packaging, language localization for Europe, and porting (O'Riain 2004).

Ireland's software industry includes two kinds of companies. There are some indigenous firms that produce packaged products, although they have not been as successful as the strongest Israeli firms. Ireland is also a packaging and localization platform for foreign, particularly US, multinationals supplying the European market. Ireland has experienced robust growth in its software industry but, like Israel, the global impact has been limited. Recently, the Irish press has expressed concern that India might be a threat to the growth of the employment in the Irish software industry (Weckler 2004).

Israel and Ireland were pioneers in entering the global software business without a significant home market. Israel's entry was at the high end of the industry, both in terms of multinationals operating there and the local entrepreneurship. Because Israeli firms quickly built strong business units in the United States, they are often treated as being the same as US firms. In fact, the growth of a successful Israeli firm often occurs as much in the United States as in Israel. In the Irish software industry, startups have produced software for the world market but they typically remain small players, while multinationals located there are fixed on one aspect of the global market, meeting the multinational's localization needs for the European market. The software industry is a significant economic contributor to Ireland even though it remains quite small in global terms.

Due to their small size and strong relationships with the rest of the developed world, the Israeli and Irish software industries were successful without disrupting the software industries in other nations. Wages in Israel and Ireland were slightly lower than the markets they serviced, primarily the United States and Europe. Israel competed not on cost, but instead on the high quality of its workforce. Ireland had a wage advantage and special subsidies from the European Union but operated on only a small scale. What these two countries showed was that a nation that did not have a large local market could nevertheless perform software work at a distance from the final market if it had a skilled workforce and access to good telecommunications infrastructure.

The next set of entrants could disrupt existing software industries. The largest and most sophisticated of these national entrants was India. By the late 1990s, software programming was no longer a skill that was highly concentrated in the developing nations. People in low-income nations could afford an increasingly powerful personal computer and had access to inexpensive, high-capacity data communications networks. Not surprisingly, these countries could and did begin offering programming services in the global economy.

Today, it is possible to benefit from labor cost savings for programming services from a large number of developing nations. Although the pattern is peppered with many exceptions, there is a global division of labor emerging with India serving the English-language market, Eastern Europe and Russia serving Western Europe, and China serving Japan. Developing nations around the world have been eager to capture the wealth and jobs associated with software offshoring.

From the inception of the computer industry in the 1950s, the United States was not only the leading center for software but also defined the global software environment because of its technology leadership, enormous market, and massive investment in IT R&D. Other national markets were, for all intents and purposes, local markets having their own software firms that were always under threat from being submerged by global firms. If local firms wanted to expand significantly, then the US market was critical to their success. This was something the Israeli firms understood from their inception. For this reason, the first two nations to be discussed are the United States and its principal offshoring destination, India.

3.3 The United States

US-based companies continue to dominate the software and services industry. Of the roughly $285 billion in total revenues of the global industry in 2004, only about $50 billion was generated by non-US companies.[1] [2]

History of the US Software and Software Services Industry

From the inception of the modern computer industry, the United States has been the leader in both the hardware and software industries. The United States has also been the source of many of the software standards such as Windows, Microsoft Office, and Unix,

[1] This was calculated from the 2004 SoftwareMag.com *Global Software 500* ranking.

[2] This accounts for only the traded software and software services. So, for example, if a firm writes software internally for only Internal use, then this is not included because it is untraded. This is an enormous category and is likely to be even greater than the amount traded. Chapter 4 examines firms that have large internal software operations whose work is being offshored even though it is not traded.

providing US firms with an important first-mover advantage.[3] Although today some might dispute US leadership in hardware due to the growth of East Asian producers, few would dispute US leadership in software and software services. Software and software services as an independent business has been practiced in the United States for more than fifty years, since the founding of the computer services firm Automatic Data Processing (ADP) in 1949. Computer Usage Corporation (CUC), founded in 1955, was the first company formed specifically to provide software development services to computer users. Its first project was a program written for a customer to simulate the flow of oil. Computer Sciences Corporation (CSC), founded in 1959, is now a $10 billion company. EDS, one of the most important computer services firms, was founded in 1962. Since then, thousands of companies that provide software and software services have been formed.

The growth of independent software and services firms was assisted by the decision by IBM in 1969 to unbundle its application software and tools from its hardware. IBM did not unbundle its operating systems from the hardware; the control system was included in every product IBM sold for many years after 1969. By 1969, there were already approximately 2,800 independent software product and services firms, and they had combined revenue of $600 million (Steinmueller 1996). At the same time the software and software services industry was emerging, large firms, especially in the financial and defense sectors of the economy, were introducing computers into their operations and building internal software competencies. For most firms, the building of internal IT expertise was both a potential competitive advantage and a necessity because computers were becoming key devices for managing the increasingly complex corporate operations they made possible. By the end of the 1960s, the combination of government funding of engineering and computer science research in the open university environment, early adoption by sophisticated lead users, and the United States' role as the largest economy and market in the world meant that the United States gained what appeared to be an insurmountable lead in the software arena.

The US software and services industry was affected by other developments as well. Drops in prices of semiconductors and data storage, driven in part by Moore's law, led to continuous price-performance increases in computers. The big mainframe of the 1960s was complemented by the arrival of the minicomputer in the 1970s and the personal computer in the early 1980s. The PC drove the cost of a computer down to a level that permitted an installed base of millions of computers, not the hundreds of computers of the 1950s or the thousands of the 1960s. This growth in the installed base was accompanied by a huge growth in the demand for packaged software for these computers. The early independent software companies developed applications and later computer tools. Originally the operating system software was provided by the hardware vendors (IBM, Digital Equipment, and others), but in recent years, independent software houses have emerged that also develop operating systems. (For a discussion, see Baldwin and Clark 2000).

The introduction of a commoditized personal computer in the 1980s and the spread of the Internet in the mid-1990s led to the creation of many new US companies, not only companies such as Netscape, providing software to facilitate the use of the Internet, but also the service and shopping companies such as Yahoo! and Priceline.com. The market leaders, for instance, Google, Yahoo, Amazon, and eBay, weathered the dot-com stock collapse beginning in 2000, and, in the process, they have transformed the way business is conducted.

---

[3] It is possible that the relative strength of US firms might eventually be eroded by widespread adoption of open source software.

US firms benefited the most from the new business models and software that drove the Internet, and these firms continue to be globally dominant. They were created from the research and private sector capabilities that were uniquely resident in the United States (Kenney 2003). The dot-com crash led to severe employment loss in the IT/software sector. It was also a watershed event for the global software industry. During the height of the boom, US companies could not find enough US workers and sought extra capacity from overseas, especially Indian workers (both imported to work in the United States and working in India). After the crash, the role of the Indian workers was more as a replacement than a supplement to US workers. The Internet has also contributed to creating a more global labor market, making it easier to access technical talent in any location with good telecommunications linkages.

The Current Situation for US Companies in Software and Services

As mentioned earlier, US firms receive about 80% of the revenue available in software and services. Of the top fifteen firms in this industry, only four – SAP (Germany), Hitachi (Japan), CapGemini (France), and NTT (Japan) - are not from the United States, and these firms occupy the bottom rungs of the top 15.

In 2004, US firms made up 16 of the top 20 packaged software firms when measured by revenue. All of these firms have factories, development labs, and sales scattered across the globe. But where is the employment? Of the approximately 595,000 workers in packaged software, the United States employs 50 percent of the total global employment, while US firms sell 84 percent of the packaged software purchased globally (McKinsey Global Institute 2005).

US firms have been remarkably successful. For example, Microsoft's fiscal year 2005 profits of over $12 billion were comparable to the $12 billion in fiscal year 2005 revenue of the entire Indian software and services export industry. Microsoft's profit was also approximately equal to the sales of the largest European firm, SAP. IBM's software and services revenues in 2004 were in excess of $61 billion. The point is that US packaged software firms, by any measure, are still globally dominant. In terms of influence, the importance of this dominance is even greater than simply sales; the United States is the global hotspot for packaged software.

The McKinsey Global Institute (2005) reports that US jobs in the packaged software industry are at risk of being offshored. McKinsey finds that 60 to 78 percent of the jobs at risk are professional engineers and associated middle-level managers, that is, the heart of the packaged software industry. Other occupational groups in the packaged software industry have lesser but very significant numbers of jobs at risk. As shown in Table 2, it is exactly in the more highly educated employment categories that US firms are recruiting actively in India and, to a lesser degree, in China. Notice that the position announcements are not confined to low-end college graduates but also include doctoral-level positions for sophisticated development projects. The beginnings of this process can be seen in Table 1 which shows the number of employees the software and software services firms currently have in India. In every case, these numbers are increasing at double-digit rates.

Table 3-1: Indian Employment by Non-Indian Software and Software Services Firms

	Nationality	Services only	Employment in India (date)	Global Employment*	% in India	Locations
Oracle	U.S.		6,900 (2004)	41,658	16.6	Bangalore, Hyderabad
Microsoft	U.S.		1,250 (2004)	57,000	2.2	Bangalore, Hyderabad
SAP	Germany		2,000 (2005)	38,802	5.2	Bangalore
IBM[4]	U.S.		23,000 (2005)	369,277	6.2	Bangalore, Delhi**, Kolkota, Pune, Hyderabad
HP	U.S.	Yes	15,000 (2004)	150,000	10	Bangalore
Veritas	U.S.		900 (2004)	17,250	5.2	Pune
Adobe	U.S.		500 (2005)	3,142	15.9	Delhi
Symantec	U.S.		0 (2005)	5,300	0	n/a
EDS	U.S.	Yes	2,400 (2004)	117,000	2.1	Chennai, Delhi, Mumbai, Pune
Dassault Sys	France		0	4,088	0	n/a
Cap Gemini	France	Yes	2,000 (2004)	59,324	3.4	Mumbai, Bangalore
Siemens Bus Sys	Germany	Yes	4,000 (2004)	36,000	11.1	Bangalore
Getronics	Netherlands	Yes	n/a	28,000		
Atos-Origin	France	Yes	750 (2004)	46,583	1.5	Mumbai
Tietoenator	Finland	Yes	120 (2005)	14,000	.9	Pune

** Hoover's 2004*

***Delhi includes Noida and Gurgaon which are suburbs in other states*

All bolded firms include large non-software based employment
Source: Internet searches

---

[4] This includes the 6,000 BPO employees when IBM acquired Daksh and also includes those working for the domestic market.

The United States leads in software services as well as in packaged software, and this lead in services is also attributable in part to the early software development in the United States. The United States is the largest single software services market in the world, accounting for approximately 41 percent ($198.6 billion) of a total 2004 global market of $484.3 billion (McKinsey Global Institute 2005). US vendors are the global leaders in the global software services industry (11 of the Top 20 globally are headquartered in the United States) with IBM Global Services at 2004 sales of $46 billion by far the largest. Software services employment in the United States is approximately 1.7 million, of which 42 percent are engineers (McKinsey Global Institute 2005). In other words, software services is a large industry and the United States supplies about 32 percent of the total global workforce (McKinsey Global Institute 2005: 158).

The occupational categories in IT services that McKinsey finds most amenable to offshoring are software and hardware engineers and associated middle-level managers, of which 47 to 56 percent could be offshored. Analysts working on software/IT architecture or market research are similarly vulnerable (45 to 55 percent). It is in software services where the most aggressive competition from Indian vendors is to be found, and where the US leaders, such as IBM, Accenture, and Hewlett Packard, are rapidly increasing their offshore and particularly Indian presence.

One can expect the number of available jobs, job tenure, and wages throughout the software and service-related industries to be pressured by offshoring during the next decade. This pressure will also be felt in the internal IT shops across all industries as management considers options ranging from establishing offshore subsidiaries to outsourcing the work to either a US firm operating abroad or an Indian firm. Routine software production and services work appears to be increasingly susceptible to offshoring.

Conclusion on the United States

During the past five decades the dominance of the US industry has been a given. What is changing is where the work will be undertaken. What has been an enormous export to the world and a well-paid source of employment for technically well-trained Americans is now in question as sufficiently well-trained individuals in much lower-wage nations are becoming participants in the global economy and will be competing for those jobs. As Chapter 7 on education discusses in greater detail, the US higher education system will have to address the question of what their students should learn to prepare for these changes. At the national level, there has been a dramatic underinvestment in engineering education and research over the last two decades,[5] and the recent decisions by the federal government to reallocate research funds from universities to industry will further weaken engineering. This is likely to contribute to an erosion of the cutting-edge research that makes the United States a desirable place to undertake software innovation and development and which has made the US high-technology industry a global leader.

3.4 India[6]

Software services have become India's largest export, and the emergence of India as a source of software service exports is attracting great attention in the developed world. India has only recently attracted attention for its software service exports despite the fact that

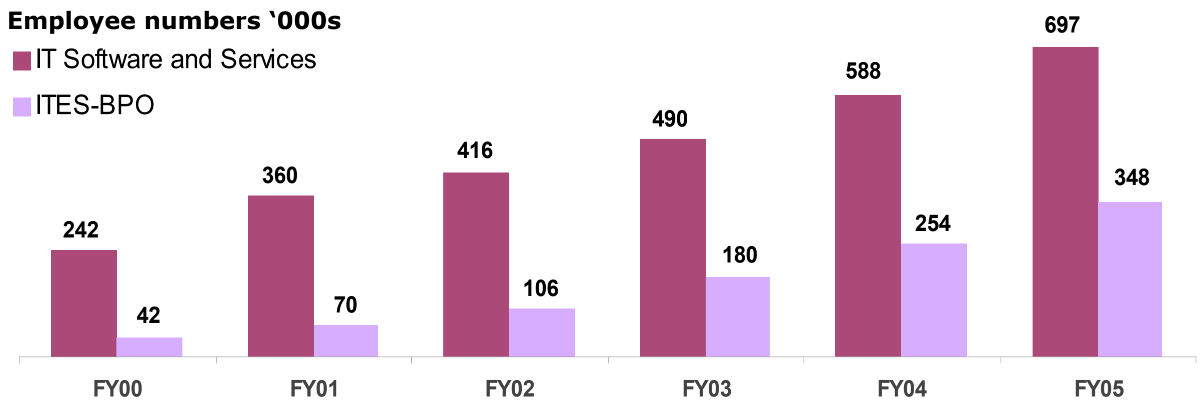
---

[5] For example, since 1970, U.S. federal spending in physical science research declined as a percentage of Gross Domestic Product - an indicator as the rate of investment relative to
growth in the economy - from just under 1% of GPD to .5% in 2004.
Source: http://www.aaas.org/spp/rd/disc04tb.pdf

[6] This section draws heavily upon Dossani (forthcoming 2006).

the industry has grown relatively steadily for three decades. Employment reached 697,000 (approximately 50% working for the domestic market) at the end of March 2005 (see Figure 2), a growth of 19.8 percent from the year earlier (Nasscom 2005). If the industry grows at 20 percent per year in 2005-2006, then the number of employees added in India would be the equivalent of all the software workers in Ireland and Israel combined. India is emerging as the single most important destination of software services offshoring.

Figure 3-2: Employment in the Indian Software Services and ITES-BPO Sector



Source: NASSCOM

As a large developing nation, India has many shortcomings including high rates of poverty, corruption, and illiteracy; a substandard infrastructure; excess government regulation; and various other problems typical of a poor nation. These obstacles are offset by a number of strengths especially for software and services production. It has a long history of producing capable mathematicians. It has a large population with adequate English language capability. There is a large cadre of Indian managerial and technical professionals working in North American and, to a lesser degree, in European high-technology occupations and organizations. For those who can afford it, India has a strong and highly competitive K-12 educational system emphasizing science and mathematics. Although India has a democratic socialist tradition with high levels of bureaucracy and over-regulation, it does have a market economy. These are all advantage that India has over China in establishing a software services industry.

History of IT in India

The roots of India's entry into the global IT industry can be traced to its initial highly protectionist regulatory environment (Heeks 1996). As in many other nations, India's national policymakers focused on manufacturing. Protected from the global market and with a domestic orientation, Indian hardware producers never became global competitors. Because US firms established facilities in East Asia and homegrown Japanese, Korean, and Taiwanese firms became subcontractors and later producers, the IT hardware industry became concentrated in East Asia. Eventually, Taiwan emerged as the center for PC assembly and India became largely irrelevant for electronics manufacturing (Dedrick and Kraemer 1998).

The Indian software industry was established to serve the local market. Prior to the decision in 1969 by IBM to unbundle its software from its hardware that spurred the growth of an independent software industry, the only private Indian software firm was Tata Consultancy Services (TCS) which had been established in 1968 to serve the in-house data-processing needs of the Tata Group. Using a Burroughs mainframe, TCS began offering electronic data processing services to outside clients and also became Burroughs' exclusive India sales agent in 1970. India's first exports occurred in 1974 when Burroughs, recognizing the competence and cost advantage of the TCS personnel, asked TCS to install its system software at the offices of its US customers (Ramadorai 2003 quoted in Dossani 2006). Aware of the profitability of providing such contracts, other domestic firms were formed to offer similar services. Sending these programmers overseas to work on the client's premises became a common phenomenon, and was pejoratively known as body-shopping.

Factors Contributing to Bangalore, India as a Principal Site of Offshoring

Bangalore is considered by most observers to be the hub of the Indian IT industry. In fact, the United Nations Human Development Report has ranked Bangalore as a global hub of technological innovation. The city of Bangalore is the largest employer of software professionals in India, employing about 160,000 people in the technology sector of which IT services accounts for 100,000 employees, with the remainder in business process outsourcing and call centers.

***The general context.* Bangalore has had a number of advantageous events, some historical and some recent, that have contributed to the rapid development of its IT industry. These include the IT boom of the 1990s and the subsequent world demand for IT products and services, the rapidly falling price of hardware, the technological progress that enabled ever larger volumes of data to be copied onto disks of the same physical size, the explosion of the Internet and the rapid reduction in costs of sending data, the liberalization of the Indian economy in the 1990s, and the Y2K problem which came at the right time and showed that Indian IT professionals could deliver.**

***High-tech center.* From 1945, when Nehru became the prime minister, Bangalore was considered to be the science city of India. The state of Karnataka, of which Bangalore is the capital, is home to a large number of engineering colleges that provide a steady supply of highly educated, skilled workers for the IT industry. Bangalore also is the home to a number of large public and private sector organizations that employ many specialized skilled personnel working in high technology occupations. Though these organizations, such as the Indian Space Research Organization (ISRO), the Hindustan Aeronauticals Limited (HAL), Bharat Electronics, and Indian Telecom industries (ITI), are located in Bangalore and were important for creating the technology-oriented environment, they have not provided large numbers of technical personnel to the IT industry (D'Costa and Sridharan 2003). Among Indians, Bangalore has a reputation as the technology capital, though other cities such as Pune and Hyderabad are intent upon challenging this perception.**

***Local government policy incentives.* Policy liberalization was the tool used by the Karnataka state government to create the environment that facilitated the growth of the software industry. In the early 1980s, state officials made their first move which was to establish a Software Export Processing Zone in Bangalore. Since then the state government has acted to promote the industry's growth in many ways such as providing preferential treatment on land allocation, provisioning electrical supply, and (until recently) providing a better infrastructure than most other Indian cities. These incentives reduced the costs of setting up and operating an IT company. (See Chapter 8 and later in this chapter for a discussion of the**

national policy environment.)

Telecommunications infrastructure. **Texas Instruments had set up an office in Bangalore in 1984 and petitioned the Indian Government for permission to lease a 64k line to be used for transferring data from India to the United States. The Indian Government, both at the national and state levels, was worried what would happen if they provided a 64k line to a foreign company, and it took three years for them to approve the petition. Connectivity was through a local telephone exchange in Bangalore that connected to the government-owned long distance monopoly, BSNL. Service quality remained an issue.**

By the early 1990s, both Western and Indian firms were demanding better connectivity. Understanding the difficulties that business experienced when interacting with the government bureaucracy, the government established the Software Technology Parks of India (STPI). This organization was given permission to provide last-mile connectivity, establish free trade zone status parks, and generally facilitate the export software business. Bangalore was the first STPI and has continued to be the most successful. STPI solved the connectivity problem in Bangalore by installing a satellite dish antenna on its property (more recently replaced by fiber optic cable). Despite the liberalization of telecommunications in the late 1990s which led to drastically improved telecommunications service and lower cost, there remains a role today for STPI Bangalore that now serves at least 1300 companies.

Bangalore's rise to prominence was due to a confluence of factors. It was endowed with an excellent climate, a large pool of universities and governmental research institutions, and a relatively robust physical infrastructure. In the 1980s, it attracted US high-technology firms, such as Texas Instruments and Hewlett Packard, to establish operations there by offering them international telecommunications bandwidth. When these operations were successful, they had a demonstration effect that attracted other multinationals. Significant political support at the state government level ensured that the growth of the IT industry was facilitated. These factors combined to make Bangalore the leading IT center in India.

The Indian scene changed in 1978 when IBM decided to withdraw from India, following the passage of a law imposing joint ownership on all foreign subsidiaries. With IBM's withdrawal, the government formed and operated its own software firm, CMC. Though CMC proved to be only moderately successful,[7] it was in software and IT services that India would become globally competitive. At the time, the Indian firms did little more than recruiting, while an overseas intermediary secured the contract and the overseas client decided on the work for the programmers who were sent to the client's site. The initial focus of this body shopping was on systems installation and maintenance. Later, the conversion of clients' existing applications software into (primarily) IBM-compatible versions began, but this still operated on the basis of sending Indian workers to the client's premises. By 1980, the Indian industry earned $4 million in export revenue, shared between 21 firms, of which TCS and a sister firm (Tata Infotech) accounted for 63 percent (Heeks 1996).

At the beginning of the 1980s, the Indian software industry was small, but it was earning much needed foreign exchange. To encourage the growth of the IT industry and recognizing India's economic difficulties and foreign exchange shortages, Prime Minister Rajiv Gandhi's

---

[7] TCS purchased CMC in 2001.

new government liberalized IT imports in 1984 through the New Computer Policy. Import duties on hardware were reduced from 135 to 60 percent and on software from 100 to 60 percent. The software business was recognized as an industry, making it eligible for loans from commercial banks. It was also delicensed, that is, permits were no longer needed to enter the business. Delicensing was very significant because government licenses were required in most of the Indian economy. Given that most sectors of the Indian economy were off limits to new entrants, entrepreneurial energies were drawn toward deregulated sectors. In addition to creating space for new Indian entrants, wholly-owned foreign firms producing software for export were once more allowed, though on a licensed basis.

Electronics export processing zones were expanded to include software. TCS located in the first of these that was opened in Mumbai in 1973. Rentals in the zones were set below market levels and procedures to establish a business were simplified; power and water were guaranteed. Most importantly, in 1985, all export revenue from these zones was exempted from income tax (an exemption that is scheduled to end in 2007). These favorable policies encouraged additional entrants.

These privileges, particularly the tax exemption, had a significant effect on the structure of the Indian industry by making the domestic market comparatively less attractive; the combination of a tax exemption and foreign currency earnings was irresistible. Thus the Indian software industry was built on satisfying foreign demand for software services, not products. India was on the verge of bankruptcy during the entire period, and the rapid growth of the software industry and the fact that it was generating much needed foreign reserves meant that the government developed a strong interest in encouraging its growth. An important initiative to encourage growth was the creation in 1990 of the Software Technology Parks of India system which was authorized to further simplify procedures and enable exporters to import equipment against their export dollars without licensing or customs tariffs.

These liberalizations were providentially timed because they coincided with an important technical change in the software world, namely, the replacement of mainframes by workstations that generally used the Unix operating system and C programming language and were commonly linked together in a local area network (Dossani 2006). The adoption of workstations as a work platform facilitated a gradual shift in the location of work from the customer's premises to remote production in India. Further, the adoption of these standards generated work for Indian firms in converting clients' installed applications into Unix-compatible programs. The growth of this activity contributed to an increase in the number of Indian firms from 35 to 700 by 1990 (Heeks 1996).

Even as the Unix-workstation standard became more prevalent, a number of multinationals, including Texas Instruments, Hewlett Packard, and Digital Equipment Corporation, opened wholly-owned subsidiaries in Bangalore to take advantage of low-cost, high-quality Indian programmers to do various kinds of software-related development work. As part of the recruitment package, the government agreed to supply them with then scarce satellite bandwidth. Not much later, a few global banks with long-established Indian operations, notably Citibank, also began producing custom software in India. By 1990, Indian custom software developers were responsible for over 80 percent of all software exports.

Despite obstacles, the Indian software industry grew and accumulated a number of competencies. In 1991, the Indian government launched another wave of deregulation. There were 700 firms, including several multinationals, operating in India at the time. Most of these firms were small by international standards. The two Tata companies, TCS and Tata Infotech, continued to dominate the industry capturing 48 percent of total revenue. Most firms usually had just one client and so were vulnerable to that client's fortunes and disposition. Two-thirds of the typical firm's exports were to a single US client (Heeks 1996).

By the 1990s, the Indian government had become cognizant of the growing significance of software exports and the need to encourage this one bright spot in a bleak industrial climate. It now accepted that the industry required input from abroad. After the earlier rollback of duties, by 1991 the duties on software had again risen to 110 percent. In 1993, they were reduced to 85 percent; in 1994, they were further reduced to 20 percent for applications software and 65 percent for systems software; and, in 1995, to 10 percent for all software (Heeks 1996). Hardware duties ranged from 40 to 55 percent in 1995, but by 2000 had been lowered to 15 percent for finished goods such as computers, and eliminated entirely for components.

The global software business was also changing as revenues in custom software overtook product software. The custom software business was driven by the increasing size of software programs that firms were using for their internal operations. Growing demand, coupled with a shortage of US programmers, provided opportunities for the Indian IT industry to offer its services. The Indian industry focused primarily on assisting in the writing of the enormous software programs that were used inside large firms to control their various business functions.

Indian sales efforts were handicapped by government regulations preventing them from investing foreign exchange abroad. In the early 1990s, legislation was passed that allowed firms to invest foreign exchange earned from exporting in order to establish offices overseas. Previously, the Indian firms had only learned about their client's needs from their programming staffs on contract overseas, supplemented by occasional senior staff visits to the United States (and occasionally to other high-wage countries) and client visits to India. Operating a foreign office strengthened relationships with existing clients and provided access to mid-sized firms. Some firms established dedicated centers at customers' sites (Dossani 2006). At that same time, the Indian government changed its regulations to allow multinational firms to establish wholly-owned subsidiaries.

The Indian industry continued to evolve and find new software work. One important opportunity was the Year 2000 (Y2K) problem that became a serious issue in 1998. In itself, Y2K business was not so attractive as it was mostly unsophisticated work done at the client's site, but the Y2K business was important in other ways. It introduced additional foreign companies to the abilities of Indian firms and programmers, thereby expanding the Indian firm's potential customer base and increasing awareness of India as a destination for software work. Y2K prompted many firms to replace their legacy systems with standardized software platforms such as Oracle and SAP. This meant that Indians could train on global standard platforms and receive globally recognized certifications, raising client confidence.

The Current Status of the Software Industry in India

The Indian software and software services industry has experienced remarkable growth over the last thirty years. The Indian software services industry is based on the use of global software platforms and thus must purchase software licenses from foreign vendors. There is little available data on Indian software imports, however. Heeks (1996) cites Dataquest reports that in 1994-95 these imports were in excess of $96 million, and they have almost certainly grown many times over as the Indian software industry came to operate on standard platforms provided by US-based multinationals such as Computer Associates, Microsoft, and Oracle. To provide some idea of the number of software-capable people there are in India, according to Oracle (2005), India is the home to more than 220,000 members of its 3-million-strong online developer community, Oracle Technology Network.

Though this study concentrates on software offshoring, today not only software but also a great range of services are being offshored to lower-wage-cost environments (Dossani and Kenney 2003). Major software firms such as IBM, Microsoft, Oracle, SAP, and Veritas have relocated work to India. Because of the way the data is reported, it is impossible to separate the software work from the back office operations. However, as Table 1 indicates, a number of these firms have large workforces in India. In the case of Oracle and Adobe, approximately 16 percent of their global employment is now in India, and the number continues to grow. Other major software firms, all of whose Indian facilities were established far later than Adobe and Oracle, are also growing rapidly.

One myth about offshore facilities for multinationals is that their employment is limited to relatively low-skilled programmers. In February 2005, Oracle was advertising for 199 positions in its two facilities in India. Approximately 30 percent of these positions were for workers with Masters or Ph.D. degrees. Microsoft, newer in India, had a relatively less highly skilled recruitment profile, but they, too, were recruiting highly credentialed workers (See Table 2). Hiring such qualified employees, these Indian firms are likely to be capable of innovation in the future.

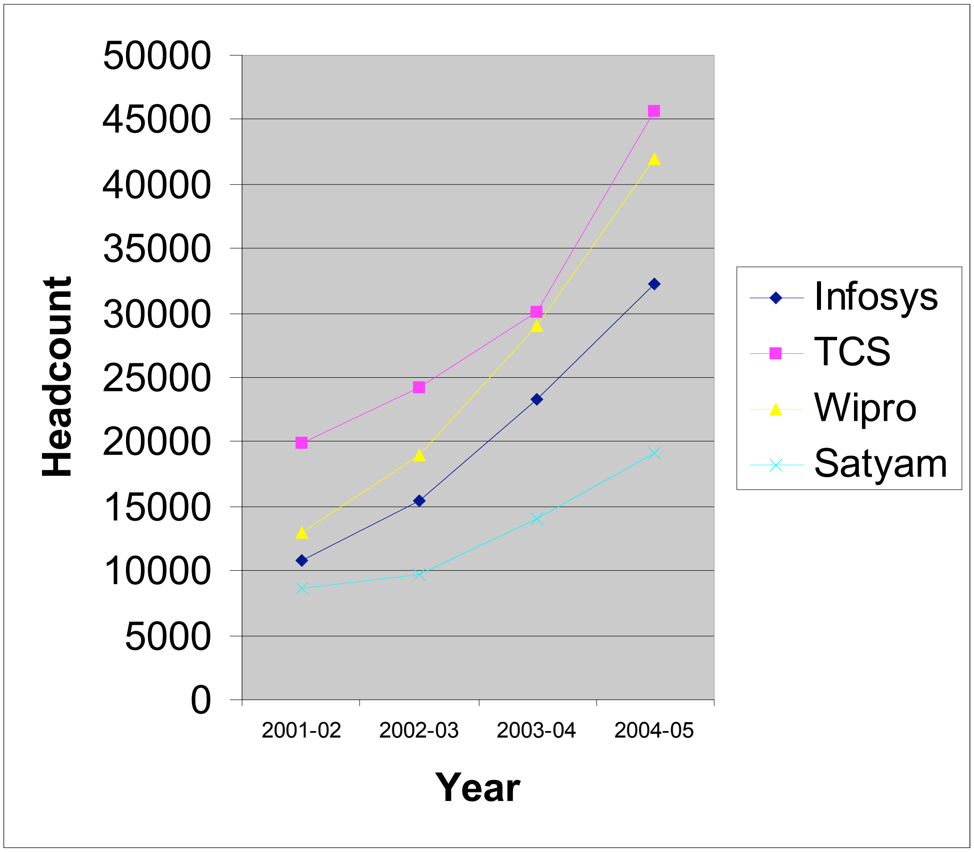
Table 3-2: Educational Requirement Posted for Job Openings for Microsoft in India and China by Highest Degree (Feb. 2005)

			MICROSOFT			
	None	**Technical**	**Bachelors**	**Masters**	**PhD**	**Total**
Beijing	2	0	0	1	0	3
Bangalore	2	0	13	5	0	20
Hyderabad	17	3	57	14	3	94

Source: Martin Kenney's compilation from various corporate websites (2005)

Like the multinational software firms operating in India, the Indian-owned software services firms are growing rapidly. They offer their services on outsourced software projects. As Figure 3 indicates, the major firms are large. Headcount at TCS and at Wipro, another major Indian firm, have already crossed 40,000 and are continuing to grow at 20-25 percent per year (CAGR). The stock market believes in these companies and places much higher values on them than on comparable US firms (Hira and Hira 2005).

Figure 3-3: Total Headcount at Major Indian Software Firms by Year

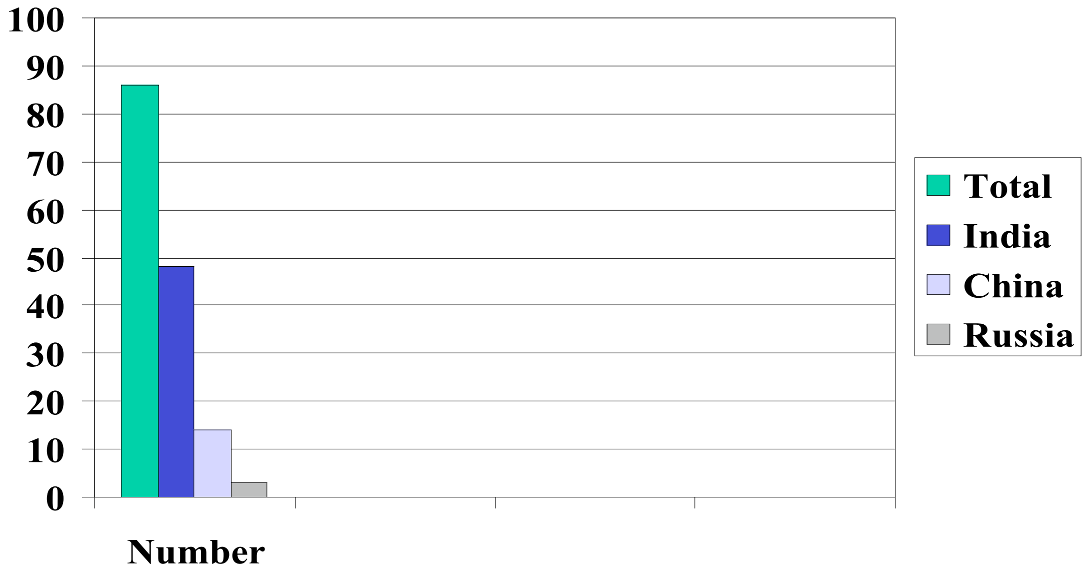


Source: Heng 2005:7, Compiled by Martin Kenney from corporate sources

The prices offered by Indian firms place enormous pressure on management in developed-nation firms to decrease costs so as to remain competitive. This resolves itself into a single issue, namely, getting costs per employee down. The way to do this is to move work to India or some other low-wage country. However, as Table 1 shows, many firms such as EDS, IBM, SAP, and Cap Gemini have relatively low percentages of their workforce located in India. From the of competitiveness perspective, this is no longer viable, and their Indian headcount is expected to increase significantly over the next few years.

There is significant evidence that a movement to higher value-added activities is occurring in both the Indian firms and the multinationals. In an Internet survey of the Top 86 U.S. software firms as identified by Software Magazine and conducted in December 2004, 48 firms had R&D facilities in India, while 14 had facilities in China, and only three were present in Russia (see Figure 4). There is also significant anecdotal evidence that US software startups are establishing facilities in India to save money and increase their headcount at low cost. (For further discussion, see Chapter 4.) This may have an indirect impact on the future growth of US software employment.

Figure 3-4: Number of R&D Operations in India, China, and Russia Operated by Top 86 U.S. Software Firms



Source: Internet searches by Martin Kenney

The Future of the Indian Industry

The Indian software industry is likely to grow in scale, scope, and value-added ability. There is little reason to believe that offshoring as a process will end in the foreseeable future, but it could slow down. The enormous investment by leading software multinationals will expand the number of Indian project managers with global-class managerial skills. This, plus the relocation of portions of startup firms to India, is likely to result in greater levels of entrepreneurship and enable firms to sell their skills on the global market at global prices. As a generalization, it is safe to say that this has not yet occurred, though I-flex, a former Citibank custom software firm recently purchased by Oracle, is now selling proprietary packages around the world (I-flex 2005). Other Indian independent firms may soon follow.

The offshoring of IT services and software for export will dominate the near future of the Indian software industry. There are several possible trajectories. Custom projects could become more complex and large, leading Indian software professionals to move from programming into systems integration, systems specification and design. The average size of projects Indian firms are undertaking has grown from 5 person-years in 1991 to 20 in 2003 (Krishnan 2003). As multinationals deepen their Indian operations, domain skills will develop in India so that managed services are likely to become more important. This will match global trends in the outsourcing of applications management and business processes.

Despite the fact that India's software production for the US market exceeds that of any other nation, it holds only a small share of the global market for all software value-added work. The only part of the software value chain in which India has made substantial inroads is in applications development where it has captured 16.4 percent of the world market. But applications development is only approximately 5 percent of the entire global software services market (see Table 3). This implies that there is much room for growth.

Table 3-3: India's Share in Various Sectors of the Software Services Industry (2003)

	Global software services spending ($ bn)	Indian software services export revenues ($ bn)	Indian service constituents by percentage (%)	Indian global market share of services (%)
Consulting	41.5	0.11	1.9	< 1
Applications Development	18.4	3.02	54.5	16.4
Managed services	124.9	1.94	35.0	1.6
System Integration: Hardware/Software Deployment and Support	91.7	0.37	6.7	< 1
System Integration: Applications, tools and O/S	62.4	0.10	1.8	< 1
IT education and training	18.5	0	0	0
Total	357.6	5.54	100	
Product software	200	1.66		<1

Source: Dossani from Nasscom 2004, p. 36 and 106. Indian figures are for 12 months ending March 2003. Indian figures do not include product development and design of $ 0.56 bn and embedded software of $1.1 bn.

The Indian software and software services industries are booming. In 2004-2005, the entire software and services industry grew at 18.5 percent and reached an all-time high of $16.8 billion of which $4.8 billion was in the domestic market. The export earnings increased at an annual rate of 30.4 percent from $11.2 billion in 2003-04 to $12.0 billion in 2004-05 (Nasscom 2005). All projections for 2005-06 indicate that it will be yet another banner year.

A key issue for India is the future of applications development in the value chain. Applications development may become commoditized just as systems maintenance has, either due to automation or the development of products that are as good as custom applications. Applications development has been losing global market share to consulting and is slipping down the value chain. However, since information is a source of competitive advantage, it is unlikely that customized application work will disappear altogether. In order to grow, the Indian industry will have to shift to more complex activities by securing larger projects, undertaking engineering services, integrating and managing services, or bidding on projects that include transforming a client's entire work process.

Increasing the value-added and IP components of Indian software services is difficult. For example, Cognizant CEO Narayanan argued that India did not yet have the capability to develop intellectual property, pointing out that R&D's contribution to overall growth is minuscule, and multinationals generally use their Indian R&D operations to upgrade existing products, not develop new ones (Economist 2004). Sarnoff India head, Satyam Cherukuri, argues that India has two of the three requirements for innovation, technical skills and access to capital, but lacks an "indigenous business model" (Economist 2004; D'Costa 2003).

Despite the assertion of many, it is plausible to argue that there is a significant entrepreneurial movement emerging in India. It could be said that there have been two clear waves of entrepreneurship already. The first was the establishment of firms such as Infosys, HCL, and Hexaware who created body-shopping businesses that evolved into the offshore programming model. Though entrepreneurial in genesis, they were pure labor-cost arbitrageurs. More recently, that situation may be changing.

The second wave of entrepreneurs consists of a few startups that are producing their own IP and marketing it globally. One of the most successful is I-Flex which was established by Indian executives who spun out of Citicorp's Indian software subsidiary. I-Flex developed a banking software package that is now being used by more than 50 medium-sized banks around the world. Today, there are only a few other examples, but given that an increasing number of Indian managers and researchers are acquiring experience in the Indian R&D laboratories operated by US firms, there is the potential for more of these startups.

Software offshoring to India is likely to grow not only through the continued growth of indigenous Indian firms, but also because foreign software firms feel compelled to increase their employment in India in product development and particularly in software services. Including not only software and software services but also other services, Accenture hired 1,600 employees in May 2005 in India and has announced that it will be hiring 50,000 more workers in India, China, and the Philippines in the next three years. IBM, which had 6,070 employees in India in 2002, saw the number rise to 24,150 in 2004. The company has a target of raising this number to 38,196 in 2005, an addition of 14,000 employees in just one year. CapGemini India plans to grow to 10,000 employees by 2007. Large multinationals, such as IBM and CapGemini, are competing with Infosys, Wipro, and TCS for offshore supremacy. As Indian companies move to global markets in their quest to expand the offshore model, these large multinationals are moving to low-cost destinations, taking the big Indian firms head on. The Indian firms are likely to face tough competition in the near future.

The cost advantage in India may diminish as labor costs increase and the rupee appreciates against the US dollar. However, interviews conducted by Rafiq Dossani and Martin Kenney indicated that costs were generally increasing rapidly only for experienced managers (15 to 20 percent per annum), while wages for beginning college graduates were increasing more gradually (5 to 10 percent per annum) (Private communication, 2005). Today, the cost of an Indian college graduate is $6,000-7,000 per year, while a US graduate is in excess of $40,000 per year. In addition to wage costs increasing among the more experienced managers, there is a generalized phenomenon of high turnover due to a supply-constrained labor market. This turnover affects projects and may have a detrimental effect on capability development both at the individual and corporate level.

There is much discussion of the high quality of the Indian IT labor force, but this may be deceiving. NASSCOM indicates that only about 27 percent of the employees in the Indian IT industry have an undergraduate or graduate degree in computer sciences or electrical engineering. In spite of India having 247 universities and 11,549 colleges in 1997, only 7 percent of the student-age population attends a university (Nasscom 2005). India has 0.3 scientists and technicians per 1000 population, ranking 42 out of 62 countries as ranked by the World Bank in 1998, below China at 1.3 (ranked 25th) and Ireland at 2.0 (ranked 20th). This lack of highly educated workers may slow India's advance into higher value-added sectors of the software industry.

Despite much improvement in the value-added per employee, India continues to trail the United States in this regard. In India, revenue per employee in software services has risen from $16,000 in 1990 to $33,000 in 2003. However, this is far behind the US average of $142,000. This differential suggests that US workers are still more productive than those in India, probably because a significant portion of the US revenue is in software products where revenue per employee is much higher than in software services.

Improvement of the value-added per employee will require a continued upgrading of the Indian workforce. The leading Indian software firms are investing in their workforces, but there is only so much training an individual firm can undertake particularly in the high turnover environment that characterizes the Indian labor market. Thus much of the responsibility falls on the central government which is the main financier of tertiary education. While India has greatly expanded the university system, problems with quality appear to have deterred enrollment.

The interaction between university and industry is minimal. There are few academic-industrial research partnerships as well as few consultancy assignments for faculty in industry. On campus, little independent research is undertaken. Until recently, faculty (even at the Indian Institutes of Technology (IITs)) have not been expected or funded to do research. Only in 2005 did the Indian government appropriate $250 million to establish a National Science Foundation. For example, at IIT Delhi, the value of sponsored research and consultancy assignments in 1998 was only $4.5 million (Parthasarathi and Joseph 2002). Faculty salaries are low, and NASSCOM concluded, "Over the years, there has been a general decline in the quality of faculty in Indian universities" (Nasscom 2002). The average number of citations over a five-year period for a faculty member at the Indian Institutes of Technology is less than three. This compares with 45 per faculty member at MIT and 52 per faculty member at Stanford University (Nasscom 2002). The country produces only 300 master's degree graduates and 25 Ph.D.s in computer sciences each year, compared with US numbers of 10,000 and 800, respectively. (For more information on the Indian educational system, see Chapter 7.)

The Indian subsidiaries of multinationals are perhaps even more important than the independent Indian firms. The reason is that the multinationals are more willing to undertake high value-added activities such as software product development within their own captive firm in India than they are to send the work to an Indian independent firm. It is within these subsidiaries where the highest value-added activities, such as globally directed research and development, take place. For at least the medium term, India should be able to retain its position of primacy for software offshoring from the English-language world. In the longer term, unless India makes an even greater effort to upgrade its universities and the technical capabilities of their graduates, China may become an important alternative destination.

3.5 China

China is one of the fastest growing economies in the world and is now the seventh largest economy in the world in terms of gross domestic product and the second largest economy in the world when the GDP is corrected by purchasing power parity. During the last two decades, it has become a manufacturing powerhouse. In 2004, the United States had a $162 billion trade deficit with China, the largest trade deficit with any single nation in US history.[8]

---

[8] These statistics can be found at

China manufactures a broad range of goods, including IT products such as personal computers, routers, monitors, cell phones, and handheld devices. The manufacturing of IT products in China is growing more rapidly than China's overall industry. From 1990 to 1999, the Chinese IT industry grew at a rate of 32 percent per annum (Dong 2004). From 2002 to 2003, sales increased at approximately 34 percent to reach $235 billion, and China became the third largest IT equipment producer in the world (STAT-USA 2004). IT exports continue to grow rapidly. For example, in the first seven months of 2003, China exported $80.6 billion, representing approximately 50 percent of its total production (China Venture Capital Research Institute 2004). The strength of the Chinese IT hardware industry is shown by the purchase in 2005 of IBM’s PC division by Lenovo. There is ample reason to believe that China may soon become the largest IT product exporter in the world.

China and IT Software and Services

Much less is known about the Chinese software industry than is known about the Indian software industry. The Chinese IT and software and service industries (ITSS) do not appear to be having an important impact on the global economy, though as we shall discuss later in the section on Japan, there are Chinese ITSS exports, and they are expanding rapidly but from a far smaller base than in the case of India. According to the Chinese Software Industry Association, there are 300,000 workers employed in over 6,000 firms, of which approximately 160,000 are software professionals, approximately 25 per firm (Tschang and Xue 2005, 133). According to the Ministry of Commerce, the revenues of the Chinese ITSS industry increased from $7.17 billion in 2000 to $19.35 billion in 2003. During the same period, software exports increased from $250 million to $2 billion in 2003 (China Software Industry Association 2005). A recent report (Krishnadas 2005), notes that China's IT services revenues are rising but are barely half of India's $12.7 billion. Growth is driven by internal demand, and exports make up only 10 percent of total annual software service revenues. The Chinese Software Industry Association indicates that 60 percent of Chinese software exports in 2003 went to Japan and another 21 percent went to Southeast Asia to nations using Chinese characters (Liu 2004).

Despite the impressive growth, the Chinese software export industry faces many obstacles. It is extremely fragmented, and few firms are capable of undertaking large projects (Krishnadas 2005). As of 2003, only six Chinese firms had received certification through the Carnegie Mellon Software Engineering Institute's Capability Maturity Model Integration, and most of these had not achieved CMMI Maturity Level 3 (China Venture Capital Research Institute 2004). In contrast, all top 30 Indian software outsourcing firms had already received CMMI Maturity Level 5 (Krishnadas 2005).

Given China's role as a manufacturing center for the global economy, many manufactured products it exports contain embedded software. Programmers preparing embedded software often need to work closely with designers and manufacturers, and there is some evidence that a portion of this work may be relocated to China (Linden and Brown 2005).[9] At the moment, there are no estimates of the size of this market, but it could be significant.

The Chinese firms providing IT services to Western nations vary by size, but most are relatively small. There are Chinese firms offering offshore software services for the US market. At this point, the Indian firms dwarf them but, over the longer term, Chinese firms

---

http://en.wikipedia.org/wiki/List_of_countries_by_GDP_%28nominal%29;
http://en.wikipedia.org/wiki/List_of_countries_by_GDP_(PPP);
http://www.economywatch.com/world_economy/china/;
http://www.census.gov/foreign-trade/statistics/highlights/top/top0412.html#total.

[9] India also is developing a strong embedded software design capability, both at the multinational and Indian firms.

may provide competition to India in providing service to US businesses. A number of the large Indian software offshoring firms have established subsidiaries in China for the purpose of capturing business in China and servicing the Asia-Pacific market. Meanwhile, the Chinese networking equipment firm, Huawei, employs nearly 800 engineers in India and has announced plans to increase the number of engineers to 2,000 by 2006 (Press Trust of India 2005). Although the outsourcing relationship between China and India remains tiny, given the growth both nations are experiencing, it is possible that they could eventually become significant.

In contrast to India where exporting is the goal of both the India independents and the multinationals, much of the IT and software services growth in China is in the domestic market. Multinationals have developed large operations bent on localizing their products and software for the Chinese market. China is the largest developing country market in the world, and, for certain products, it is rapidly becoming one of the overall largest markets in the world. Many foreign goods must be localized to meet the special requirements of the Chinese market. For this reason, China is becoming an increasingly important location for R&D facilities in a wide variety of industries, including software and electronics (Zedtwitz 2004). In an effort to tap the Chinese market and utilize Chinese production prowess, a number of US software firms as well as US, European, and particularly Taiwanese electronics firms have established R&D facilities in China. The Shanghai area is an important stronghold not only for computer machinery assembly, but also for semiconductor manufacturing and, on a slower track, semiconductor design (Reuters 2005). Most of these operations are geared to adapting products for the local market or doing production engineering; however, some are developing global product mandates or are doing research for the firm's global operations. One of the most celebrated of these is the Microsoft research laboratory in Beijing which as of November 2004 employed approximately 170 scientists and planned to add 80 more (Heim 2003). According to Huang (2004), "more than 70 technologies developed [there] are already used in Microsoft products, including software for Windows operating systems and graphics packages for X-box video games. More of the lab's latest software is slated for the next version of Windows due out in 2006." Global software leaders such as SAP, Oracle, and Adobe are also establishing or expanding their Chinese operations.

Given the general economic growth in China, the Chinese market for software is expanding rapidly. Today, US packaged software firms are having some difficulty in the Chinese market due to uncompensated software copying. Though China has joined the World Trade Organization, it seems likely that these difficulties will continue. One possible answer to the uncompensated copying is the current Chinese effort to move to open source software (Marson 2005). Were this to come to fruition, it would dramatically decrease the problem of uncompensated copying, but it would also have a significant impact on the future prospects for growth of the US packaged software industry.

Conclusion on China

Given the past growth record, the apparent opportunities, and the importance given to the software industry by the Chinese government, the Chinese software industry is likely to continue growing more rapidly than the rest of the Chinese economy, and probably faster than the software industry in the rest of the world. In the short term, the Chinese software and software services exports are focused on Japan (see Section 3.6). In the long-term, China could possibly emerge as a competitor to India in the general software export market. More easily predicted is that China will become an enormous market. Given the relative paucity of data, it is difficult to predict when China will become one of the largest software markets in the world, but given the number of Internet and cell phone users, the rapid roll out of broadband networks, and the gadget orientation of Chinese consumers, it might happen quickly. However, it seems unlikely that Chinese firms will be able to compete with the major Indian IT and software services firms in the near-term.

3.6 Japan

The Japanese software and software services industry had sales of about $140 billion in 2004 and is the second largest single-country market in the world, accounting for 10.8 percent of the world's IT industry. Further, IT and software services is the fastest growing industry in Japan. In 2003, there were 5,482 information service companies employing 567,060 workers in Japan. Of these, technical positions included 240,096 system engineers, 114,479 programmers, and 7,398 researchers. The number of software engineers in all industries is about 800,000. Thus, more than 40 percent of software engineers are working in the information/service industry (JISA 2004a).

As Table 4 indicates, Japanese software imports were $2.9 billion in 2003.[10] The type of software imported is specific to the nation from which it was imported. The United States is the largest source of software imports, and it overwhelmingly provides system and applications software. In contrast, the imports to Japan from China and India are mainly custom software. Japan imported $102 million worth of custom software from China and $38 million from India. Japan also received $262 million in software services from China and another $63 million from India (Umezawa 2005a).

Table 3-4: Japanese Software Imports in 2003 (US$ millions)

	Basic Applications	**Applications**	**Custom**	**PC Games**	**IT Outsourcing**	**Total**
U.S.A.	686	1,874	47	6	49	2,606
China	1	1	102	0	262	104
Ireland	0	45	0	0	0	45
India	2	0	38	0	63	40
Australia	0	0	26	0	26	26
Others	6	27	43	0	91	76
Total	695	1,947		6		2,901

The Japanese software industry differs significantly from that of the United States. Outside of a few fields such as game software, Japanese software firms develop custom software for the Japanese market. Few Japanese companies produce packaged software products. For those firms that do prepare packages, their market is almost exclusively domestic, and the entire industry, not counting game software, exports only $93 million.[11]

---

[10] The true value of the imports is much larger because all major foreign software package firms have subsidiaries in Japan. For example, Microsoft's Asia-Pacific earnings in 2003 were $3.437 billion (Microsoft 2004), and Japan is as large as the other markets combined so Microsoft alone probably earned more than $1.5 billion in Japan.
[11] For further information on Japan and offshoring, see Umezawa (2002; 2005a; 2005b).

There is no authoritative data on offshore software development for the Japanese market. The most reliable data comes from surveys conducted by the Japan Information Service Association (JISA). According to Tsukazaki (2002), 19,000 foreign engineers were working in Japan in 2001, and, during that year, 3,943 foreigners acquired the status of engineer. Of these, 61.8 percent were estimated to be software engineers. In the JISA sample, Chinese professionals were by far the largest group represented, followed by Koreans, and a relatively small number of Indians.

The typical pattern in the past has been for Japanese firms to import Chinese or Indian software engineers to work on projects in Japan. This has changed because the cost of dispatching Chinese software engineers to Japan has increased to the point where it is no longer attractive (Umezawa 2002). The more typical pattern in 2005 is that a Japanese customer identifies a need for custom software and engages a Japanese software firm. The Japanese software firm then contracts with a Japanese subsidiary of a Chinese firm to have the work done either by Chinese programmers in Japan or, increasingly, by programmers located in China.

Another mode of offshoring has emerged in which Japanese firms invest in China to form a wholly-owned subsidiary or a joint venture with a Chinese firm. The most popular locations for Japanese firms to operate subsidiaries in China are Dalian and Beijing. The other mode of offshoring from Japan is for Western multinationals to move their programming and back office functions from Japan to a lower-cost environment in China. Dalian's software industry has grown (from a small base) at over 50 percent annually in sales volume and reached $544 million in revenues in 2003 (Xiong 2004).

Japanese firms, such as Fujitsu, NEC, Sharp, and Sanyo have subsidiaries to produce software in India. For example, through a publicly listed affiliate, Fujitsu (in 2005) employs more than 2,000 workers in its four facilities in Pune. It is difficult to establish whether these operations support the Japanese market or the English-language operations of Japanese firms. Despite great effort on the part of Indian vendors, with only a few exceptions, their sales in Japan have been small.

Impact on Japan of Offshoring

The impact on Japan of IT and software services offshoring is uncertain for two reasons. First, the software services offshoring phenomenon is recent so that patterns are not yet well established and data is scant. Second, Chinese vendors generally do not conduct business directly with their Japanese customers so the role of the Chinese company is somewhat obscured. There is typically an intermediary such as a Japanese software firm or a US or European-based multinational, that holds the contract with the Japanese client; the Chinese company is a subcontractor. The Japanese software firms have typically retained the higher value-added activities in Japan.

Actual sales are relatively small. While sales of the Japanese information services industry are $141.7 billion, the share offshored is $480 million or only 0.3 percent of the total sales (Umezawa 2005a). This may underestimate the total amount of offshoring because many multinationals operating in Japan have begun servicing the Japanese market from China or India. For example, in 2004 the US consultant firm, BearingPoint, established a development facility in Dalian with 60 employees, and it planned to increase employment to 1,000 “as soon as possible” (Thibideau 2004). Although Dalian has just begun to grow as a software offshoring center, Western multinationals there already include IBM, General Electric, Accenture, Dell, and SAP. Among the Japanese firms in Dalian are Sony, Matsushita Telecom, Mitsubishi, Toshiba, Nokia, Omron, CSK, Alpine, Furuno Softech, FTS, and Sino-Japan Engineering (Xinhua News Agency 2003). Despite this rapid growth, these operations are still not significant enough to have much impact on the Japanese economy.

The movement of Japanese software production to China is likely to continue. However, there seems to be a division of labor emerging with Japan undertaking the higher-end software development, while the Chinese subsidiaries and subcontractors undertake the more mundane coding functions. This is borne out in the China Venture Capital Research Institute (2004) assessment of the situation, "the export to Japan was mostly done in the form of outsourcing, just like traditional manufacturing, what was subcontracted to our country was only the development of lower-layer modules."

Conclusion on Japan

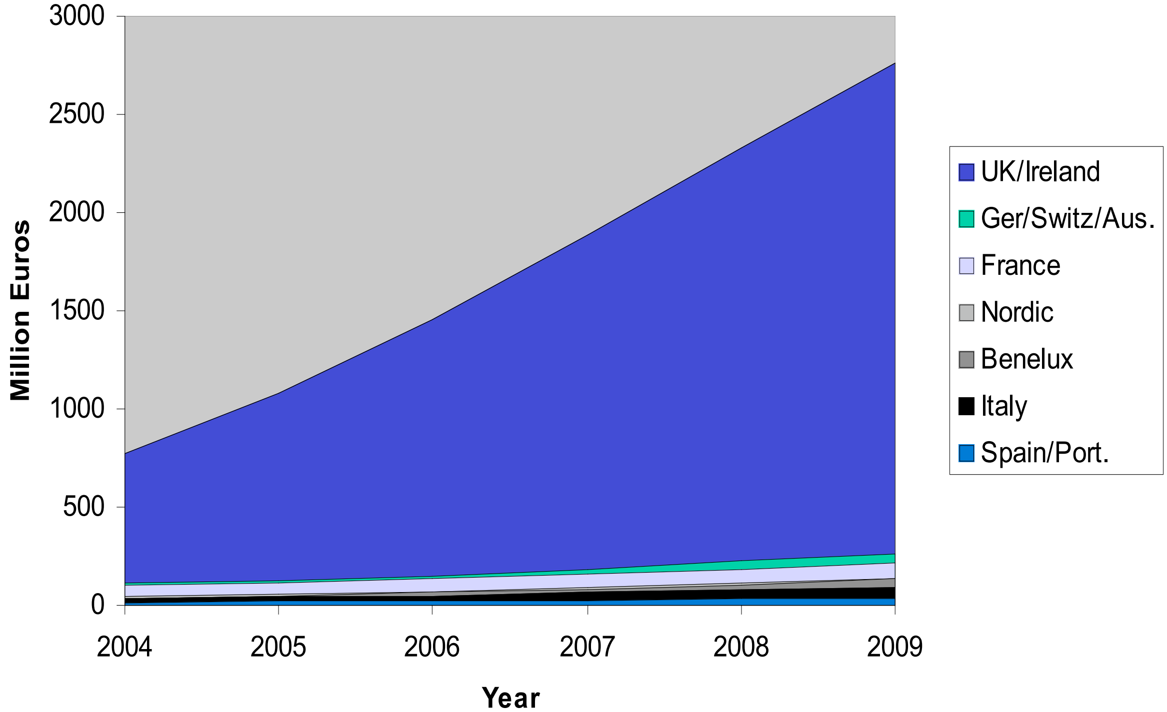
The amount of work offshored to China is likely to increase due to the increasing pressure to lower prices. Users are beginning to require that their Japanese vendors offer software development prices that assume offshore development in China. Given the strong linkages Japanese firms have with their customers, it is unlikely that Chinese firms will be able to establish direct relationships with Japanese customers. However, Japanese firms will be under pressure to reduce costs and thus will almost surely have to increase the scale of their Chinese operations or form alliances with Chinese firms. This suggests that Japan will not be immune to the pressure to offshore.

3.7 The European Union – Western and Eastern Europe

After the United States, the European Union as a whole is the second largest software market in the world. In 2004, Germany accounted for 8.1 percent (15.4 billion Euros), and the United Kingdom accounted for 7.1 percent (13.5 billion Euros) of the world software market (Heng 2005). This is much smaller than the US share of 44.5 percent (96.6 billion Euros). However, this statistic is somewhat misleading in that the Europe Union is not yet a single market but is rather a loose confederation of markets with different customs and languages. Europe has only one major software products firm (SAP). With the exception of SAP, US firms are dominant in Europe's packaged software market. Europe has no major software service firms. The European market for IT services is divided by national language differences. For example, Siemens Business Services is a leader in Germany, while Cap Gemini is a leader in France. The giant US software service providers, such as IBM, Hewlett Packard, and Accenture, play an important role in European markets where they usually face firms that are only significant in their home nation (see Table 3-1). The greatest European strengths are in software embedded in other products. Unfortunately, there are few statistics publicly available to gauge the size of the embedded software market.

The European Union has been slower to embrace offshoring than the United States. The United Kingdom was the first European country to do a sizable amount of offshoring, and it is responsible for almost two-thirds of the IT and service jobs offshored from the European Union (see Figure 3-5). Thirty percent of the jobs offshored come from Germany and Benelux, and there is a noticeable increase in interest in offshoring in the German-speaking nations recently. French, Italian, and Spanish firms have been more reluctant to send work offshore.

Figure 3-5: European Offshore Services Spending by Region



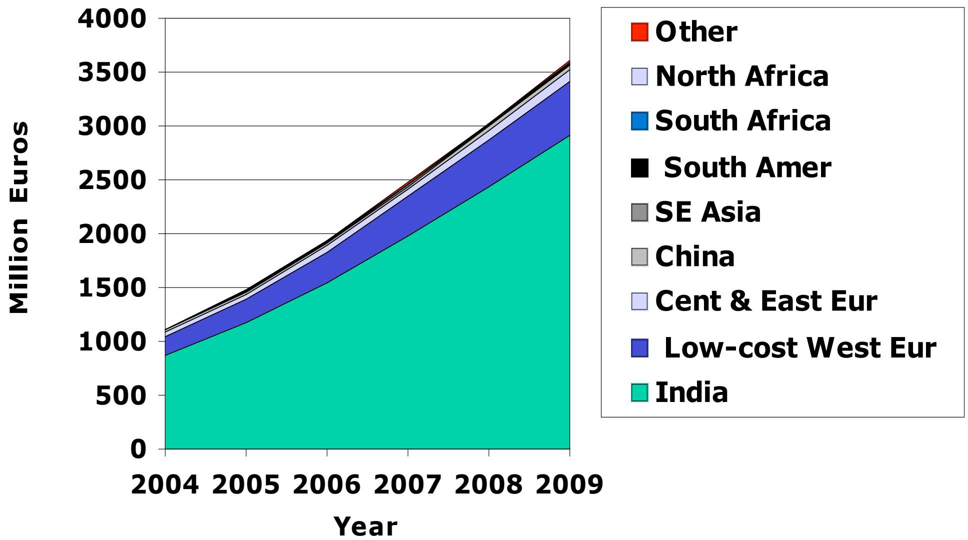
Source: Parker 2004

Cost pressures are driving Continental European software and software services firms to consider offshoring. According to a study by the consulting firm Roland Berger Strategy Consultants (2004) in which executives at 93 major European firms were interviewed, almost 40 percent of the firms have already relocated some services offshore, and 50 percent of all of the firms intended to offshore more activities. The firms already offshoring gave the strongest indication of willingness to offshore new functions in the future. There is anecdotal evidence that offshoring is increasing across Continental Europe. For example, in 2005, the Renault-Nissan alliance awarded IT services outsourcing contracts worth approximately $600 million to two US firms, Hewlett Packard and Computer Sciences Corporation, and the French firm Atos (Ovum 2005). With this outsourcing contract, much of the work will be transferred to lower-cost environments since all three of these firms have global operations.

Where the work is sent divides primarily along language lines. The United Kingdom sends most of its work to India, while the Western European nations speaking languages other than English are more likely to look to Eastern Europe. Due to the European Union's expansion into Eastern Europe, this is a natural near-shore location for the movement of services. A significant percentage of Eastern Europeans speak a Western European language such as German and, in the case of Estonia, Finnish. Hungary, Poland, and Romania are seen as prime sites for this nearshoring work.

Although many studies predict that Eastern Europe and Russia will receive much of the future offshoring work from Continental Europe, Figure 6 shows that, for Europe overall, the most attractive location by a considerable margin will continue to be India. India wins on price. For example, even though Romania is one of the lower-wage Eastern Europe destinations, it still has wages that are higher than those in India. India also wins on language and culture factors for the United Kingdom.

Figure 3-6: European Offshore Service Spending by Recipient Location



Source: Parker 2004

Germany provides an interesting case study. A sample of 93 major German industrial firms conducted by Horst Wildemann (2005) of the Technical University of Munich found that, of the firms that have offshored, 29 percent sent their work to Eastern Europe, while 46 percent went to India and China. R&D and administrative functions were areas that received considerable attention. This study also showed that the number of firms planning to offshore service functions is increasing and predicts that Germany could lose 152,000 jobs per year, for a total of 758,000 jobs potentially lost in the next five years. A recent study by A. T. Kearney (2004) predicts that by 2007 Germany will lose 130,000 jobs to offshoring. Although German labor unions have resisted offshoring, the state government of Bavaria is actively advising small and medium-sized enterprises on how to offshore their IT functions.

Cost reduction is the prime driver of this offshoring for German firms. According to the Roland Berger report (2004), the cost savings achieved through service offshoring were typically in the range of 20 percent to 40 percent with an average of almost 30 percent, which is similar to the results reported by Dossani and Kenney (2003) for US firms offshoring to India. The wage differential between Germany and Eastern Europe is significant. For example, in Germany, a systems engineer with a university degree and three years experience earns between 57,000 and 63,000 Euros per year, while a counterpart in Poland receives 15,000 to 18,000 Euros per year. Eastern Europe also has the advantage in that there are no time zone differences to complicate communication. Nevertheless, India and China are 50% less expensive than Eastern Europe which may be a determining factor is some offshoring destination decisions.

SAP and Globalization of the European Packaged Software Industry

SAP is the only major package software firm in Europe. Established by a group of former IBM Germany managers and headquartered in Walldorf, Germany, SAP had global sales of $9 billion in 2004. In keeping with its global reach, the company has internationalized its sales, support, and development operations, and staffing is growing in India in particular. The company employed approximately 32,000 people globally in 2004, including 13,500 workers in Germany, 5,000 in the United States, and 1,500 in India. SAP's operations in Bangalore are not only at the low end. For example, the Bangalore facility is developing software dealing with international taxation which will be sold globally. However, with the exception of SAP, it does not appear as though the European software industry will significantly increase its strength in packaged software and thus, in packaged software, it is unlikely that the employment offshored by the other software firms will be large.

Case Study: Siemens Business Services and Globalization of European Software Services

Siemens Business Services (SBS) is a Siemens subsidiary that does software and other outsourced production work on a global scale. It employs approximately 36,000 workers and has developed a strong business in helping companies to implement SAP software. Its 2004, revenues of 4.8 billion Euros came from Germany (48 percent), the rest of Europe (39 percent), the United States (8 percent), and the rest of the world (5 percent) (Siemens Business Services 2004). Like many other large service firms, SBS has been globalizing its service delivery operations and, in the process, downsizing its domestic workforce. Of the company's 36,100 global employees, only 15,100 are now located in Germany, and 4,000 are located in its rapidly growing Indian subsidiary.

SBS has developed a customer service strategy that uses a matrix of vertical industry knowledge and sets of general competencies. One aspect of the matrix is the industry expertise (vertical knowledge) concentrated in competency centers that are scattered across different nations. For example, the paper and pulp vertical center is located in Finland (Hallez 2004). The other part of the matrix involves general activities, which are located in offshore sites in Canada, Ireland, and Turkey to handle stabilized processes. India has two roles: it functions as a back office operation for finance and accounting, and it does general software programming and service and applications development for SAP programs. SBS uses Russia for very labor intensive and repetitive back office and software application development (Hallez 2004).

Conclusions on Europe

The European software industry and employment pattern is different from that of the United States with much software production done in-house and embedded in physical products. This does not prevent offshoring, and certainly many leading European industrial firms are establishing offshore facilities to produce embedded software. Much of this employment is subsumed under research and development and other activities such as application-specific integrated circuit design that are not directly relevant to this report.

Continental European firms continue to lag the Anglophone nations in sending software work across their borders. The Germanic and Nordic nations have only recently begun to build offshore software and software service delivery capabilities, but firms with global practices such as SAP, SBS, and others are moving rapidly to build their offshore capabilities in Eastern Europe, China, and India. The geography of European offshoring will be somewhat different from that of the United States in that Nordic and German firms will use Eastern Europe and Russia in addition to India. Those parts of Europe speaking a Romance language as the predominant language have been slower to begin offshoring. But now their major firms are sending work to Romania, Francophone Africa (particularly Morocco), and Latin America, in addition to India. There is no reason to believe that the pressures to offshore software-related work in these Romance-language countries will be substantially different from in the Anglophone nations. Given that US-based multinationals with strong global delivery capabilities, such as IBM, EDS, Hewlett Packard, and Accenture, are present and competitive in all European markets, there are cost and delivery pressures on companies throughout Europe to offshore, similar to the pressure on US firms. The only possible mediating factors that will make the European and US situations different are union and government opposition to offshoring in Europe. The most likely impact of this opposition is a delay in offshoring, not a change in the final outcome.

3.8 Russia

In Russia, the largest state formed out of the former USSR, software was traditionally a relatively neglected field outside the military. In the late 1980s, software comprised only 1.5 to 2 percent of the total outlays on computer systems, while the corresponding figure was 50 percent in the United States. At the time, there were reportedly few highly skilled professionals among the country's 500,000 programmers (Katkalo and Mowery 1996). In the 1990s, Russia began a transition to a market economy, and many skilled software engineers left the low-paid state enterprises, research institutions, and universities. They either emigrated or moved to multinationals or Russian startups. The greatest international product success of any of these companies was the computer game Tetris.

Large US and EU firms are active in Russia. Russia's advantage is that, as a legacy of the Soviet era, it has "more people working in R&D than any other country, and ranks third in the world for per capita number of scientists and engineers" (American Chamber of Commerce in Russia 2001). Russia's investments in education mean that it has a large stock of technically trained individuals. On the other hand, a recent Forrester report indicates "while [the number of programmers in Russia] has increased during the past two to three years, there is still less total development capacity than any of the large global system integrators can provide in the United States or Europe alone (Hoppermann and Parker 2004)". Even though Russia has trained technical personnel, the local software market is small and undeveloped compared to those in Western Europe and the United States. Russian firms have yet to play an important role in producing products or participating in global software services.

Offshore software development in Russia represents a small fraction of the worldwide offshoring headcount, although the number appears to be growing rapidly. Hawk and McHenry (2005) estimated that the Russian offshoring software industry generated revenues of between $200 and $450 million in 2003 and employed about 15,000 of the 70,000 programmers in Russia.[12] The stock of potential programmers, that is, those with some training in programming, may be as high as 200,000 and, in 2003 alone, there were approximately 68,000 new graduates in electrical or telecommunications engineering, computer science, mathematics, and physics (Hawk and McHenry 2005). Using the most liberal definition of programmers, that is, college graduates from all disciplines who might

---

[12] In 2001, the American Chamber of Commerce in Russia (ACCR 2001) estimated that there were 5,000 to 8,000 professional programmers in Russia doing $60 to $80 million per year.

be capable of programming, it has been estimated that Russia could have graduated as many as 225,000 in 2003 (Hawk and McHenry 2005).

Wages in Russia are low. In 2001, programmers with less than two years experience were paid between $300 and $500 per month, while more experienced programmers earned between $600 and $1,500 per month. Wage rates are increasing rapidly. Hawk and McHenry (2005, 12) cited a 2003 survey that found that wages for development staff ranged between $380 and $1,200 per month, with experienced managers receiving from $700 to $1,900. Wages in Moscow were higher than these scales.

Contrary to the report cited, concerning the small number of high-skill programmers in the Soviet era, Hawk and McHenry (2005) report that the skill levels of today's Russian programmers is quite high quality and they are considered to be good problem solvers. On the other hand, project management skills are viewed as not so strong. Russia also presents a difficult business environment. Experienced managers are in short supply, and few Russian firms have secured certification from standards-setting bodies. Hawk and McHenry (2005) state that only recently have Russian firms applied for certification, and only Luxoft had reached CMMI Level 5 (Luxoft 2005). This may change over time as Russian firms become more experienced and hire IT managers returning from abroad (American Chamber of Commerce in Russia 2003). In addition, programmers with adequate English-language capabilities are in short supply, bandwidth costs are higher than in most of the other contracting nations, and the general legal environment in Russia is also quite uncertain.

The Structure of the Russian Software Industry

The independent Russian software industry consists of small firms. As of March 2005, the largest firm, Luxoft, had over 1,000 employees (Luxoft 2005). There are a few other firms in the 500 to 1,000 employee range. Despite this size limitation, Russian firms have won business from important multinational customers, including Boeing, IBM, Dell, and Citibank (Luxoft 2005; Hawk and McHenry 2005). A number of multinational corporations, including Intel, Sun Microsystems, Motorola, Boeing, and Nortel, have opened R&D centers in Russia to take advantage of the skills of Russian scientists and engineers. Intel is one of the firms with the most ambitious plans for its Russian operations. In 2004, it purchased two Russian technology companies, Elbrus and UniPro, increasing its total employment in Russia from 900 to 1,550 engineers and staff (Intel 2005). Sun Microsystems employs over 300 Russian technologists in Moscow, St. Petersburg, and Novosibirsk (Nicholson 2004).

Conclusion on Russia

In terms of cost, quality, and volume, Russia is an attractive destination for offshored work. There are a considerable number of capable, low-cost personnel available in Russia; however, the stability of the business environment and the capabilities of management preclude the type of massive growth seen in India or even China. The independent Russian software firms are currently too small to tackle the largest and most sophisticated projects. Russia's strengths appear to be a number of technically sophisticated engineers capable of doing cutting-edge research. Predicting Russia's offshoring future is difficult because of uncertainty regarding the continuing development of the system of higher education and more general political and economic uncertainty.

3.9 Conclusions

Despite the changing geography of software and software services production, the most important global relationship in software continues to be US firms providing software and software services to the world. What is new is the perception by managers that capable technical talent is available in developing countries, particularly India. For managers under intense pressure to reduce costs, offshoring is now considered a normal response, and there is a growing infrastructure of lawyers, executive search organizations, and accountants in place to facilitateit.

This chapter has reviewed the countries exporting work (e.g., United States, Western Europe, and Japan) and their relationship with the countries that perform the work (e.g., India, China, Eastern Europe/Russia). A few conclusions can be drawn from this survey.

In the absence of major political or economic changes, the movement of software jobs from developed nations to lower-wage environments will continue, perhaps at an increasing pace, due to global markets, lower costs, and increased access to skilled labor.

Much of offshored IT work today is in lower skill areas, but this is changing. The change in the nature of the work will require changes in the skills of the offshoring managers as well as the employees who perform the offshored work. For the developed nations, it will be critical to find ways to utilize this new resource of lower-cost IT workers to develop high value products and services. This will require improvement in and the evolution of the educational systems in both the developed and developing nations.

India has become the primary recipient of software and software services offshoring, and this situation will continue for the foreseeable future. However, India is only the largest beneficiary of the globalization of IT work. Any developing nation with properly trained personnel, good telecommunications linkages, and the right cost structure can participate.

As a useful simplification, it can be said that India is the global center serving all geographies, but that there are also regional divisions of labor emerging with Eastern Europe and Russia tending to serve Western Europe, and China tending to serve the Asia Pacific area, particularly Japan.

An emerging form of offshoring is the formation by multinational companies of in-house laboratories located in lower-cost countries. This is one of the ways that the developing countries can participate in more advanced research and development since traditional offshoring does not lend itself as easily to advanced work.

3.10 Bibliography

A.T. Kearney Inc. 2004. The Future of Bay Area Jobs: The Impact of Offshoring and Key Trends. San Francisco, CA.

American Chamber of Commerce in Russia (ACCR). 2001. White Paper on Offshore Software Development in Russia (March).

Arora, A., Gambardella, A., and Torrisi, S . 2004. In the Footsteps of Silicon Valley? Indian and Irish Software in the International Division of Labor. In T. Bresnahan and A. Gambardella Eds. *Building High-Tech Clusters.* Cambridge University Press, Cambridge, UK, 78-120.

Baldwin, C. and Clark, K. 2000. *Design Rules: Volume One. The Power of Modularity* The MIT Press, Cambridge, MA.

Brown, C. and Linden, G. 2005. Offshoring in the Semiconductor Industry: A Historical Perspective. In Susan M. Collins and Lael Brainard Eds. *Brookings Trade Forum*. Brookings Institution Press.

Tarabusi, C. and. Vickery, G. 1998. Globalization in the Pharmaceutical Industry. *International Journal of Health Services 1*, 67-105.

China Software Industry Association. 2005. China Software Export Achieved 7 Times Growth in Five Years. Available at http://www.csia.org.cn/chinese_en/index/. (Accessed March).

China Venture Capital Research Institute. 2004. *China Venture Capital Yearbook 2003.* China Venture Capital Association, Hong Kong.

D'Costa, A.P. 2003. Export Growth and Path-Dependence: The Locking-in of Innovations in the Software Industry. In D'Costa and Sridharan, Eds. *India in the Global Software Industry: Innovation, Firm Strategies and Development*. Palgrave Macmillan, New York, NY.

Dalian Software Park. 2005. http://www.dlsp.com.cn/english/Investment/inv_Soft.asp.

De Fontenay, C. and Carmel, E. 2004. Israel's Silicon Wadi: the Forces Behind Cluster Formation. In T. Bresnahan and A. Gambardella Eds. *Building High-Tech Clusters* Cambridge University Press, Cambridge, UK, 40-77.

Dedrick, J. and. Kraemer, K.L.. 1998. *Asia's Computer Challenge Threat or Opportunity for the United States and the World?* Oxford University Press, New York, NY.

Dong, Yuntin. 2004. The Chinese Experience. In P. Drysdale Ed. *The New Economy in East Asia and the Pacific.* Routledge Curson, London UK, 130-139.

Dossani, R. To appear. Evolution of the IT Industry in India. In M. Hancock, W. Miller, and H. Rowen Eds. *Making IT.* Stanford University Press, Stanford, CA.

Dossani, R. and Kenney, M. 2003.'Lift and Shift: Moving the Back Office to India. *Information Technology and International Development 1,* 2, 21-37.

The Economist. 2004. India's Growing Strength in Innovation. (April 1).

Fujitsu India. 2005. Global Outsourcing Strategies. Available at http://www.fujitsu.com/downloads/SVC/fc/fs/india_gdc.pdf. (Accessed Sept.).

Hagel, J. 2005. Capturing the Real Value of Offshoring to Asia. Working Paper. Available at http://www.johnhagel.com/paper_offshoring.pdf.

Hallez, F. 2004. Global Sourcing and ICT Offshoring: The Approach of Siemens Business Services. *The EU-U.S. Joint Seminar on Offshoring of ICT Services and Related Services*. Brussels, Belgium (Dec.).

Hawk, S. and McHenry, W. 2005. The Maturation of the Russian Offshore Software Industry. *Journal of Information Technology for Development. To appear.*

Heeks, R. 1996. *India's Software Industry: State Policy, Liberalization and Industrial Development.* Sage Publications, New Delhi, India.

Heim, K. 2003. Microsoft Expands in China. *San Jose Mercury News* (Nov. 4). http://www.mercurynews.com/mld/mercurynews/business/7177608.htm. (Accessed March).

Heng, S. 2005. Software Houses: Changing from Product Vendors to Solution Providers. Economics: Digital Economy and Structural Change*. Deutsche Bank Research* (April) #50.

Hira, R. and Hira, A. 2005. *Outsourcing America.* AMACOM.

Hoppermann, J. and Parker, A.. 2004. Debunking Russian Offshore Myths. *Forrester Research* (June).

Huang, G.T. 2004. The World's Hottest Computer Lab. *Technology Review* (June). http://www.techreview.com/articles/04/06/huang0604.asp. (Accessed March 2005).

I-flex. 2005. Home Page. http://www.iflexsolutions.com/iflex/Home.aspx, (Accessed June).

Intel Inc. 2005. Intel Expands R&D Teams in Russia. www.**intel**.com/technology/ techresearch/research/rs08041.htm. (Accessed March).

Israeli Export and International Cooperation Institute. 2005. Israel's Software Industry. http://www.export.gov.il/Eng/_Articles/Article.asp?CategoryID=582&ArticleID=1148. (Accessed June).

JISA (Japan IT Services Association). 2004a. The Export and Import of Software and Foreign Software Engineers in 2004. Tokyo, Japan.

JISA (Japan IT Services Association). 2004b. IT Services in Japan. Tokyo, Japan.

Katkalo, V. and Mowery, D.C. 1996. Institutional Structure and Innovation in the Emerging Russian Software Industry. In D. C. Mowery Ed. The International Computer Software Industry. *Oxford University Press, New York, NY. 240-271.*

Kenney, M. 2003. The Growth and Development of the Internet in the United States. B. Kogut Ed. *The Global Internet Economy* MIT Press, Cambridge, MA. 69-108.

Krishnadas, K.C. 2005. Fragmented China Software Sector No Match For India, Report Finds. *EE Times* (Feb. 21). http://www.cmpnetasia.com/ViewArt.cfm?Artid=26204&Catid=2&subcat=86.

Krishnan, K.A. (Vice President, Tata Consultancy Services). 2003. Personal Interview by Rafiq Dossani.

Liu, X. 2004. Technology Policy, Human Resources, and the Chinese Software Industry. *Conference on Strategies for Building Software Industries in Developing Countries*. Hawaii. (May). www.iipi.org/Conferences/ Hawaii_SW_Conference/Liu%20Paper.pdf.

Luxoft Inc. 2005. http://www.luxoft.com/eng/about/info/. (Accessed March).

Marson, I. 2005. China's Linux Market Grows. *ZDNet* UK (March 15) 1. http://news.zdnet.co.uk/software/linuxunix/0,39020390,39191343,00.htm.

McKinsey Global Institute. 2005. The Emerging Global Labor Market: Part I – The Demand for Offshore Talent in Services (June).

Microsoft Inc. http://www.microsoft.com/msft/earnings/FY03/earn_rel_q4_03.mspx.
Nasscom. 2005. Indian IT-ITES – FY05 Results and FY06 Forecast (June).

Nicholson, A. 2004. Intel Adds Russian Research Centers. *St. Petersburg Times* (May 28). http://www.sptimes.ru/archive/times/972/news/b_12585.htm.

Oracle, Inc. 2005. Oracle India Factsheet. http://www.oracle.com/global/in/pressroom/factsheet.html. (Accessed June).

Ó'Riain, S. 2004. The Irish Software Agglomeration: Technology Driven Commodity Chains, Global Regions and the Developmental State. *International Journal of Urban and Regional Research 28*, 3, 642-663.

Ovum Inc. 2005. Renault Gives the French Outsourcing Market a Kick-Start. http://www.ovum.com/outsourcing/ovumc2.asp. (Accessed July).

Parker, A. 2004. Mapping Europe's Offshore Spending Impact. *Forrester Research Inc.* (July).

Parthasarathi, A. and Joseph, K. 2002. Limits to Innovation in India's ICT Sector. *Science, Technology and Society 7*, 1, pp. 13-50.

Press Trust of India. 2005. Huawei India Gets New COO, Plans R&D Campus in Bangalore. (May). www.hindustantimes.com/news/181_1350343,00030001.htm. (Accessed Sept.).

Reuters. 2005. China Emerging as Chip Design Center. (Aug.). http://news.zdnet.com/2100-9584_22-5813302.html. (Accessed Sept.).

Roland Berger Strategy Consultants. 2004. Service Offshoring (June).

Shah, R. 2005. Ketera India Case Study. Conference on the Globalization of Services. *Stanford University* (June).

Siemens Business Services. 2005. Corporate Website. (Accessed March). http://www.siemens.com/.

Sigurdson, J. 2004. The Emergence of the People's Republic of China: Challenges and Opportunities for Latin America and Asia. *LAEBA Annual Conference*. Beijing, China (Dec.). http://www.adbi.org/files/2004.12.3.cpp.prc.technological.capability.pdf (Accessed March).

Singh, J. 2003. Country Analysis: Mexico. http://www.american.edu/initeb/js5518a/Country-analysis-mexico.html (Accessed June 2005).

STAT-USA. 2004. A Year-End 2003 Summary of China's Electronics Information Industry Market (March). http://strategis.ic.gc.ca/epic/internet/inimr-ri.nsf/en/gr123374e.html (Accessed March 2005).

Steinmueller, W.E.. 1996. The U.S. Software Industry: An Analysis and Interpretative History. In D. C. Mowery Ed. *The International Computer Software Industry.* Oxford University Press, New York NY, 25-52.

Thibideau, P. 2004. BearingPoint Opens Second Development Facility in China. *ComputerWorld* (July 6) http://www.computerworld.com/managementtopics/outsourcing/story/0,10801,94337,00.html.

Tschang, T. and Lan Xue, L. 2005. The Chinese Software Industry. In A. Arora and A. Gambardella Eds. *From Underdogs To Tigers: The Rise And Growth Of The Software Industry In Brazil, China, India, Ireland, And Israel.* Oxford University Press, New York, NY, 131-167.

Tsukazaki, Y. 2002. Requirement and Situation of Acceptance of Foreign Workers with Special Reference to IT Engineers. in *The Report of the Study Committee on Employment Management of Foreign Workers in the Field of Specialists and Technology* (March).

Umezawa, T. 2002. The Situation of Foreign Software Engineers- The Division of Labor of he Software Industry and International Immigration. *The Report of the Study Committee on Employment Management of Foreign Workers in the Field of Specialists and Technology* (March).

Umezawa, T. 2005a. Report on Foreign Software Engineers in Japan. *Waseda University* (April).

Umezawa, T. 2005b. Case Study on the Chinese Software Iindustry in Beijing. *The Division of Labor of Software Industry* (April).

UNCTAD. 2004. World Investment Report 2004: The Shift Towards Services. *United Nations*, New York, NY.

Weckler, A. 2004. The India Jobs Timebomb. *Sunday Business Post* (Jan. 4). http://archives.tcm.ie/businesspost/2004/01/11/story728704866.asp. (Accessed June 2005).

Wildemann, H. 2005. *Unternehmensstandort Deutschland Wege zu einer wettbewerbsfähigen Wertschöpfungsgestaltung*. TCW Transfer-Centrum, Germany.

Xinhua News Agency. 2003. IBM Launches R&D Center in Dalian. (Feb. 9) http://www.china.org.cn/english/BAT/55333.htm.

Xiong, S. 2004. Dalian To Build Software Industry Corridor. *Xinhua Newsnet* (July 4) http://www.openoutsource.com/resource-dated7236-Dalian%20to%20build%20software%20industry%20corridor.phtml (Accessed June 2005).

Zedtwitz, M. von. 2004. Managing Foreign R&D Laboratories in China. *R&D Management 34*, 4, 439-452.

Authors: Alok Aggarwal, Orna Berry*, Martin Kenney*, Stefanie Ann Lenway, and Valerie Taylor

Chapter 4: Corporate Strategies for Software Globalization

4.1 Introduction

The previous chapter examined the provision of software production and services for the global market from a national perspective. This chapter examines the same issue from the perspective of the firms involved. Our interest is in how firms use low-wage environments to undertake software work for their global operations. The interest here is not in the relocation of work from companies in a high-cost nation such as Germany or Japan to firms in another high-cost nation such as the United States or the United Kingdom even though this type of relocation is common. This chapter also omits work sent to Canada which does have somewhat lower wage rates than the United States and is the beneficiary of what some have termed near-shoring from the United States. Also excluded from this presentation are the operations of multinational or domestic firms that service the local economy of a low-wage nation. In most cases, these are relatively small operations except in the case of China whose domestic consumption of software is increasing rapidly.

This chapter does not debate the reasons firms offshore to nations with significantly lower wages; it simply accepts the fact that the wages are significantly lower. (An analysis of the various reasons firms send work offshore is presented in Chapter 1.) In addition to reducing costs, a company's decision to offshore is often dependent upon two dimensions. The first dimension involves its strategic decision regarding the kind of human capital that it would be able to access when it goes offshore. Put differently, it is an uncontroversial observation that if the nation where work is sent did not offer the proper skill set in its workers, firms would not relocate work to that environment. The second dimension is cost. It is uncontroversial to state that, given the right skill set,[1] a sufficiently low cost of labor, and work that can be done remotely, firms will find it attractive to locate to that environment even if there is no market in that locale.[2]

A decision to offshore software work may come about in a variety of ways and may take a variety of forms. The decision to offshore work has traditionally been made by the manager with responsibility for a project, including profit and loss responsibility. In cases where the contract involves strategic operations, critical company proprietary information, or very large budgets, for example, the decision is often made at a higher level in the organization, sometimes as high as the CIO, CFO, or CEO. In certain cases, the real reason for offshoring might be simply that competitors have already done it or the board of directors is demanding an offshoring initiative to save money. Rarely are the answers so simple, but there are numerous anecdotes about how an executive team in the United States will demand that the overseas operation achieve a certain headcount reduction by a clearly

[1] This chapter focuses on the availability of technical personnel as the attraction for offshoring. It is important to add that capable managers are also extremely important. As Parthasarathy (2005) points out, the executive management team is critical for the success of an offshore subsidiary.

[2] For example, Nike produces athletic shoes in a large number of nations where there are few, if any, customers for its shoes.

 *O. Berry and M. Kenney took a leadership position in the writing of Chapter 4.

unrealistic date. The responsible executives will achieve the headcount goal regardless of the economic justification. In other words, rationales for action vary. Moreover, similar firms often have different recipes for using offshore resources. One basic decision a company that has decided to offshore must make is whether to undertake the work in its own offshore premises or outsource it.

This chapter considers five kinds of firms that are involved with software production or software services that are provided by one or more developing nations.[3]

1. Packaged software firms headquartered in developed nations that make and sell software as a product, for example, Adobe, Microsoft, and Oracle.
2. Software service vendors headquartered in developed nations. These companies may also provide packaged software, though not all of them do so. Examples include IBM, Accenture, and EDS.
3. Internal software operations in firms headquartered in developed nations that have software operations but are not part of the software industry. This encompasses all the companies producing non-IT goods and services. (The group is eclectic and enormous. The importance of this category is that software is now at the heart of value creation in nearly every firm. This is true of financial firms, such as Citibank and HSBC, and manufacturing firms, such as General Motors and Siemens. Each of these companies has a large staff writing software. To illustrate, it is estimated that by 2010, 40 percent of the value of an automobile will be in its electronics of which embedded software will become an increasingly important component. In 2002, it was estimated that the typical luxury automobile had 105 microprocessors. up from 70 in 1998 (Tsai 2004).)
4. Software-intensive, high-technology startups based in developed nations. (This category, though small in numbers of jobs, is important because these firms provide many of the jobs of the future. For these firms, frequently there is no job displacement at all. Rather it is the location of the future employment growth that is in question.)
5. Offshore IT service providers headquartered in developing nations that provide services for firms in the developed nations. As was discussed in Chapter 3, firms providing software services have emerged in a number of countries, though the largest by far are located in India.

This classification of firms is only heuristic. The global Fortune 1000 firms have complicated webs of relationships which might include newly built facilities, facilities they acquired, contractors from developed nations (e.g., IBM and Accenture), and contractors from developing nations (e.g., Infosys (India), I.T. United (China), and Softtek (Mexico). Some product firms outsource certain activities to contract R&D firms and even form joint ventures. There are also intermediate solutions such as the build-operate-transfer option, which lies in between building one's own facility and outsourcing. The tasks being

[3] We do not use the term captive in this chapter, even though it is used elsewhere in this report. In keeping with the literature on international business, we use the term subsidiary. It is more accurate and does not suffer from the bias reflected in the term captive. The categories are not divided on the basis of which firms are subsidiaries because #1, #2, #3, and #4 are all subsidiaries. Only the developing nation firms' operations are not subsidiaries. The categories developed in this chapter are for the purposes of understanding the impact of globalization on software professionals and thus they may not be useful for other purposes. For example, if one was merely interested in globalization, it might be that the packaged software firms should be combined with software services firms. Or, alternatively, software and software services might be combined. The separation of small start-ups from large software and software services firms is justified only because of the importance they have for the high-technology economy. For other purposes, this separation might not be proper.

undertaken vary widely and include activities such as low-level software support, product testing, product development, and research and development. The options and permutations are numerous, and the case studies in this section are merely overviews, thus they cannot do full justice to the breadth and scope of the software and software service operations of these firms.

For each category, the chapter gives a general discussion of the outsourcing issues faced by a specific kind of firm, followed by several case studies to illustrate the types of operations the firm carries out in developing nations and why those particular countries were chosen. These case studies are intended to be illustrative but not exhaustive. The particular cases were selected in order to provide a balance across sizes of companies and do not constitute a random selection upon which generalizations should be based.

4.2 Offshoring Firms

Large, Established, Developed-Nation Software Firms

Because of the somewhat different dynamics of the packaged software firms and the software services providers, we discuss them separately despite the fact that there is significant overlap between these two categories of firms. For example, Oracle and Cadence, which are usually considered packaged software providers, have large consulting arms to assist with the installation and operation of their software. IBM sold $15 billion in software in 2004, yet it is today more of a software services firm (with revenues of $46 billion in its global services unit). Accenture is a massive consulting firm that provides a variety of services, including software services. Thus the line between the two categories is somewhat difficult to draw, but it is nevertheless a worthwhile distinction because a pure packaged software firm such as Adobe or Microsoft hires programmers almost exclusively, while a firm such as SAP, IBM, or Oracle also hires consultants and analysts who are not necessarily working on products but are providing services.

Packaged Software Firms

The packaged software firms are what most people think of when they think of software. As a general rule, the largest and most successful packaged software firms in the world are headquartered in the United States (the notable exception is SAP in Germany). Successful packaged software firms can be very profitable because they only need to write an application a single time (although perhaps in several variations) and then reap their revenues from the sales of many copies. One reason for establishing offshore facilities is to localize the package for particular language groups. For example, Ireland has a large industry that specializes in localizing products from US software firms for the European markets (O'Riain 2004). Localization work characterizes a significant portion of the work by the R&D laboratories of packaged software firms in various nations. This type of work, though important for the global economy, is not of particular interest here.

There are, of course, other motivations for package software firms to locate in developing countries. The most frequently given reason is access to the talented labor force working in these lower-cost locations.[4] One important motivation behind offshoring for these package

[4] The decision to move to a location for lower cost is a complex one. Lower cost includes not only wages but also the lower cost of benefits including health care. It also includes issues such as reduced concerns about discipline problems, substance abuse in the workplace, and governmental regulations concerning harassment, racial policies, etc. that are part of the protections commonly expected in the developed nations. This chapter does not place a judgement upon these policies. Quite naturally, in each nation, there are different regulations and standards that channel business activities and create various costs and benefits.

software producers is that their packages are constantly increasing in size and complexity, driving the cost of writing the software, testing, and debugging it ever higher. Whichever of these causes is the most significant, what is certain is that nearly all major packaged software firms are establishing offshore facilities in lower-cost environments, ranging from Eastern Europe and Russia to India and China. In the following case studies of Adobe and SAP, we examine this new geography of the software industry.

ADOBE

On account of its Acrobat program, Adobe has a wide global footprint. Its software has applications in digital imaging, design, and document technologies. The firm does its product development in the United States, Canada, Germany, Japan, and India. In India, Adobe has its largest physical office space outside of the United States, and the Indian operation is growing more rapidly than any other location.

In 1997, Adobe established a sales office in New Delhi, India, to market its products. In 1998, it established an R&D center in New Delhi (Noida) to utilize the low-cost R&D talent available in the country. By 2005, Adobe had 3,800 employees worldwide and approximately 500 (13 percent) were located in India. Adobe has invested $10 million in India but plans to increase that to $50 million over the next two years as the R&D center grows. Adobe was perhaps the first international software company to develop a full-fledged product in India, Page Maker 7 (Rediff 2005). The Indian center has filed 25 patents in the last four years, an indication of the sophistication of the work it is undertaking.

In 2005, Adobe acquired Macromedia, another Silicon Valley firm. Rather than consolidate Macromedia's Bangalore research operation into its own research operation in New Delhi, it is retaining and expanding the Bangalore facility which in April 2005 had 150 workers and was expected to grow to 250 by year-end 2005 (Verma 2005).

> Adobe's Indian R&D center works on Adobe Acrobat desktop applications and server-based products as well as products related to digital imaging and video. It develops components for almost the entire range of Adobe's product line. Products it has worked on include PageMaker, FrameMaker, Postscript, Photoshop Album Starter Edition, and the Acrobat Reader on Unix and alternate platforms.

From the managerial perspective, the Indian operation is becoming increasingly integrated into Adobe, as is evidenced by the fact that Naresh Gupta, who managed the Indian operation since its inception, is being relocated to the San Jose headquarters where he will join the executive management team (Rediff 2005).

There can be little doubt that India has become Adobe's low-cost development center. To date, Adobe has not established development centers in other low-cost countries. In 2002, there were articles in the press stating that Adobe might abandon sales in China because of concerns over software piracy; this was quickly denied by Adobe spokespersons, but the company has not moved to open a development center there (Sim 2002). There are indications that Adobe's Indian operations will continue to grow at least through 2007. If the last four years are any indication, the percentage of the company's employees located in India is likely to increase (given that the total global headcount is growing slowly).

SAP LABORATORIES

SAP, established in Walldorf, Germany, is one of the world's largest software vendors with operations throughout the world. SAP Laboratories is its R&D arm and has units in nine locations worldwide: Walldorf, Germany; Palo Alto, California, United States; Bangalore, India; Tokyo, Japan; Sophia Antipolis, France; Sofia, Bulgaria; Montreal, Canada; Tel Aviv, Israel; Shanghai, China; and (most recently, in 2005, with about 50 employees) Budapest, Hungary. The role of SAP Labs is to distribute global development efforts, enable SAP to access the world's best IT experts, support local and global markets, develop first-class solutions, and drive innovation and competitive advantage for SAP, its customers, and partners.

Most of the laboratories are relatively small. For example, SAP's fourth largest lab worldwide is in Israel and it employs 500 people (it also has another, smaller R&D operation in Israel located within a firm that it acquired), while Sofia, Bulgaria employs only 200 programmers (SAP 2005). Each laboratory has its own specialties. The Shanghai laboratory has focused on localization work, but is slated to grow to 1,500 engineers by 2009 and is expected eventually to do more than just localization (People's Daily Online 2004). In China, SAP is cooperating with the Chinese Linux supplier Red Flag Software to develop corporate applications for Linux (Bishop 2005).

> The India SAP Laboratory was established in 1996 and has grown to be the largest lab outside Germany with 2,000 employees today, and employment expected to reach 3,000 by 2006. According to SAP AG executive board member Shai Agassi, "Indian developers had contributed substantially to the global success of the NetWeaver, the first appli-structure platform for enterprises across the verticals. The SAP Labs India team is one of our most important development teams for NetWeaver worldwide" (Indo-Asian News Service 2005). Even though the Indian operations for the global economy are categorized as research and development, many of the employees are in the services and consulting operations (Barlas 2004).
>
> SAP has a global R&D and operations strategy with its various laboratories specializing in different areas of software development. The plans for employment growth for both India and China are aggressive. If current plans are realized, India and China will become even greater portions of SAP's total global headcount. Given their economic growth, these countries will also become sizable markets for SAP.

Conclusion

The large package software firms are building increasingly global operations. In many cases, their offshore operations are for localization work for the domestic market. However, particularly in the case of India, but also in Russia, the work is for their worldwide software packages. Locating in low-wage countries enables these firms to have access to lower-cost programmers, many of whom are comparable in skill levels to the workers in the developed nations. This is not the only benefit. Having operations in other time zones can speed up production by facilitating round-the-clock production. These opportunities are encouraging the rapid expansion of employment by major packaged software firms in India and other lower-cost nations.

Offshoring will have a complicated effect on the packaged software firms and developed nations. First, it might, and likely will, put employment pressure on software firms to decrease employment in the developed nations. Alternatively, the lower cost and faster production could allow the development of new features in old software and could contribute to the production of lower-priced software products, thereby increasing usage that could result in higher revenues and greater hiring. If the trends as described in these case studies continue for the packaged software firms, elements of both of these scenarios may occur.

Software Services Providers

Software service firms have been among the fastest growing firms in the IT sector, and in general they are far larger than the packaged software firms. This section confines discussion to the software service activities of these firms, but it is important to remember that firms coming from the software service side (such as IBM or Hewlett Packard) and from the service side (such as Accenture) are converging. In the case of IBM, this has been achieved both through hiring and its recent acquisition of the Indian service firm Daksh (with its approximately 6,000 employees). For service providers, software and various other software-based services (i.e., anything done on a computer) may be converging. The software services firms are basically in what might be called a headcount business; they grow by hiring more workers. Thus they tend to have more employees than most of the packaged software firms.

IBM

Established in 1911, IBM has been the global leader in computer hardware and software products and services. In this section, we focus on three different IBM activities, namely, software products, software services, and research and development. It is important to understand IBM's scope and scale. In 2004, it had annual revenue of approximately $96 billion. Global headcount at the end of 2004 was expected to be more than 330,000 employees, excluding employees gained from acquisitions and strategic outsourcing contracts (IBM 2004). The company's geography of revenue growth is shifting dramatically. In Brazil, China, India, and Russia, IBM's annual revenue growth from 2003 to 2004 was 25 percent (though from a small base), while growth in the developed nations was on the order of 4 percent. Between 2002 and 2004, IBM increased its workforce in these four nations by 30 percent (Palmisano 2005).

As of 2005, IBM's Software Group had revenues of $15 billion and contributed one third of IBM's profit. In the Asia-Pacific region, this group employed 5,000 people, including sales and marketing. In India and China, IBM's software development laboratories employed 1,500 in each country (Smith 2005).[5] Richard Smith, the vice president of the Asia-Pacific region for IBM Software, stated that "the Chinese market is internally focused. In India, a lot of the software development activity is mixed - it is focused internally as well as on exports." As an example of the contributions of offshore centers, "a significant chunk of the code for its AIX version of the Unix operating system was developed in India." (Smith 2005)

> IBM is already well advanced in using global software development teams. Hayward (1997) described a global application development team it created that uses two shifts. The first one is a small group of 25 people in Seattle that would set a daily work specification for a particular application and assign it to offshore teams of 31 programmers each in India, China, Latvia, and Belarus (a former Soviet republic). The offshore team in each location would write code to those specifications during their daytime work hours. The code would then be sent back to Seattle where it would be reviewed and tested. In principle, this process should not only lower labor cost but also accelerate production.[6]

Software development at IBM is now a global process with the offshore low-cost nations growing rapidly to meet increasing demand. In the illustration by Hayward, the Seattle team was clearly the dominant team. However, given the increasing capabilities in developing nations, this hierarchical division of labor may no longer be as distinct in the future.

> IBM Global Services is the largest service provider in the world with revenues in excess of $46 billion and 175,000 employees spread across 160 nations as of 2004. The services it provides include application development, data storage, infrastructure management, networking, technical support, business consulting, and outsourcing

[5] According to the IBM (2005) website, its China Software Development Laboratory employed 2,000 engineers.

[6] There continues to be debate regarding the success of such follow-the-sun strategies. Carmel (1999) argues that these global development projects are difficult to manage and often are unsuccessful. On time-shifting, see Carmel and Tjia (2005).

services. At the end of 2004, IBM employed 23,000 people in India, and an internal planning document stated that, by the end of 2005, this would increase to 38,000; the bulk of these employees were in Global Services. India now has more IBM employees than any nation except the United States (Hamm 2005).

IBM Global Services is active in providing services to domestic Indian and Chinese firms. For example, in March 2004, it signed a ten-year IT outsourcing deal for $700 million with Bharti Tele-Ventures Ltd., India's leading telecom company that included the transfer of Bharti's IT-related assets (including workers) to IBM. Not only did IBM acquire a new customer; it also purchased more skilled employees to expand its Indian operations. In 2004, IBM also purchased a leading Indian business process outsourcing firm, Daksh, which though not an IT firm, had 6,000 employees. This acquisition illustrates how the IT and non-IT services are blurring for the providers. For this reason, the discussion in this section incorporates an overview of IBM's entire range of offshoring service operations not only the software services.

India is becoming IBM's central delivery center for services. However, like all of the multinational service firms, IBM has also established facilities in a number of other lower-cost nations, including China. In China, IBM Global Services has three centers, including one opened in Dalian in 2005 with 600 workers. The Dalian center is expected to grow rapidly with its main purpose to serve the Asia Pacific market (ZDNet 2005). IBM Global Services also has a service center in Mexico.

In August 2005, IBM announced that it was establishing an IT services research center in Bangalore as an extension of its India Research Laboratory located in New Delhi with an initial staff of 10 researchers. According to P. Gopalakrishnan, the director of IBM's India Research Lab, it would look "at how technology can improve the capabilities and efficiency of delivery. This would include the whole spectrum of services from infrastructure management, application maintenance, BTO to BPO services." (CyberMedia News 2005). If this pattern continues, India may become the hub not only for doing offshore work but also for developing ways to automate service delivery using software.

India has clearly become a core location for IBM to provide offshore software services, and with the establishment of a research laboratory there to develop methodologies for the automation of service provision, it appears as though India may become IBM's global center of excellence for these functions. However, all of the multinational software service providers have a global footprint so that they can offer their customers a wide variety of services in many different languages. IBM is likely to continue expanding its workforce in software and other services in lower-wage nations, while growth in the developed nations is expected to be slow.

With eight laboratories around the world (three in the United States and one each in Switzerland, China, India, Israel, and Japan), IBM Research employs approximately 3,050 researchers. The company has steadily increased its R&D expenditures outside the United States, from 28% in 1993 to close to 60% in 2003. In the 1990s, IBM opened three new research labs in Austin (1995), China (1995), and India (1998). For the research laboratories, access to the most creative individuals is the greatest priority, but it is also true that the research centers in China and India have lower operational costs. The main point of these research centers is to attract local talent and to conduct some of the research on problems that are relevant to the local environment using global-class research.

There appear to be some differences in emphasis between the Chinese and Indian laboratories. The India Research Laboratory (IRL) has about 100 researchers and focuses on areas critical to expanding India's technology infrastructure so, while IRL researchers work on some local issues such as text mining and speech recognition for Indian languages, they also work on more general research problems in the areas of bioinformatics, natural language processing, grid computing, and autonomic computing. The IBM China Research Laboratory (CRL) also has approximately 100 researchers. It has been working on Text-To-Speech systems and can now provide language support for Chinese, Taiwanese Chinese, Cantonese, Korean, Japanese, and French. It has also been working on IBM's Websphere Translation Server that provides machine translation between English and Chinese. In this sense, the research profile in the Chinese laboratory is more localized.

All IBM research laboratories actively cultivate relationships with local academic institutions. For example, the India research lab is located on the Indian Institute of Technology (IIT), Delhi, campus where it has access to a vast pool of talent. In Israel, IBM has built strong relationships with Haifa University and Technion. The R&D laboratories in India and China are still quite small; however, there appears to be a commitment to increase their size rapidly. Their missions are different: in the case of China, much of their work will continue to be on localization and the Chinese language, while the Indian laboratory is more likely to undertake work directly applicable to global business needs.

As the largest software/software services firm in the world in both revenue and headcount, IBM has the most sophisticated global footprint of any firm. Not only is it increasing its employment in developing nations in the more mundane and routine aspects of service delivery, it is also increasing employment in software product development and research and development. In the process, IBM's global posture is changing from being heavily weighted toward the developed nations to a more equal weighting globally.

Siemens Business Services

Siemens Business Services (SBS) is a Siemens subsidiary that has a global practice in performing software and other outsourced work. It employs approximately 36,000 workers and derives substantial revenue from installing, customizing, and maintaining SAP software in businesses. Its 2004 revenues of 4.8 billion Euros were roughly divided between Germany (48 percent), the rest of Europe (39 percent), the United States (8 percent), and the rest of the world (5 percent) (Siemens Business Services 2004). SBS has been under significant cost pressure and has instituted layoffs to bring its costs under control (Blau 2005). SBS, like many other large service firms, has been globalizing its service delivery operations and, in the process, has downsized its domestic workforce. Of SBS's 36,100 global employees, only 15,100 are now located in Germany, and 4,000 are located in its rapidly growing Indian subsidiary.

SBS has developed a business strategy that uses a matrix of vertical industry knowledge and sets of general competencies to serve its customers. One aspect of the matrix is the industry expertise (vertical knowledge) or competency centers that are scattered in different countries, for example, the paper and pulp vertical is located in Finland (Hallez 2004). The other part of the matrix is the general activities, located in offshore sites in Canada, Ireland, and Turkey, and they handle stabilized processes. India has two roles: it functions as a back office operation for finance and accounting, and it does general software programming and service and applications development for SAP programs. SBS uses Russia for very labor-intensive and repetitive back office and software application development (Hallez 2004).

> Siemens also operates its Siemens Information System Laboratory (SISL) in Pune, India.[7] SISL has been involved in the development of an atmospheric disturbance model for Boeing flight simulators, engine and auto throttle control simulation, modeling and simulation of Weibul clutter, and GPS and INS error modeling for measurement simulation. It has also designed a control system for wind shear

[7] This section draws heavily upon Express Computer (2002).

control on the Boeing 767, a control system for the flight management system for the Boeing 747, and primary flight control system software as well as executing the development of Kalman filters for GPS and INS, integrated with GPS in feed-forward and feed-back configurations. SISL has been able to use Indian engineers to design sophisticated software for developing-nation customers.

SBS and other parts of Siemens are interesting because, in contrast to US firms, they place a strong emphasis on nearshoring facilities to Eastern Europe, Russia, and Turkey. Nevertheless, SBS India is the location with the largest non-German headcount, and it continues to grow rapidly.

Conclusions About Developed Nation Software Services Firms

Software services is in most respects a headcount and labor-cost business. The multinational software services firms have been experiencing increasing pressure on costs due to competition from developing-nation producers, particularly the Indian service giants (as described later in this chapter). This has forced the multinationals to secure lower-cost offshore labor. Both IBM and SBS are typical of other service firms such as EDS, ACS, and Accenture in that they operate globally, but only in the last five years have they found it necessary to build significant operations in developing nations to decrease their labor costs. Today, the larger firms such as IBM and Accenture are rapidly increasing their headcount in a number of developing nations, particularly India. At the same time, these firms are holding steady on their developed-nation headcount or gradually drawing it down. Given the ferocious competition in software services, there is little likelihood that prices will increase substantially. This suggests that, for the large multinationals, the offshoring of services will continue to increase in both absolute numbers and percentages of the global workforce.

Software Operations in Non-Software Firms

Today, virtually every firm in every industry sector is dependent on software. These needs range from routine software for personal computers and small servers to more complicated and customized software for complex and proprietary systems. All of these systems require customization, maintenance, or updating on a regular basis. IT systems have become an increasingly significant expenditure for businesses in developed countries, and firms are actively trying to control these costs. One way to lower them is to offshore the work to nations with lower labor costs.

It is difficult to even estimate the amount of software work that is offshored. Businesses do not provide this information in their reports. If work is transferred to an overseas subsidiary, this is an internal transfer and may remain unannounced and difficult to trace. It is more clear who does the work. If it is not an overseas subsidiary of the company, then it is likely to be one of two other kinds of firms. The service might be supplied by a large service firm from a developed nation such as IBM, CapGemini, SBS, or Accenture (as discussed in the previous section). Alternatively, the work might be outsourced to a firm from a developing nation such as TCS or Infosys (India), Luxoft (Russia), or Softtek (Mexico) (as discussed later). When a multinational company does the software work for its developed-nation facilities itself in one of its developing-nation locations, it is likely that this is not the only work done at that location. For example, as of April 2005, Dell Computers employed approximately 10,000 people in India in a variety of tasks, one of which was to produce software for Dell's internal operations. The overseas operations undertake many tasks, only one of which is software production. Having a mélange of activities can provide the scale needed to make establishing an overseas subsidiary more attractive since the software work may not have been of a sufficient scale to justify a subsidiary.

Agilent Technologies Inc. (ATI)[8]

In the technology sector, ATI is a good example of how a firm normally considered a hardware firm also undertakes considerable amounts of software-related work. ATI develops tools and technologies that sense, measure, interpret, and communicate data. The company operates in four business areas: test and measurement, automated test, semiconductor products, and life sciences and chemical analysis. ATI, which was separated from Hewlett Packard in 1999, established its first Indian offshoring operation in 2001. By 2005, it had offices in over thirty countries. Manufacturing was located in the United States, China, Germany, Japan, Malaysia, Singapore, Australia, and the United Kingdom. ATI Laboratories are located in California; Mizonokuchi, Japan; South Queensferry, Scotland; and Beijing, China.

> The dot-com crash had a severe effect on ATI. At the end of 2003, revenue was $6.1 billion, down from $9 billion in 2000,[9] and the number of employees had been pared from 40,000 in 2000 to 29,000 in 2003. In addition to eliminating headcount in the developed nations, ATI decided to establish an offshoring center in India. It already was outsourcing some software work to India. Although the company established a facility in India, it also decided to outsource maintenance and technical work (largely programming) to outside vendors, while retaining strategic control.
>
> ATI introduced what it terms the *hybrid model*, where outsourcing service providers are required to operate out of its offices. This has proved to be advantageous because it mitigates the perceived security risk of having separate leased lines from non-ATI locations feeding into the VPN (virtual private network). It also allows ATI to induce competition among outsourcers and minimizes transition and operational costs, and it facilitates cross-functional communication between outsourcers and the firm.

Work transfer has not been simple. For example, in early 2002 Agilent established a communications software engineering group in India to automate some software test suites. When the project encountered release delays, there was friction between the US and Indian engineers. This was exacerbated by the dot-com crash which resulted in large US layoffs. These difficulties slowed the transfer of additional work, and, over a period of 18 months, the Indian team experienced a greater than 70 percent attrition rate. Despite these difficulties, the software test suite project has expanded to include the development of new modules and maintenance and defect correction for the entire product in India.

ATI India began with simple projects. For example, the first technical project was data entry related to engineering services. Other initial tasks assigned to India were similarly simple such as CAD support for engineering and quality assurance. Rather rapidly, however, the work became more sophisticated in both the technical and administrative areas. For example, only three years later, Indian engineers were designing application-specific integrated circuits. The Indian engineers took on more and more R&D work in wireless solution systems, OSS, and billing software for telecom service providers. Employment has grown at 20 percent per year, and total employment in India reached 1,250 in March 2005.

ATI's Indian operation is typical of those established by high-technology firms. It uses both offshore outsourcing and developing-nation subsidiaries. ATI has established operations and R&D laboratories in a number of nations, but India has become its largest and most important center. Though it does the more mundane software testing and

---

[8] The material in this case study is taken from Dossani and Manwani (2005).

[9] These figures exclude the company's healthcare business, sold to Philips in 2001.

maintenance, the Indian operation also does more challenging work, for example, developing software that is embedded into ATI's core telecommunications and wireless test equipment products. ATI is an example of a process that is underway in many high-technology and other industrial firms whose core products are becoming more complicated and more software-intensive.

CITICORP

There is relatively little information available about offshoring of business or software services in financial firms. What is well known is that the large money-center banks, insurance firms, and financial firms are among the largest IT users in the world. To support their operations, they have large internal staffs and many software service vendors. One of the world leaders in using offshore facilities for global operations is Citicorp. It uses outsourcing both on-shore and offshore and was one of the first firms to establish a substantial software service subsidiary in India.[10]

> In 1984, Citibank established its Indian software subsidiary, Citibank Overseas Software Limited (COSL). COSL wrote software in India for Citibank's global operations and particularly its effort to computerize its worldwide operations (Arthreye 2003). By the time the global computerization was completed in 1989, COSL had developed a robust banking solution and had approximately 500 employees (Bitsaa nd). COSL used other domestic companies such as Silverline and Nucleus Software for coding, while it handled the development of the architectural components itself. In 1992, while COSL was being converted into a proprietary subsidiary, two executives convinced 150 employees to follow them to form Citicorp Information Technology Industries Limited (CITIL) which was funded by Citicorp's venture capital arm. CITIL did not sell to Citicorp but rather became a merchant software firm. In 2000, CITIL was renamed I-flex. As of 2005, I-flex had 5,500 employees worldwide and over 500 customers. In August 2005, Oracle purchased a 40 percent stake in I-flex for $900 million.

The remaining part of COSL continued to work for CitiGroup. Then in 2001, COSL was merged with another arm of Citibank, India (known as Global Support Unit (GSU)) to form OrbiTech Solutions Ltd. which developed a suite of banking products. In 2002, OrbiTech merged with Polaris Software Laboratories (Udani), and, by 2005, Polaris had approximately 6,000 employees, working mainly in the financial arena.

> Citicorp pioneered the use of India to lower its cost of software production. From Citibank's initial investment in India, it spun off CITIL and COSL and apparently today does not have large in-house software operations in India. In addition to the software operations, Citibank also had a large service operation that did everything from transaction processing to customer-focused call centers. In 1999, this was spun off as e-Serve and listed on the Bombay Stock Exchange. In 2004, Citi delisted e-Serve and brought it back in-house. As of 2005, e-Serve employed more than 10,000 workers in India. In terms of software services, Citibank was the financial industry's pioneer in using India and has been very important in training Indians in software development for the global market.
>
> Since Citicorp's pioneering establishment of a wholly-owned software services subsidiary in India, many other banks and financial institutions, including Deutsche Bank (Deutsche Software), Bank of America, Barclays, ING, and JP Morgan Chase, have established facilities in India to provide software services support for their

[10] For an excellent account of Citicorp's early Indian operations that was drawn upon heavily for this account, see Arthreye (2003).

global operations. Regardless of the ownership configuration, there is ample evidence that the relative amount of software service offshoring by financial institutions to India and possibly other locations will continue to grow. For example, insurance firms, which thus far have been more conservative than banks, have recently begun offshoring their IT operations.

Conclusion

It is difficult to be certain that offshoring will lead to a decline in the number of software service employees in the internal IT operations of firms outside the software industry, but it does seem possible. At ATI, there were lay-offs in the IT sector; however, the losses came in the context of massive lay-offs because of the dot-com crash. In the current recovery throughout the IT sector, existing firm headcount in the United States appears to be stagnant. In other sectors, there is very little data available. For example, in financial services, it is unknown whether the increasing headcount in developing nations such as India has had any impact on employment in the developed nations. The most that can be said is that non-IT firms are increasing their IT and engineering-related employment in developing nations, and this trend is underway across many different industries, including manufacturing firms such as Caterpillar and Nissan (Kenney and Dossani 2006).

Software-Intensive, High-technology Startups

For small startups, offshoring is often a difficult decision, although recently a number of firms in the United States have been established with the express purpose of leveraging lower-cost engineers offshore. For smaller firms, an offshore facility can be demanding on management time. This is especially true because in India hiring and retaining highly skilled individuals is difficult. In developing nations, particularly China (but also India), the protection of intellectual property, which is usually the only asset that a technology startup has, can be difficult. Despite these obstacles and risks, under pressure from their venture capital backers and due to the need to conserve funds, there is ample anecdotal information suggesting that small startups are establishing subsidiaries abroad, particularly in India, to lower the cost and speed software development.

There is a wide variety of models for utilizing offshore skills, and the following case studies are intended only as examples of what high technology startups are doing abroad. These case studies are by no means exhaustive, and whether they are even representative of current practice is uncertain. However, all of these cases indicate that engineers in lower-wage nations can be an important resource for entrepreneurial firms.

HELLOSOFT

Hellosoft is a private company established in Silicon Valley in 2000 and funded by Venrock Associates, Sofinnova Ventures, Acer Technology Ventures, and JumpStartup Venture. It is a growing provider of high-performance communications intellectual property for Internet telephony (VoIP) and wireless devices. The founders are Indian-Americans who had entrepreneurial experience in US startups, and the company was established with the express purpose of using low-cost Indian engineering talent to create the intellectual property that would be marketed by the US headquarters team. By plan, nearly all of Hellosoft's research and development is done in Hyderabad, India, where the company employs over 100 digital signal processing engineers (Hellosoft 2005). Marketing and sales operate out of the company's San Jose headquarters.

The Hyderabad center develops software in areas such as 3G wireless, 802.16 (a broadband technology), and EDGE (advanced data rates for GSM evolution). It has already had significant research success, and, in July 2005, Hellosoft raised another $16 million from venture capitalists which will be invested in marketing and further research and development.

Hellosoft's business plan is based on leveraging low-cost engineering talent, and the US headquarters operates largely as an interface with the market and customers. Nearly all the growth in technical employment will occur in India. Should Hellosoft be successful, the other beneficiaries will be venture capital firms that may garner significant capital gains and further relationships with other Silicon Valley service firms that assisted in the establishment of the firm.

NETSCALER[11]

Netscaler was founded in 1998 to redesign a specific piece of infrastructure, *the load balancer*, used in regulating Internet traffic flow. Netscaler aimed to reduce the set-up and tear-down time for each backend server connection. After Netscaler developed a product to demonstrate its more efficient way to handle Internet traffic, the company needed to add other features in order to attract customers who were unsure about moving from legacy products to new hardware that did not have industry backing. Netscaler understood that, as long as it had the ability to see inside a connection, it could offer other on-the-fly services. To create this ability, Netscaler hired an Indian firm known as NodeInfoTech to help develop an on-the-fly SSL encryption engine (NodeInfoTech 2005). With the aid of NodeInfoTech, Netscaler introduced an extension to its product, allowing the backend servers to send unencrypted data to the Netscaler product that encrypted it and forwarded it to the client over a secure connection.

> The success with NodeInfoTech convinced Netscaler to establish an Indian subsidiary, Netscaler India. To staff the new operation, Netscaler hired many of the developers from NodeInfoTech (Tillman and Blasgen 2005). In 2004, Netscaler India employed approximately 60 engineers to develop other features such as on-the-fly compression, virtual private networks (VPNs), and integrated cache, and it planned to double the number of Indian employees in 2005 (Hindu Businessline 2004). Netscaler had grown to 200 total employees by 2005 when it was purchased for $300 million by Citrix Systems who retained both the Silicon Valley and Indian operations.

The reason Netscaler formed an Indian subsidiary was to allow the company to increase the types of work it could do and develop tighter engineering integration (Tillman and Blasgen 2005). Netscaler's CEO, B.V. Jagadeesh, found that "[Indian] employees of similar skills are as efficient as they are here. The only handicap they have against their counterparts in the US is that they are not directly exposed to customers and customer challenges as India is not a destination market yet. When Indian companies start to buy our products, even that gap will be reduced pretty dramatically." (as quoted in Tillman and Blasgen 2005).

> Netscaler continues to both offshore to its subsidiary and outsource to vendors lower-level engineering support. With the aid of both the internal Indian and US engineering teams, Netscaler can provide all levels of support 24 hours a day. Since the low-level support is fully outsourced, it is hard to learn much more about its operation.
>
> At Netscaler, technical writing is done by in-house technical writers because it is necessary for the writers to work closely with the engineers to provide good documentation. Netscaler originally employed a single technical writer in the United States, but in 2003, as the staff in India grew, a technical writer was hired there. The company's main reason for dividing up the writing was that the writer had to

---

[11] This section draws heavily on a case study done by Joshua I. Tillman and Nicholas W. Blasgen (2005).

work with the engineers in order to correctly document the various product specifications. This allowed Netscaler to divide documentation writing between the two development sites, and the lower wages in India allowed a net reduction in the costs of producing documentation.

As a part of Citrix, it seems likely that Netscaler's future growth will be divided between the United States and India. The exact division is not yet clear, but cost pressures indicate that Indians will become an ever greater portion of the entire workforce.

KETERA[12]

Ketera is a venture capital-financed firm established in 2000 to help firms cut purchasing costs, streamline procurement processes, and achieve higher performance from suppliers without the expense and overhead of traditional software applications. The company provides its software as a service. To lower costs, Ketera made a strategic decision to use India for all functional areas in the company. In its first phase of offshoring in 2002 and 2003, it contracted three Indian firms to provide software development, client services, customer support, and IT support. In April 2004, the company decided to create a wholly-owned subsidiary in India and to transition from all outsource to mostly in-house offshore operation. In 2005, Ketera has a wholly-owned subsidiary in Bangalore employing about 75 people. The company still outsources a small portion of work to a legacy provider and contracts with new providers for special needs.

Why did Ketera set up a subsidiary? In 2004, the company was offshore outsourcing some software development of its core service product, customer support, IT support, and some other functions. However, the company decided that the engineers at the outsourcing firms were not as productive and quality-oriented as Ketera desired. This problem seemed to be due to compensation and attrition issues, and to engineers with no motivation to innovate. There were also difficulties in the United States, where there were too few US managers to handle the Indian engineers, resulting in significant communication gaps. These issues prompted Ketera to establish its Indian subsidiary. Their first Indian hire was a general manager who had experience working in both a Silicon Valley start-up and in India.

The software-related functions offshored internally were software development, operations IT, marketing, and customer support, and portions of product management. In 2005 there was discussion of whether to move certain back office functions and telemarketing to India. According to one report, the center was tapped to be the product engineering and development site for the company's entire suite of *spend management solutions* (Times News Network 2004).

Shah (2005) believes that as the Indian teams mature, they will be able to perform more sophisticated work and that other functions could be at least partly offshored. Maturation is occurring quickly, and Ketera is already creating a new technology prototype in Bangalore.

Conclusion

An increasing number of US technology startups are utilizing lower-cost workers in developing nations. These case studies indicate that, although startups may initially use outsourcing as a strategy, they often soon opt to establish a subsidiary for a variety of reasons, including concerns about intellectual property protection, workforce control, and management efficiency. According to Shah (2005), the minimum staff size for an offshored operation is about 10 people. If this is accurate, then it may be possible for many more small firms to establish subsidiaries in developing nations. Unfortunately, data on the scale and scope of offshoring by startups is unavailable.

[12] The source for the discussion of Ketera is Shah (2005).

It is tempting to view this offshoring as an unmitigated loss of jobs for US workers. However, the reality is more complicated. Lowering the cost of undertaking a startup means that the barriers to entry are lowered, and this is likely to encourage greater entrepreneurship in the United States. The jobs created by this entrepreneurship should be counted against those lost to offshoring. For example, Rakesh Singh, Netscaler's General Manager of Asia Operations, was quoted as saying, "The cost savings through outsourcing have helped us become more competitive and experience rapid growth as a company. As a result, we have a lot more employees in the US today than we did when we set up the India operations" (Tillman and Blasgen 2005). So, correctly estimating the employment effect of offshoring in the case of startups is difficult when one takes into consideration jobs created as well as jobs lost.

Offshore IT Service Providers

The availability of capable software programmers in developing nations provided an opportunity for entrepreneurs and existing firms to hire them and offer their services on the global market. As discussed in Chapter 3, it was in India where this practice first began in a significant way. Initially, in the early 1980s, because telecommunications links were not so sophisticated, the Indian programmers were moved to the US customer's premises. This practice was profitable and gradually expanded and evolved as both customers and providers became more comfortable.[13] This level of comfort and the lower cost that could be offered through remote provision of services led to a shift wherein a major portion of the contract work was completed in the offshore offices of the contractor.

Indian firms were the pioneers in providing the offshore outsourcing of software production and services. As Dossani (2006) shows in his case study of India, but in a lesson that can be generalized to firms in other nations, the real explosion of outsourcing came during the dot-com boom of the late 1990s when there was great concern about a shortage of programmers. US firms, in particular, were concerned about the Y2K problem and sought low-cost assistance in preparing their IT systems. These developments created an environment where major corporations were willing to experiment with overseas vendors, and a sufficient number of these experiments were satisfactory. The result was that offshore vendors, particularly Indian firms, were validated as candidates for software projects. These projects also allowed offshore vendors, again particularly Indian firms, to grow rapidly in headcount, experience, and financial resources so that they could undertake ever larger and more complicated projects.

TATA CONSULTANCY SERVICES[14]

Tata Consultancy Services (TCS), the largest and oldest Indian software services provider, is an excellent example of the growth of Indian vendors (see Table1). TCS was established in 1968 to service the in-house data processing requirements of the Tata Group and, in 1969, offered electronic data processing (EDP) services to outside clients. In 1970, it became the exclusive Indian licensee to sell and maintain mainframe computers built by the American firm, Burroughs. In an effort to encourage the development of an Indian computer industry, the government enacted the Foreign Exchange Regulation Act of 1973, forbidding

---

[13] Obviously, comfort is a subjective term that refers a person's faith that another person(s) will respond in certain predictable ways or that a set of agreed upon tasks will be discharged according to a set of expected criteria. Cultural, social, economic, legal and other practices and beliefs impact our comfort with a relationship. Comfort is increased through repeated successful interactions. As levels of trust increase due to positive interactions, the client becomes more willing to escalate its commitment.

[14] This case study draws heavily upon Dossani and Kenney (2004).

foreign firms from operating fully-owned subsidiaries. A number of foreign firms established joint ventures, and the Indian industry grew gradually. During this period, all of these firms including TCS, sold and maintained computers and software systems made overseas by their joint venture partner and offered electronic data processing services to local clients.

TCS's overseas experience in providing software-related services began in 1974 when TCS was asked by Burroughs to install systems at US-based clients. Burroughs was attracted by the combination of software engineering talent and the English language skills that it had found in the TCS workforce. This was the beginning of the body-shopping business which entailed the dispatch of Indian programmers to the sites of overseas clients. Typically, these assignments lasted for a few months at a time. During this period, Indian firms were basically labor recruiters.

Table 4-1 TCS Revenues, Number of Employees and Percent of Revenues Derived from Outside to India, 1991-2005

Year	**Annual Revenues (in $million)**	**Total Employees**	**Revenue Derived from Abroad, %**
1990	28.1	2,300	70.8
1991	45	2,600	75.6
1992	52.3	4,761	80
1993	55.9	6,450	80.7
1994	64	5,589	79.2
1995	90.1	6,071	80.5
1996	123.9	7,864	81.9
1997	169	9,929	84.2
1998	241.8	11,176	88.2
1999	357.8	12,770	89.8
2000	417.9	15,044	86.1
2001	616.2	17,607	91.3
2002	792.1	20,459	92.7
2003	1,000	24,168	
2004	1,560	30,100	
2005	2,240	45,700	

Source: Compilation by Rafiq Dossani and Martin Kenney

As the software industry changed and Burroughs continued to lose market share, TCS developed a growing competence in conversion work, that is, converting clients' existing Burroughs' systems to work on IBM hardware. To further its growth, in 1979, TCS opened an office in New York, the first overseas office by an Indian software firm. Entering the

1980s, TCS remained the largest Indian software services firm. In 1980, the Indian software industry exports were $4 million, shared by 21 firms of which TCS and a sister firm, Tata Infotech, accounted for 63 percent. By 1984, the number of firms increased to 35 and export revenues reached $25.3 million.

When, in 1985, TI persuaded the government to supply it with scarce satellite bandwidth, Indian firms such as TCS also demanded telecommunications access. But it was the acceptance of UNIX as a programming standard in the 1980s that made offshore work for clients feasible. Again, TCS pioneered the remote project management model as it came to be called. In 1988, only 10% of TCS's work was done in India, but this rose to 37% in 2005. The industry shift to UNIX and workstations also benefited Indian firms since they could secure work converting installed applications into Unix-compatible programs. Again TCS was a leader, but soon other Indian competitors such as HCL, Infosys, Satyam, and Wipro emerged.

> The type of work TCS performed changed substantially in the 1990s. Conversion work tapered off once most corporations completed the adoption of the common Unix platform. This work was replaced with writing applications programs, a more profitable activity. TCS eagerly sought higher value-added work such as systems integration and focused considerable effort by the end of the decade into bidding for larger projects, that is, those that required from 20 to 150 people-years. The largest industry serviced by TCS continues to be financial services. Today, 72 percent of its revenues continue to be in application development and maintenance, while body shopping still provides over 60 percent of its revenue (Mahalingam 2005).

By 1991, TCS had grown to 2,300 employees and had revenues of $28 million. During this period, the company pioneered the establishment of India-based, client-specific offshore development centers (ODCs) which enabled firms such as TCS to undertake large, turnkey projects that combined Indian-based and overseas staff (the latter often supplying critical industry expertise otherwise unavailable in India). Y2K was a bonanza for TCS and the other Indian firms. At the end of the fiscal year 2000, TCS had 15,000 employees and revenues of $428 million. To accelerate its growth, in 2001, TCS acquired CMC, an Indian government-owned firm with 2,500 employees. Rather than slow down after 2000, the rapid improvement in telecommunications capabilities combined with serious pressure on the bottom lines of firms in the developing nations expanded the opportunities for TCS which grew to over 20,000 employees in 2003. TCS began offering new services such as real time database management, quality assurance, and web services.

By 2005, TCS had grown to over 45,000 employees and was continuing to grow at approximately 25 percent per year. As TCS continues its efforts to overtake firms such as IBM and Accenture, it is establishing a global network of operations facilities, not only marketing, customer liaison, or concentrations of dispatched personnel. In 2005, the company had development centers in Europe, Latin America, and Japan, although most of its employees continued to be located in India.

TCS and its major Indian competitors have had a significant cost advantage over their developed-nation rivals. Until very recently, however, they did not have either scale or a sufficiently global footprint to compete against the IBMs and Accentures. This is changing as the Indian firms experience annual growth rates in excess of 25 percent and have significantly better profitability than their US-based competitors (Hira and Hira 2005). The marketplace dynamic may change as the rivals from developed nations increase the percentage of their workforce located in lower-cost environments. Regardless of the outcome, firms such as TCS have successfully forced firms from developed nations to dramatically increase the portion of their global workforce located in developing nations, and thereby have shifted the geography of software service provision.

SOFTTEK

Indian firms, due to their size and sophistication, have rightfully received the bulk of the attention from those considering offshoring. However, there are firms in other developing nations that are also providing software services to developed nations. One noteworthy example is Softtek, a privately-owned Mexican firm based in Monterrey with development centers in Monterrey, Aguascalientes, and Mexico City, two others in Brazil, and one in Spain. Like the large Indian firms, Softtek operates certified Six Sigma programs and has reached a CMM 5 rating (Softtek 2005b). The company was established in 1982 to employ graduates of Mexico's best technical university, the Tecnologico de Monterrey, to provide IT consulting services to Mexican firms and later to firms in other parts of Latin America. It entered the US market in 1997 with the business strategy of providing a near-shore alternative. In recent years, Softtek has grown from 2,000 employees in 2000 to approximately 3,400 in 2005 (Lopez 2005; Softtek 2005a). With about $135 million in revenue, it is growing at 30 percent per year, although it still is only about one-tenth the size of providers in the large developed nations or India.

Softtek's value proposition is based on the fact that its software development centers are near-shore, and thus operate synchronically with its customers. Because its employees are more highly paid than those in the Asian developing nations, Softtek had to develop a somewhat different model than Indian vendors.[15] Their business strategy is not to displace offshore vendors, but rather to capture a portion of the total offshore spending. What Mexico offers is an opportunity to diversify risk which is important for highly interactive processes that could benefit from running at the same time. To further their advantage, Softtek even adopted the US vacation calendar for their US-focused operations. In addition, the United States and Mexico share similar cultural and commercial environments. Proximity facilitates the logistics of arranging face-to-face meetings. This limits the need for Softtek engineers to be stationed onsite, thus lowering costs and helping to make Softtek competitive with the lower-cost Indian or Chinese competitors (Lopez 2005). Travel is simplified because, when it is necessary to visit, as a Mexican firm, employees can use NAFTA visas. In general, Softtek works on fixed-price contracts, not the time-and-materials contracting that is typical of body-shopping.

Despite the opportunities, Mexico's growth in the IT area has been limited. Softtek is the largest independent Mexican software services offshoring firm serving the global market, although there are other smaller firms. Only recently has the Mexican government recognized the opportunity in software services offshoring and formed an organization (Prosoft) to improve Mexico's position by funding training projects. Even five years ago, few Mexican universities outside of the Technologico de Monterrey were providing well-trained graduates for this industry. This has changed as Mexican universities and students have recognized the career potential in IT. To improve the preparation of Mexican IT workers, Softtek and the other Mexican IT vendors are interacting with a number of Mexican universities to improve IT training (Lopez 2005).

Softtek's experience demonstrates that it is not only the Indian majors that are finding opportunities to provide software services to developed nations. Yet, its status as one of the largest Latin American software services firms indicates the lead the Indian firms have built. This case study also shows that high-level CMM qualification is not confined to Indian firms. Most importantly, it demonstrates the entrepreneurial opportunities available in any developing nation that has a reservoir of technically trained personnel.

---

[15] An IT graduate from a Mexican university starts at between $15,000-18,000 per year as opposed to an Indian graduate that starts at $6,000 per year.

Conclusion

Software services firms from a number of the developing nations are players in the global economy. They have not yet become significant players in the packaged software industry, and given the propensity for the large international players to buy promising software startups wherever they may be located, it could be difficult for packaged software firms from developing nations to capture significant global market share. The large Indian firms, such as TCS, Infosys, Wipro, Satyam, and HCL, are at this time the global leaders. However, in China, Mexico, and Russia, there are smaller but also rapidly growing software service firms that employ between 1,000 and 5,000 workers. Currently, the firms from other nations are not large enough to compete with either the developed-nation multinationals or the large Indian firms. These medium-sized firms in other geographies can reduce country risk for customers, although it is also possible that some of them will be acquired. The larger multinationals and Indian firms are also establishing facilities in other geographies, particularly Eastern Europe and, more recently, Mexico.

4.3 Overall Conclusion

The variety of case studies in this chapter illustrates the breadth of the phenomenon of software and software services offshoring. The reasons for offshoring vary by firm and particular recipient nation, and often decisions are made for a complicated amalgam of reasons. In the case of the elite R&D laboratories, the desire to tap into the most talented individuals, wherever they might be in the world, is clearly the foremost motivation. Particularly in the case of China, but also increasingly India, the growing local markets are attractive and a reason for siting software facilities locally. Labor costs are a primary motivation for much of the offshoring being undertaken by the firms examined.

There can be little doubt that offshoring is still small in comparison to how large it is likely to become. The case studies in these chapters are firms that can be considered early adopters; the followers have only recently begun to investigate the opportunities for offshoring. As the case of ATI showed, particularly in the subsidiaries of Western firms, it is likely that more sophisticated work will be relocated during the coming decade. Firms are becoming increasingly willing to entrust core activities to their offshore subsidiaries.

Whereas some believed that a certain size was necessary prior to offshoring, the case studies of startups showed that this is not true. US startups are establishing offshore subsidiaries even before their headcount reaches 50 people, and for some firms, their entire business plan is built on the premise of using lower-cost offshore IT professionals. This suggests that employment growth in the United States might be constrained. However, the availability of low-cost technical talent also can lower the barrier to entry for entrepreneurship, and this may encourage greater entrepreneurship and, as a result, wealth and job creation in the United States.

Every firm in this admittedly small sample is pursuing a global strategy for R&D and IT provisioning. It is entirely possible that this will become the norm for nearly every firm in the developed nations. The labor-cost arbitrage factor is and will remain significant and all executives, in large and small firms, are considering the most economical footprint for their IT operations.

4.4 Bibliography

Athreye, S.S. 2003. Multinational Firms and the Evolution of the Indian Software Industry. *East West Center Working Paper #51*.

Barlas, D. 2004. SAP Doubles Indian Commitment. (Nov.). http://www.line56.com/articles/default.asp?articleID=6168&TopicID=3. (Accessed Sept. 2005).

Bishop, J. 2005. China's Red Flag Software Sees Strong Growth This Year. *Xinhua Financial News* (Sept. 14). http://www.linuxinsider.com/story/mmLJtyG9rg5jby/Chinas-Red-Flag-Software-Sees-Strong-Growth-This-Year.xhtml. (Accessed Sept. 2005).

BITSAA International. How They Did It. http://www.bitsaa.org/sandpaper/leaders/hukku.htm. (Accessed Aug. 2005).

Blau, J. 2005. Siemens Business Services Faces Change. *Network World* (Feb. 4). http://www.networkworld.com/news/2005/0204siemebusin.html. (Accessed Sept. 2005).

Carmel, E. 1999. *Global Software Teams: Collaborating Across Borders and Time Zones.* Prentice Hall, Upper Saddle River, NJ.

Carmel, E. and Tjia, P. 2005. *Offshoring Information Technology*. Cambridge University Press.

Cyberhood News. 2005. IBM Opens Dedicated IT Services Research Center in Bangalore. (Aug. 18). http://www.ciol.com/content/news/2005/105081813.asp. (Accessed Sept.).

Dossani, R. and Kenney, M. 2004. Moving Tata Consultancy Services into the Global Top 10. *Journal of Strategic Management Education 1,* 2. 383-402.

Express Computer. 2002. SISL Grows Out of Parent's Shadow. (July 1). http://www.expresscomputeronline.com/20020701/company1.shtml. (Accessed Aug.).

Hamm, S. 2005. IBM'S Passage to India. *Business Week Online* (Aug. 8). http://www.businessweek.com/technology/content/aug2005/tc2005088_6314_tc024.htm. (Accessed Aug.).

Hayward, D. 1997. How Offshore Programmers Save IBM Millions. *TechWire* (Feb. 18). http://www.offsiteteam.com/outsourcing1.html. (Accessed Aug. 2005).

Hellosoft, Inc. 2005. Corporate Home Page. http://www.hellosoft.com/aboutus/default.htm. (Accessed Aug.).

Hira, R. and Hira, A. 2005. Outsourcing America. *AMACOM*.

IBM. 2004. IBM Increases Hiring Plans. (Aug). http://www.ibm.com/investor/viewpoint/ircorner/2004/12-08-04-1.phtml. (Accessed Aug. 2005).

IBM. 2005. China Software Development Laboratory. http://ibmcampus.51job.com/businessunit/businessunit_7.htm. (Accessed Aug. 2005).

Indo-Asian News Service. 2005. SAP India To Hire 2,000 More Techies. http://www.hindustantimes.com/news/181_1420811,0003.htm. (Accessed Aug.).

Kumar, V. R. 2004. NetScaler To Double Headcount. (June 16). http://www.thehindubusinessline.com/2004/06/17/stories/2004061702170700.htm. (Accessed Aug. 2005).

Lopez, B. (Softtek CEO for US Near Shore Services). 2005. Telephonic Interview by Martin Kenney. (Sept. 7, 2005).

Mahalingam, S. 2005. (Tata Consultancy Services). Presentation at the India Conference – Shaping the Future (Aug.). http://www.tcs.com/investors/pdf/TCS_Presentation.pdf. (Accessed Aug.).

NodeInfoTech. 2005. Home Page. http://www.nodeinfotech.com/expertise.html. (Accessed Aug.).

Orian, S. 2004. *The Politics of High Tech Growth: Developmental Network States in the Global Economy.* Cambridge University Press.

Palmisano, S. 2005. 2005 Investor's Briefing. http://www.ibm.com/investor/events/inv_day0505/presentation/inv_day0505prepared.pdf. (Accessed Aug.).

Parthasarathy, A. 2005. Global Sourcing—The New Reality. Paper presented at *The Globalization of Services, Stanford University* (June 17).

People's Daily Online. 2004. SAP vows to enhance R&D capacity in China. (Dec. 16). http://english.people.com.cn/200412/15/eng20041215_167405.html. (Accessed Aug. 2005).

Kenney, M. and Dossani, R. 2005. Offshoring and the Future of U.S. Engineering. *The Bridge.* (To appear).

Rediff. 2005. Rediff Interview with Naresh Gupta. (April 21). http://www.rediff.com/money/2005/apr/21inter.htm. (Accessed Aug.).

SAP. 2005. SAP Bulgaria Home Page.Available at www50.sap.com/company/saplabs/bulgaria/. (Accessed Aug.).

Shah, R. 2005. Ketera India Case Study. *Conference ON The Globalization of Services, Stanford University* (June 17).

Siemens Business Services. 2005. Corporate Website. http://www.siemens.com/. (Accessed March).

Sim, S. 2002. Adobe Says It's Committed to China Despite Piracy. *ITworld.com* (Jan. 15). http://www.itworld.com/Tech/2418/IDG020115adobe/. (Accessed Aug. 2005).

Smith, R. 2005. Partnerships Are Important. *Rediff* (Aug.). http://us.rediff.com/money/2005/aug/24inter.htm.. (Accessed Aug.).

Softtek, S.A. 2005a. Corporate Home Page. Available at http://www.softtek.com (Accessed Aug.).

Softtek, S.A. 2005b. Our People..in their own words. Available at http://www.softtek.com/nearshore/html/about_people.htm. (Accessed Aug.).

Tillman, J. I. and Blasgen, N.W. 2005. Case Study of Netscaler. Paper written for CRD 199

Special Study Course, *University of California Davis* (June 16).

Time News Network. 2004. Another IT Firm Deserts US for India. (Dec. 8). Available at http://economictimes.indiatimes.com/articleshow/950969.cms. (Accessed Aug. 2005).

Tsai, M. 2004. Inside DSP on Automotive Signal Processing: Feeling the Heat. *Inside DSP* (Sept. 13). Available at http://insidedsp.eetimes.com/features/printableArticle.jhtml?articleID=30900019. (Accessed Aug. 2005).

Udani, D. The Quest for HTMLParser. Available at http://htmlparser.sourceforge.net/articles/quest.html. (Accessed Aug. 2005).

Verma, P. 2005. Adobe To Buy Macromedia's B'lore Development Centre. *The Economic Times* (May 16). Available at http://economictimes.indiatimes.com/articleshow/1111152.cms. (Accessed Aug.).

ZDNet. 2005. IBM Expands in China. *ZDNet News* (May 26). Available at http://news.zdnet.com/2100-9589_22-5721779.html. (Accessed Aug.).

Authors: Juris Hartmanis, Roli Varma, Richard C. Waters*

Chapter 5: The Globalization of IT Research

5.1 Overview

IT research has historically been, and still is, concentrated in a few countries. However, IT research is becoming more equally spread around the globe. This globalization is almost certainly unstoppable and may well accelerate. If current trends continue over the next twenty to thirty years, it is likely that IT research will spread to the far corners of the world, and China and India will emerge as centers of IT research rivaling the United States and Western Europe.

There is little hard data on the migration of IT research jobs. However, it appears that, to date, such migration has been limited and has on balance gravitated toward traditional centers of IT research rather than away from them. A much more significant phenomenon has been the migration of IT researchers themselves from one country to another. This migration has been overwhelmingly to the traditional centers of research. The migration of both jobs and researchers to traditional centers of IT research is lessening. The direction of job migration may well reverse.

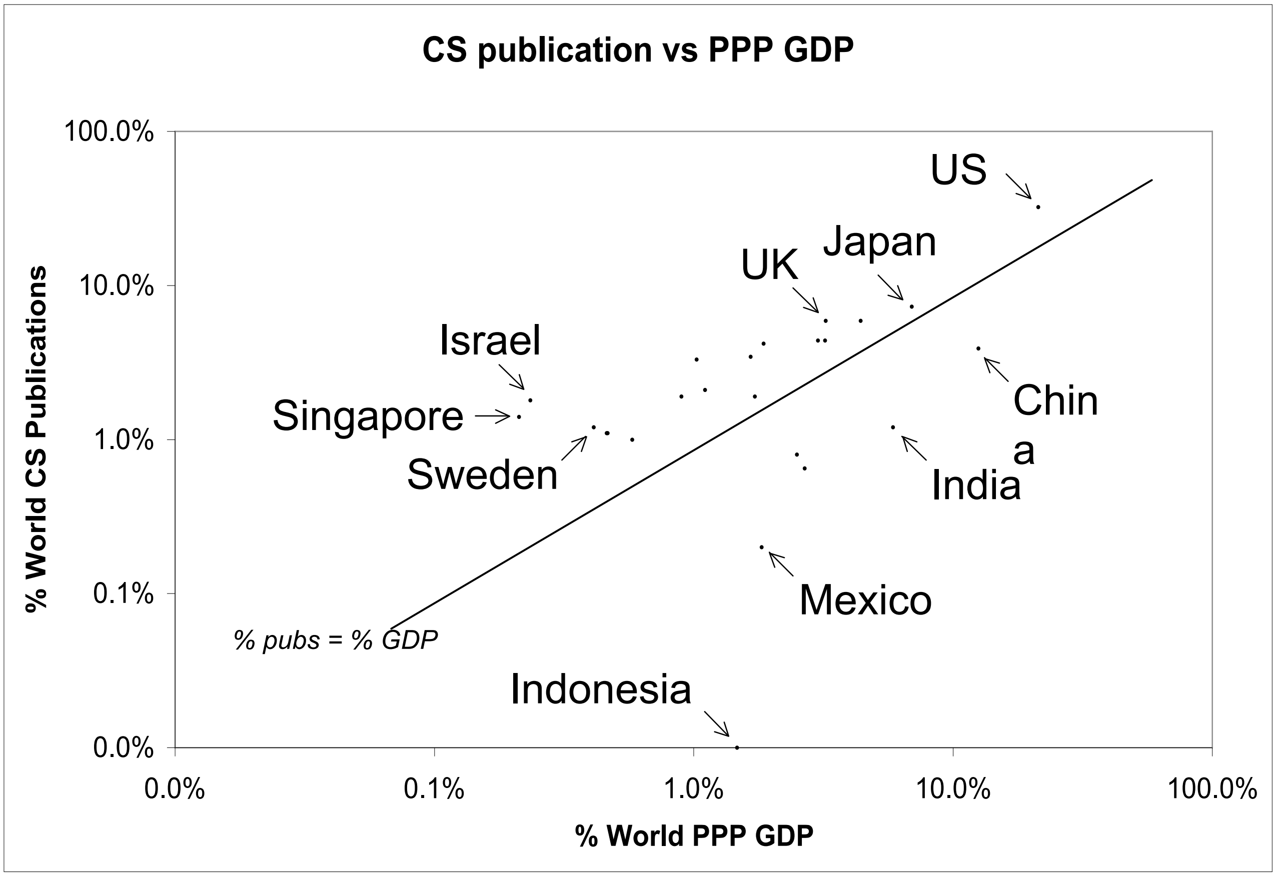
Globalization presents challenges to the traditional centers of IT research. If they become complacent, or even merely inattentive, they may well dwindle in significance with strong negative consequences for their local economies. However, the globalization of IT research is happening in the context of a general increase in the amount of IT research. It is not a zero sum game where increased opportunities in one place inevitably result in decreased opportunities in other places. If they take strong action, it is entirely possible that the traditional centers of IT research will continue to flourish even as additional centers emerge.

The Concentration of IT Research

According to data collected by the Thomson ISI science citation index for the years 1999-2003 (see Figure 1), about a third of computer science papers come from the United States alone. A few additional traditional centers of concentration in IT research (Australia, Canada, France, Germany, Israel, Italy, the Netherlands, Sweden, Switzerland, and the United Kingdom) account for another third.

*R.C. Waters took a leadership position in the writing of Chapter 5.

Figure 5-1: The Globalization of IT Research



The line shows where a country would be if its share of CS publications were equal to its share of PPP GDP. The data underlying this graph are shown in Table 5-3.

Much, but not all, of the large share of the world's IT research in these eleven countries is explained by the large part of the world's Gross Domestic Product (GDP) that is concentrated in these same countries. Figure 1 plots the percentage of the world's computer science publications against the percentage of the world's Purchasing Power Parity (PPP) adjusted Gross Domestic Product (GDP) for all those countries that produce more than 1% of one or the other. There is a basic correspondence between PPP GDP and computer science publication. However, the share of computer science publications by scientists in the traditional centers of concentration of IT research is more than 60% greater than their share of world PPP GDP (65% vs. 40%).

IT research was even more concentrated in the past than it is today. The initial bloom of IT research occurred in only a few select locations in the United States and a couple other countries in the aftermath of the Second World War. This small group of research centers expanded shortly after to the full list of traditional research centers given previously. Over the later 20th century, the list of IT research centers has continued to grow, but relatively slowly. For example, in Europe, Spain, Greece, and Belgium have joined the list, and in East Asia, Japan, South Korea, Taiwan, and Singapore have become significant research centers. With these additions, the centers of IT research listed produce about 85% of all IT publications.

China and India are moving toward becoming centers of IT research, but they are not there yet. Some other countries with significant GDP such as Brazil, Indonesia, Mexico, and Russia produce very little IT research. These six countries combined produce 27% of world PPP GDP but only 7% of computer science papers.

Particularly in the United States, the initial surge of IT research was driven by ample government funding and a significant migration of scientific talent from the rest of the world. The continued importance of government funding is illustrated by the fact that countries such as Israel, Singapore, and Sweden that have particularly high per capita government funding for IT research also have particularly high levels of computer science publication in comparison to PPP GDP. In addition, as shown in the data presented in this chapter, there has been a general migration of scientists from countries that do not support graduate education and research to countries that do.

Due to strong efforts to foster research on the part of a number of national and local governments outside the traditional centers of research, IT research is slowly but steadily becoming more global. This has been accompanied by a significant increase in the numbers of PhDs outside the traditional centers of concentration and a reduction in the migration of researchers to these centers. In the long run, there is no obvious reason why IT research should be any more concentrated than world economic activity in general.

What Globalization Means for the World as a Whole

Globalization allows more and better people to participate in IT research. The growing availability of educational opportunities around the world means that more people with research potential are able to realize this potential, increasing the size of the IT researcher pool and the quality of the best researchers. A freer worldwide market in research means that potential funding for IT research can more easily be targeted to those that can most effectively and efficiently create research results. Both of these trends increase the amount of scientific advancement that can be obtained from a given level of resources. There is little doubt that this is good for the field of IT and for the world as a whole; however, while we gain as a group, there can be individual losers.

What Globalization Means for Individual Locations

Research, in general, and IT research, in particular, is one important foundation for high value-added economic activity and is actively sought by more and more locations. This chapter uses the word location instead of country to highlight the fact that issues of change in IT research activity are not tied to countries so much as to particular regions within countries. For example, inside the countries that are the traditional leaders in IT research, there has long been competition between established research locations and new locations wishing to achieve that status. This competition is little different and no less intense than the global competition that is now emerging.

Becoming (or maintaining one's status as) a center of research in any field requires consistent long-term effort. The required measures include building basic economic infrastructure, providing first-rate education through the doctorate degree level to train high quality researchers and attract first-rate students who stay in the location, and providing ample direct government funding for research as demonstrated by the data presented in this chapter.

Every location must realize that it is competing in a truly global marketplace. This presents opportunities for locations that are not yet centers of research and challenges to those that are. It is likely that the traditional centers of concentration of IT research will remain important centers of research because as significant research centers, these locations will naturally attract research funding and research talent. However, these centers must take continued active measures to foster research. They cannot be complacent and assume that merely being a center of concentration of IT research is, by itself, a guarantee of indefinite success.

What Globalization Means for Individual Researchers

Globalization provides improved opportunities for people who live outside the traditional centers of concentration of IT research. It also provides improved opportunities for the best researchers due to increased global competition for their services. However, it limits the opportunities of the least skilled researchers in the traditional centers of concentration, for whom global competition may mean declining wages or even the loss of jobs.

Every researcher must realize that he or she is competing in a truly global marketplace. There are many people worldwide who could be good IT researchers. Among those who are already researchers, huge differences in skill exist, and this translates into large productivity differentials. Those with talent who pay attention to maintaining a high skill level should see opportunities from globalization, but they must realize that they can no longer fall back on merely living in a traditional center of concentration of IT research as a guarantee of indefinite success. Because of the higher quality and productivity that results, talent and skill level will eventually win out wherever it is to be found globally.

Worldwide Changes in the Balance of Supply and Demand for IT Research

The globalization of IT research will inevitably reduce the dominance of the traditional centers of concentration in relative terms. However, IT research is not a zero sum game.

The most important question for individual locations and researchers is not whether they will prosper in comparison to others, but whether they will prosper in comparison to their own past history. If a given location has a vibrant and growing IT research community, it matters little if other locations are growing more rapidly. Similarly, if a given researcher has a career that is growing in interest and pay, it does not matter much if the prospects of other researchers are increasing more rapidly.

This chapter is primarily about changes in the balances between locations. If the demand for IT research and the supply of IT researchers were static, then this would be a primary determiner of the future prospects of locations and the researchers in them. However, the situation is far from static.

Both the demand for IT research and the supply of IT researchers are increasing rapidly. The most important question of all is whether the demand or the supply is increasing more rapidly. Changes in the worldwide balance of supply and demand for IT research is a more important factor for predicting the future than changes in the balance between locations. Unfortunately, forecasting the future balance of supply and demand comes down to forecasting the difference between two large, rapidly growing, and hard to forecast numbers—a very difficult task.

The goal of IT research is the automation of information and knowledge manipulation tasks, and as such, it is arguably one of the most fundamental of all disciplines, contributing to every area of science, engineering, and the economy. There is therefore every reason to believe that the overall demand for IT research will be very strong—quite possibly strong enough to grow faster than the worldwide supply of quality researchers.

Why IT Research Is a Separate Section in This Report

Discussion of research is in a separate section of this report because it is a self-contained microcosm with product flows that are quite different from IT in general. In addition, the indicators of what is happening in worldwide research, such as the publication of research papers and the numbers of PhDs, are different from the indicators of IT development activities. However, developments in the globalization of research may well be fundamental harbingers of changes to the field as a whole.

The Lack of Direct Data

It would be advantageous to start with a clear definition of what IT research is and then collect a set of data that directly targets that definition. However, there is little available data that directly targets any definition of IT research. Rather, data typically lumps IT research with other kinds of research, advanced development, or both. For instance, much of the data from the National Science Board combines all of natural science and engineering together. Similarly, economic data on the IT industry typically lumps research expenditures with advanced development costs and often with other things as well.

As a result, we see little advantage in arguing for any particular definition of IT research. Instead, we present a range of data relating to IT research. No single piece of this data is authoritative in its presentation of what is happening in IT research. However, since every piece of data paints a qualitatively similar picture of steady globalization, we are confident that this picture substantially applies to any plausible definition of IT research.

5.2 Worldwide Distribution of IT Research

Insight into the distribution of IT research can be gained by looking at R&D expenditures, the publication rates of research papers and patents, the international ranking of universities, and the granting of doctoral degrees.

Overall R&D Expenditures

As shown in Figure 2 from the National Science Board's (NSB) Science and Engineering Indicators for 2004, worldwide research and development is concentrated in a few industrialized nations. Of the $603 billion in estimated R&D expenditures in the year 2000 for the thirty OECD countries, fully 85% is spent in only seven countries (Canada, France, Germany, Italy, Japan, United Kingdom, United States) and more than 40% in the United States alone.

Note that all the curves in Figure 2 are trending upward but that research is growing fastest in the countries that currently do the least research. Continuation of these trends will inevitably lead to a more equal distribution of research around the world.

Figure 3 from the NSB (2004) shows R&D expenditures as a percentage of GDP. Comparing the two figures reveals that most of the differences in R&D spending stem from differences in GDP. However, within the G-8 countries, non-defense research and development as a percent of GDP differs by a factor of three between the lowest and highest. It is interesting that these differences have been quite stable over the past twenty years. In comparison to Figure 3, China spends only 1% of its GDP on research, and some small high-tech powerhouses, including Israel and Sweden, spend in the range of 4% and more (see the NSB (2004, Table 4-17)).

These figures aggregate data on many kinds of research and development. Consider the following more detailed information about US government funding of research and development. The US National Science Foundation (NSF) (see James (2005) reports that US government R&D funding dropped from 1.25% of GDP in 1985 to only 0.75% of GDP in 2002. Over this time, research and development in the life sciences remained more or less flat at 0.41% of GDP, but funding for research on technology dropped precipitously, from 0.55% of GDP to 0.24%. As a result, while overall research and development is rising in the United States, the government is not emphasizing technology research nearly as much as in the past. This change of emphasis in the United States is likely to accelerate the globalization of IT research.

Overall Research Publication

The US National Science Foundation compiles statistics on the publication and citation of Science and Engineering (S&E) papers in general. Figure 4 from the NSB (2004) presents the output of S&E articles for various regions and countries.

The picture painted by Figure 4 is broadly similar to the one painted by Figure 2 but focused more on IT research. The principal S&E research contributors are Western Europe and the United States. There has been steady growth of Western Europe's research output that overtook the US output in numbers of publications in the mid-1990s. The research output from Emerging East Asia (Taiwan, South Korea, Singapore, and China) is small but growing rapidly. Given the economic vitality and the strong growth of S&E PhD degrees in this region, it is reasonable to expect East Asia to emerge as a strong new research region.

In addition to the publication of papers, NSF tracks the citations to these papers. This correlates with the quality and influence of the papers coming from various regions which is much more important than mere numbers. This data is summarized in Figure 5 from the NSB (2004).

Here the dominance of the United States is greater, but the same picture of slow and steady globalization emerges. Western Europe is steadily catching up with the United States. Papers from Japan are cited approximately half as many times on average as US papers, and to date papers from Emerging East Asia have even less influence. It will probably take a long time for Asia to catch up with the United States, but it is in the process of doing so.

Another way of assessing the influence of S&E research from various countries is by considering the number of citations in US S&E literature, shown in Table 1 from the NSB (2004). The absolute level of citations may not be all that meaningful because US researchers are more likely to read and cite articles written in English and because they are perhaps more likely to read articles from researchers located geographically close to the United States. However, the relative level compared to other countries should have meaning. The strong stability of the citation percentages of the countries shown suggests that the importance of the research in these countries has changed little on a relative basis between 1994 and 2001.

University Rankings

A large portion of research is carried out in universities, and much of the best research is performed at the best universities. Insight into the distribution of the highest quality research can be obtained from the distribution of the world's best universities. As demonstrated in Table 2, the distribution of the top 100 universities in the world has the same basic form as the distributions in Figure 5 and Table 1. (The data in Table 2 are based on a list of the world's best universities compiled by Shanghai Jiao Tong University in 2004.)

IT Research Publication

Table 3 shows the percentage of the world's computer science publications (as compiled by the Thomson ISI science citation index for the years 1999-2003) along with the percentage of the world's Purchasing Power Parity (PPP) adjusted Gross Domestic Product (GDP), for all those countries that produce more than 1% of either. The table uses PPP GDP rather than nominal GDP because the primary expenses of computer science research are salaries, and PPP GDP is more closely aligned with salary costs in a country.

Unsurprisingly, there is a strong correlation between computer science publications and PPP GDP. However, there are important deviations from this correlation. The principal centers of IT research (United States, Japan, United Kingdom, Germany, Italy, France, and

Canada) generally produce considerably more computer science publications than would be expected from their PPP GDP alone. Some smaller countries including Taiwan, the Netherlands, Greece, Sweden, and Switzerland produce more than twice as many publications as would be expected from their PPP GDP. Singapore and Israel produce 7 and 8 times as much, respectively.

At the other end of the spectrum some countries with substantial PPP GDP (e.g., China, India, Russia, and Brazil) produce relatively few computer science publications. Mexico produces less than one ninth of what would be predicted by PPP GDP, and Indonesia produces almost no computer science publications at all.

From Table 3, it is clear that the correlation of computer science publication is not just with PPP GDP, it is also with leading-edge, high-value-added economies.

PhD Degrees Conferred

The number of S&E PhDs conferred is an indicator of a region's research effort because much of the world's IT research is done at universities by doctoral students. In addition, the number of computer science PhDs is a key factor supporting a region's future ability to perform research because highly trained researchers are the most important foundation for research. Figures 6 and 7 from the NSB (2004) show the rate of Natural Science and Engineering (NS&E) PhD degrees awarded for selected countries.

Particularly striking in these graphs is the recent huge growth of NS&E PhDs in Asia, in general, and China, in particular. This contrasts with the United States and Germany, where strong growth in the 1980s has given way to decline, and also other countries, where there has been steady growth for many years. Changes in the number of PhD degrees suggest that research output will soon rise in East Asia, while stagnating at best in the United States and Germany.

These data are for NS&E PhDs as a whole. Looking more specifically at computer science PhDs, the data is not as comprehensive but suggests similar trends. According to the NSB (2004), there were 7,389 PhDs awarded in mathematics and computer science lumped together in 2000. Of these, 1,832 (24%) were in the United States, while 4,057 (55%) were in the European Union, with 956 in Germany, 800 in France, 760 in the United Kingdom, and 704 in Italy. This data is difficult to interpret because Europe has a higher proportion of mathematics doctorates than the United States, and the data set is missing information about countries in Asia. As a result, the US share of computer science PhDs may well be higher than the US share of NS&E PhDs as a whole.

Figure 8 is taken from the Computing Research Association (CRA) (2004) and shows that, while there has been a bit of an up-tick in the past year, the number of computer science PhDs in the United States has been basically trending downward for many years. Other data from the same survey shows increases in the number of students passing PhD qualifying exams, which suggests that the recent higher level of PhDs may continue. Nevertheless, Figure 8 still stands in marked contrast to the vast increase in graduate education in places such as China and India.

The Big Picture in Research Distribution

The previous data all indicate that the United States has the world's preeminent S&E research effort, followed at some distance by the United Kingdom, Germany, France, and Japan. Looking more specifically at IT research, some smaller countries such as Israel, Singapore, Taiwan, Greece, Sweden, Switzerland, Canada, and the Netherlands stand out as producing a large amount of research in comparison to their size.

The data showing trends over time all indicate that the preeminence of the United States and Europe is waning, and the gaps between countries are narrowing. It is not a question of whether these gaps will narrow significantly, but when. In particular, the data on PhD degrees conferred indicates a rapid narrowing.

For example, if the trends in Figure 6 continue, the number of PhD degrees in China will equal current US levels in 15 years or so. The output (and particularly the impact) of science from China is not yet rising as quickly, but this is not surprising given the assumption that the number of PhD degrees awarded is a leading indicator of scientific output, and the increase in output has not yet fully responded to the major acceleration in Chinese PhD degrees that started ten years ago.

Unless something seriously derails current trends, it seems almost certain that China will be a research center rivaling the United States and Western Europe in importance within twenty to thirty years. The development of critical scientific infrastructure in India is a few years behind developments in China but moving down a similar road.

Figure 5-2

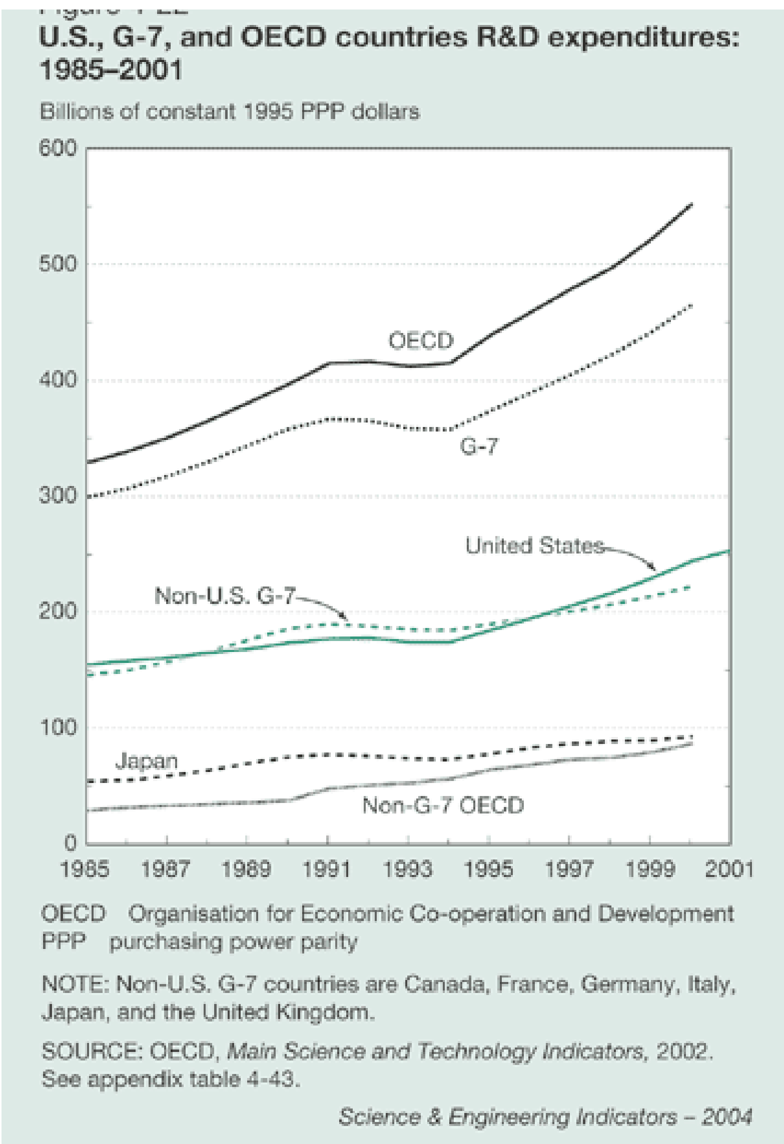
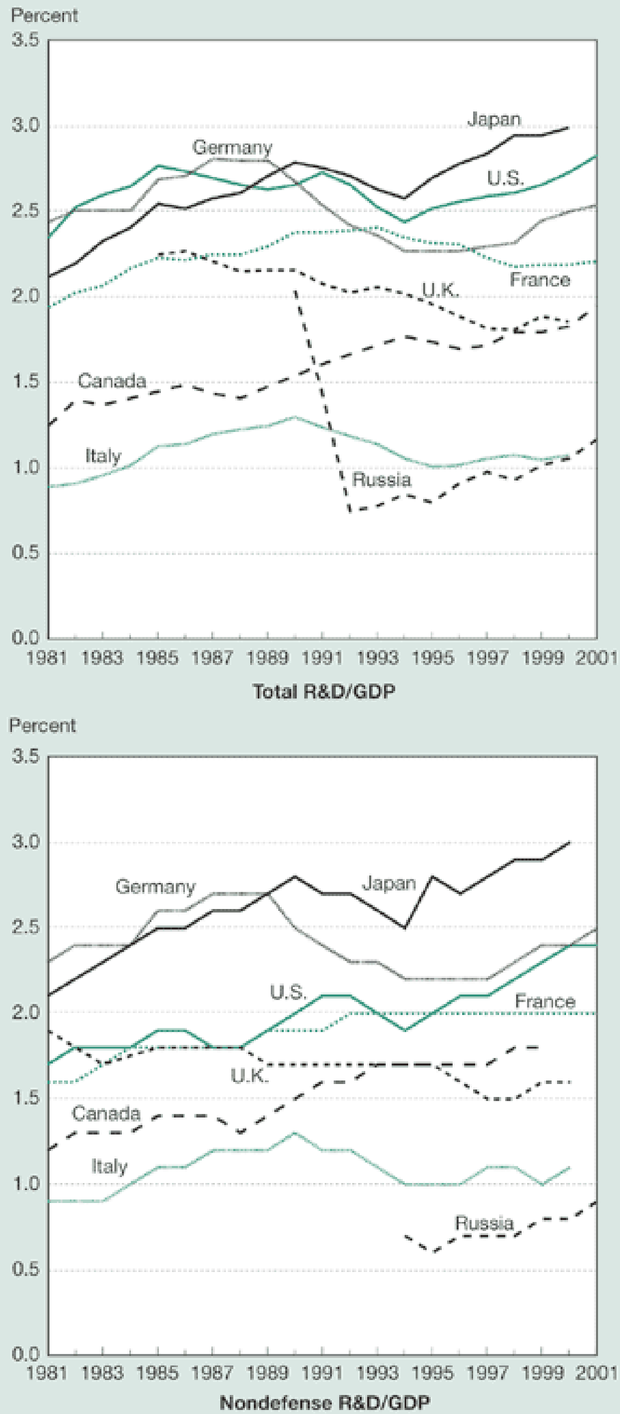


Figure 5-3

R&D share of GDP, selected countries: 1981–2001



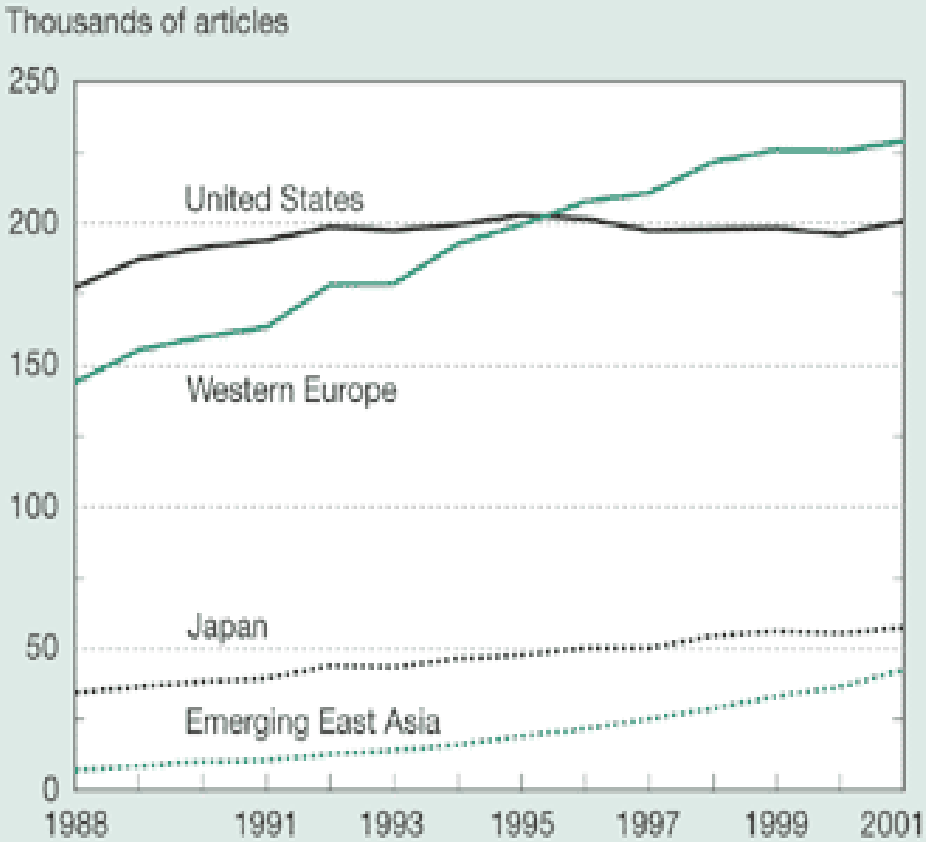
GDP gross domestic product
U.K. United Kingdom
U.S. United States

SOURCE: Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators*, 2002.

Figure 5-4

Figure 5-30

Output of S&E articles by selected countries/ regions: 1988–2001



NOTE: Emerging East Asia consists of China, Singapore, South Korea, and Taiwan.

SOURCES: Institute for Scientific Information, Science Citation Index and Social Sciences Citation Index; CHI Research, Inc., and National Science Foundation, Division of Science Resources Statistics, special tabulations. See appendix table 5-35.

Science & Engineering Indicators – 2004

Table 5-1: Countries whose S&E articles were cited most in U.S. S&E articles: 1994 and 2001

		1994			2001	
Rank		***Country***	***Percent***		***Country***	***Percent***
.						
1		United Kingdom	17.8		United Kingdom	16.0
2		Japan	12.4		Germany	12.7
3		Germany	11.9		Japan	11.9
4		Canada	10.4		Canada	8.9
5		France	9.2		France	8.7
6		Netherlands	4.5		Italy	5.1
7		Italy	4.2		Netherlands	4.5
8		Switzerland	3.9		Australia	3.9
9		Sweden	3.7		Switzerland	3.8
10		Australia	3.7		Sweden	3.2

NOTE: Countries ranked by share of foreign S&E literature cited in U.S.-authored scientific articles.

SOURCES: Institute for Scientific Information, Science Citation Index and Social Sciences Citation Index; CHI Research, Inc.; and National Science Foundation, Division of Science Resources Statistics, special tabulations.

Table 5.2: University ranking. Data taken from Institute for Higher Education, Shanghai Jiao Tong University, 2004, Academic Ranking of World Universities.

Number of top-100 universities in countries					
	In 1st 25	In 2nd 25	In 3rd 25	In 4th 25	In top 100
US	18	17	10	6	51
UK	4	1	2	4	11
Germany		1	2	4	7
Japan	2	1	2	1	6
France		2		2	4
Sweden		1	1	2	4
Canada	1		1	1	3

Switzerland		1	1	1	3
Netherlands		1	1		2
Australia			1	1	2
Denmark			1		1
Finland			1		1
Norway			1		1
Russia			1		1
Austria				1	1
Israel				1	1
Italy				1	1

Source: http://ed.sjtu.edu.cn/ranking.htm

Table 5.3:. The %CS publications numbers are from the Thomson ISI science citation index for the years 99-03. The Purchasing Power Parity GDP numbers are from the US CIA world handbook 2004, see http://www.indexmundi.com/. (This data is graphed in Figure 5.1.)

Country	**% CS pubs**	**% PPP GDP**
United States	32.3%	21.3%
Japan	7.3%	6.9%
United Kingdom	5.9%	3.2%
Germany	5.9%	4.4%
Italy	4.4%	3.0%
France	4.4%	3.2%
Canada	4.2%	1.9%
China	3.9%	12.5%
South Korea	3.4%	1.7%
Taiwan	3.3%	1.0%
Australia	2.1%	1.1%
Netherlands	1.9%	0.9%
Spain	1.9%	1.7%
Israel	1.8%	0.2%
Singapore	1.4%	0.2%
Greece	1.2%	0.4%

India	1.2%	5.9%
Sweden	1.1%	0.5%
Switzerland	1.1%	0.5%
Belgium	1.0%	0.6%
Russia	0.8%	2.5%
Brazil	0.7%	2.7%
Mexico	0.2%	1.8%
Indonesia	0.0%	1.5%

Figure 5-5

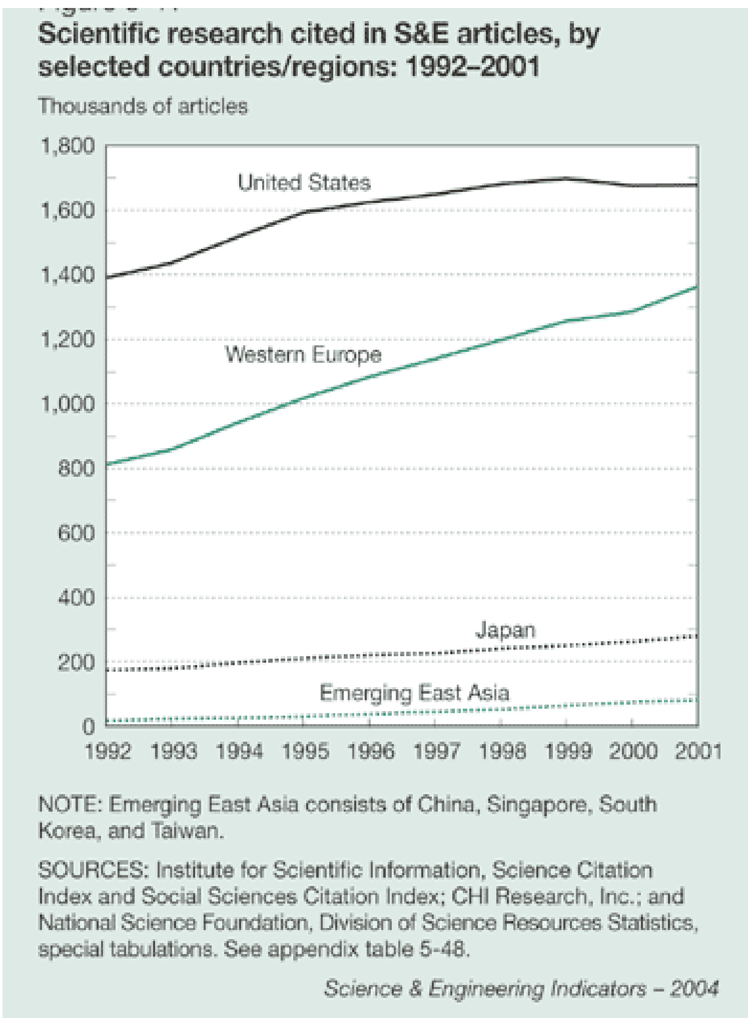
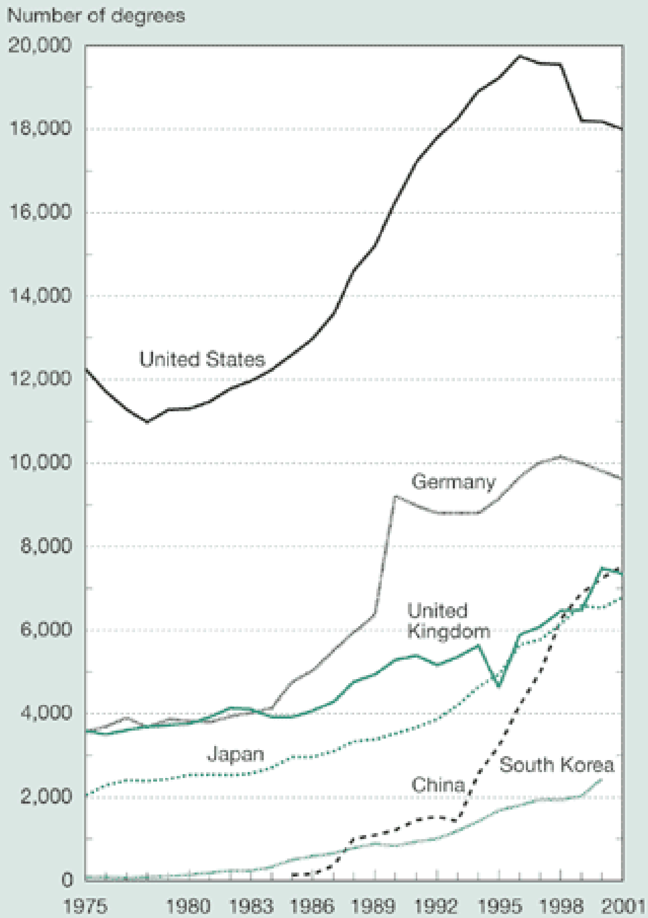


Figure 5-6

NS&E doctoral degrees, by selected countries: 1975–2001



NS&E natural sciences and engineering

NOTE: NS&E includes natural (physical, biological, earth, atmospheric, and ocean sciences), agricultural, and computer sciences; mathematics; and engineering.

SOURCES: China—National Research Center for Science and Technology for Development, special tabulations; United States—National Science Foundation, Division of Science Resources Statistics, Survey of Earned Doctorates; Japan—Government of Japan, Monbusho Survey of Education; South Korea—Ministry of Education, *Statistical Yearbook of Education*, and Organisation for Economic Co-operation and Development, *Education at a Glance 2002;* United Kingdom—Higher Education Statistics Agency; and Germany—Federal Statistical Office, *Prüfungen an Hochschulen*. See appendix tables 2-38 and 2-39.

Science & Engineering Indicators – 2004

Figure 5-7

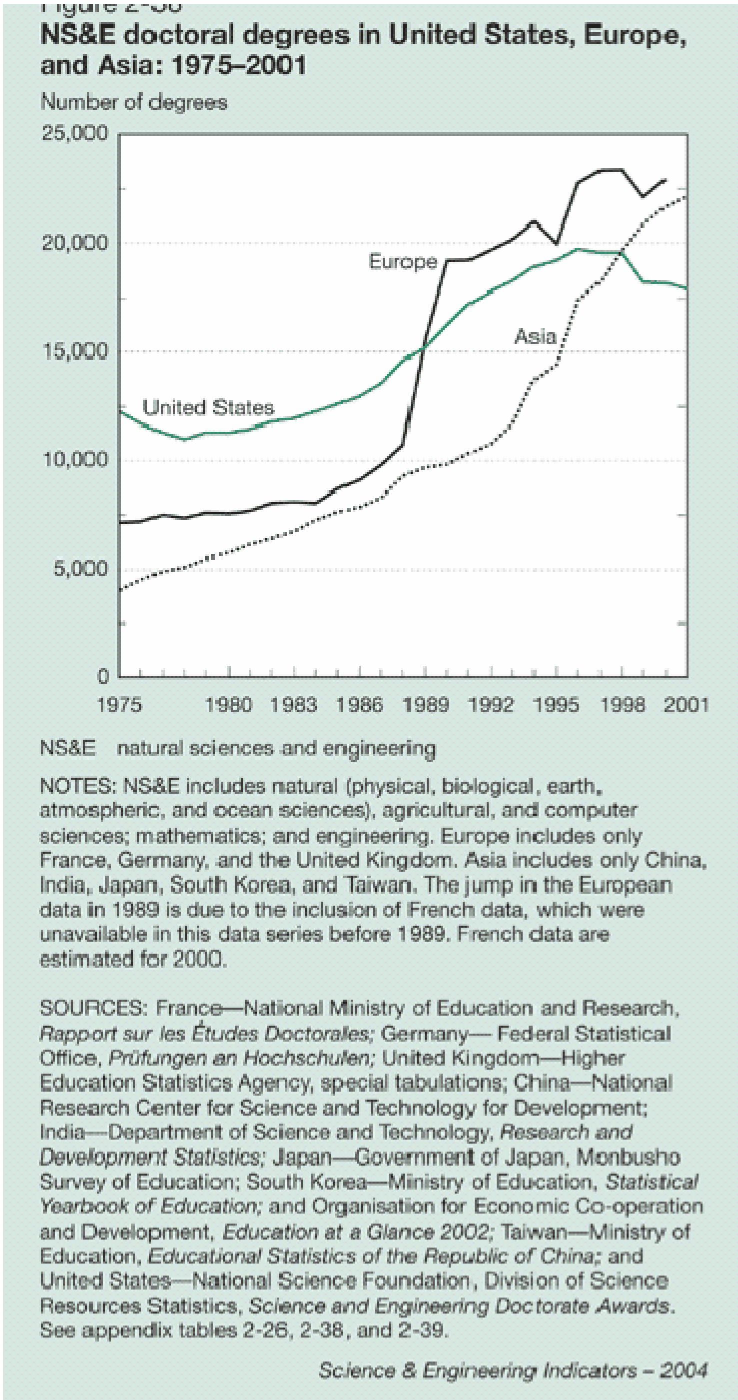
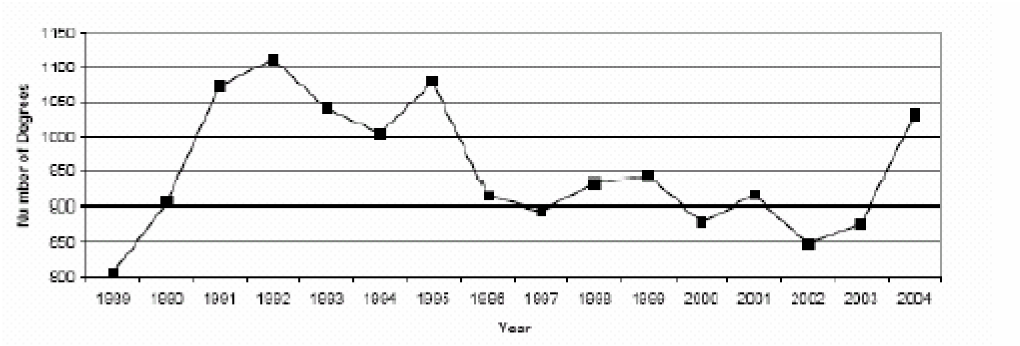


Figure 5.8: PhD Production. 19 forward to fill the gap.bringFrom the 03-04 CRA Taulbee survey.



5.3 Researcher Migration

The knowledge of scientists and engineers can be transferred across national borders easily through the physical movement of the scientists and engineers themselves. This movement can be for a short term or involve permanent migration. Since the beginning of IT research, the permanent in- migration of scientists and engineers from other countries has been a vitally important basis for the dominance of the traditional centers of research. The primary reason for this migration has been people moving in search of better job opportunities. This is aided and abetted by multinational corporations that vigorously recruit permanent employees from overseas.

Consider the movement of researchers to the United States as an example. The National Science Board (2004) reported that, in April 1999, at least 27% of S&E doctorate holders in the United States were foreign born, along with 20% of those with S&E master's degrees and 10% of S&E bachelor's degree holders. These individuals came from a wide range of countries around the world; however, India and China provided the greatest number of transplanted researchers, particularly for PhD-holding immigrants, 20% of whom come from China and 16% from India.

Mobility of Inventors

Manuel Trajtenberg (2004) of Tel Aviv University has done a study of the movement of inventors of US patents between countries during the period 1975 to 1999. He looked at the 650,000 people who are inventors on more than one patent and calculated statistics based on the country they were in when each patent was filed. There were only 20,767 inter-country moves recorded in the data. This means that 3% or less of these inventors are known to have moved. Nevertheless, interesting patterns are evident in their movements.

Figure 9 shows the number of moves per year for each 10,000 US patents filed. The mobility of inventors has increased steadily and markedly, rising eightfold in twenty five years.

Figure 10 tabulates the countries these inventors moved between. The United States had by far the largest net immigration of these inventors. Trajtenberg (2004) argues that the total turnover of inventors to and from a country is even more significant than the net migration because the ebb and flow of people and their ideas is a vital stimulus to research

Whether or not Trajtenberg's conjecture is true, the increasing mobility of inventors is a clear indicator of the increasing globalization of the market for scientific talent.

Students

A major factor in technical migration is students who relocate to study in universities and then remain in the countries where they obtain their degrees. The United States is the most common destination for such students, but a number of other highly developed countries (e.g., in Western Europe) are the targets of significant numbers of students as well. The great importance of this migration of technical talent on research in the United States is discussed in a recent report by the US National Academies (2005).

In 1997, 66% of the people in US universities who received PhDs in computer science held student visas (see the NSB (2004, Table 3-28). By 2001, this number had decreased slightly but was still 63%. These numbers are particularly important because many of these students stay permanently in the United States.

According to Michael Finn (2003) of the Oak Ridge Institute for Science and Education), 56% of 1996 US S&E doctoral degree recipients with temporary visas remained in the United States in 2001. The number of foreign students staying after obtaining their doctorates implies that approximately 3,500 foreign students remain from each annual cohort of new S&E doctorates in all fields. Stay rates differ by field of degree, ranging from 26% in economics to 70% in computer and electrical engineering.

As shown in Figure 11 from the NSB (2004), there has been a significant decline in foreign students coming to the United States in recent years. One can speculate that this is partly due to the restrictive visa atmosphere following the events of September 11, 2001. (The refusal rate for F-1 student visas has risen from 28% to 35%, and the application rate has fallen by 18%.) However, other forces are at work as well. This issue is discussed further in Chapter 8.

International competition for high-quality graduate students is increasing as both advanced and advancing countries seek more foreign talent. Job opportunities are also becoming more widespread in the world. As a result, students now have more choices of where to go to study, and they have more opportunity to stay in or near their home countries.

Figure 5.9: Moves from one country to another for inventors of multiple patents, normalized by the number of patents filed (moves per 10,000 filings).

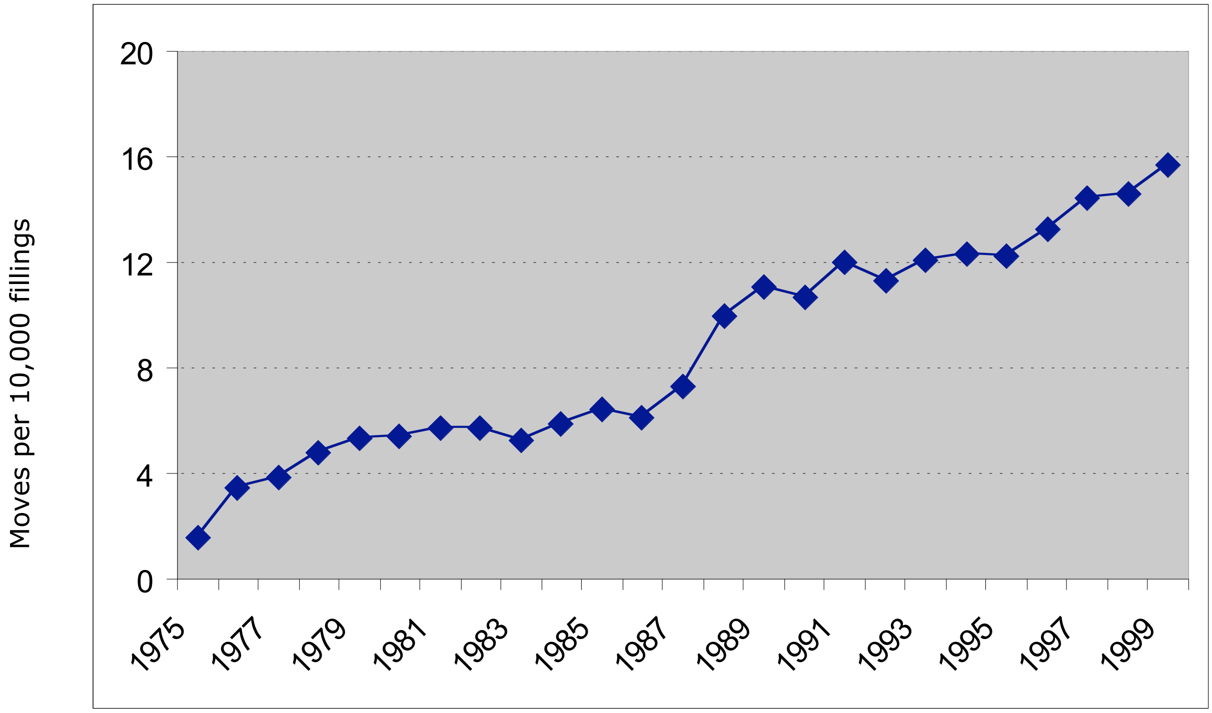
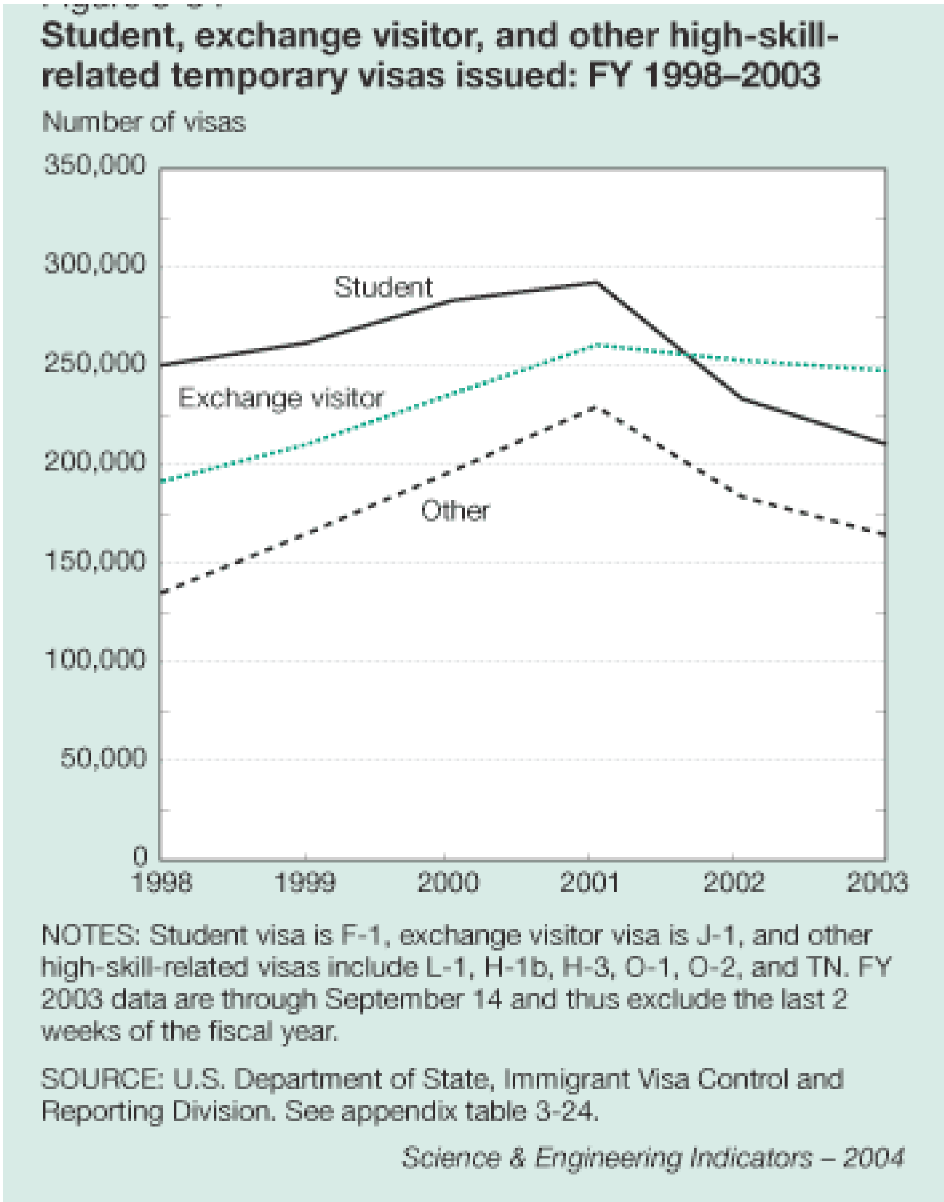


Figure 5.10: Total flows of inventors between countries.

Country	Moves in	Moves out	Net	Turnover
Canada	1392	1554	-162	2,946
Switzerland	702	693	9	1,395
Germany	1551	1701	-150	3,252
France	665	665	0	1,330
UK	2181	2809	-628	4,990
Israel	248	219	29	467
Italy	205	186	19	391
Japan	1114	1244	-130	2,358
Korea	371	270	101	641
Netherlands	453	527	-74	980
Taiwan	275	176	99	451
US	8041	7272	769	15,313

Figure 5.11



5.4 Research Job Migration

The question of exactly what is IT research job migration is fraught with complexity. The standard definition of job migration is that a job migrates from country X to country Y when a company C fires a worker in X that was making product used in X and then hires a worker in Y to produce the same product for use in X. In particular, it is not considered job migration if C hires workers in Y to produce product to be used in Y. It is difficult to apply this definition to research and there are questions surrounding this standard definition that are particularly pointed from the perspective of research.

For one thing, unlike manufactured goods, there is little if any information about where companies that create research use it. One could say that this issue is not as relevant to research as to other kinds of economic activity, but it does not seem reasonable to say that it is totally irrelevant. If a company C opens a lab in China in order to experiment with human-computer interfaces supporting the Chinese language so that C can sell more product in China, is that job migration?

In addition, for much of the history of IT research, the research workforce has been growing in every place where IT research is done. Is it job migration if the workforce in one geographical location merely grows more slowly than it might have? Is it job migration if the only alternative to moving the job from country X to country Y would have been moving a person from country Y to country X to do the job? Here too, there does not appear to be anything other than anecdotal information about what is actually happening.

Due to these difficulties, this section focuses primarily on where research is done rather than on whether jobs have migrated; however, Figure 12 from the NSB (2004) shows that the balance of trade in research is such that the United States exports more research than it imports. Figure 13 from the same report shows that most of the research investment flow into the United States comes from other traditional centers of research concentration and most of the investment outflow goes to these other centers.

These data do not directly address the question of job migration, but they suggest that, to the extent there has been job migration, it has probably been to the United States rather than from it. Since the United States is one of the most expensive places in the world to do research, this job migration is clearly not motivated by a search for low-cost labor.

Why Companies Do Research in Remote Locations

Before considering why companies do research in remote locations, it is important to note what kind of research companies do in their remote locations. There are numerous examples of companies that have moved their primary manufacturing, or even all their manufacturing, to distant places. However, there are very few examples of companies that have done that with research. In general, distant research labs are relatively small satellite operations focusing on specialized areas. That is to say, companies that have distant labs typically have much larger labs in their home areas that are the backbone of their research.

Focusing on IT research in particular, there are anecdotal reports of recent start-up companies in California that have all of their technical operations, including research, in India. However, other than that, we are not aware of any company in the IT business that has a primary research lab (as opposed to a satellite lab) in a distant location nor are we aware of any company in the IT business that is thinking of opening such a lab. It seems entirely likely that there will be primary IT research facilities in places such as India and China, but that will be because these places will have major IT companies that chose to have primary IT research facilities in their home areas just as Japanese companies in the IT business chose to do decades ago.

It is useful to distinguish two quite different cases of companies opening labs or utilizing independent research labs in distant locations: (a) companies opening research labs in the traditional centers of IT research concentration and (b) companies opening labs in other locations. As noted previously, it appears that to date (a) has been more common than (b). However, it is hard to imagine that (b) will not also be important.

Dalton and Serapio (1993, 30) present an interview survey of senior R&D executives of Japanese electronics companies, which found the following to be important reasons to open research labs in the United States (in no particular order).

1. Keep abreast of technological developments.
2. Help the parent company decide what technology to acquire.
3. Cooperate with other US R&D labs.
4. Hire US scientists and engineers.

5. Assist the parent company in meeting US customer needs.

We think this list is entirely reasonable. Note that items 1-3 are central reasons for placing research in an existing center of concentration rather than somewhere else, and they are likely to be key reasons why such centers are self-perpetuating. Item 4 could be interpreted various ways, but, in this case, it can be assumed to focus on exploiting the talent pool in the center of concentration. (Given that US wages were higher than Japanese wages in 1999, It certainly was not an attempt to save on labor costs.) Item 5 is the only item unrelated to the fact that the United States is a center of IT research concentration.

Turning to case (b), here is a comparable list of reasons for investing in research outside the traditional centers of concentration.

1. Take advantage of local offers of cost sharing.
2. Meet local demands for research investment.
3. Hire local scientists and engineers.
4. Assist the parent company in meeting local customer needs.

As discussed in the following, items 1-2 are the result of locations working to attract research to their shores. Item 3 typically involves hiring lower cost labor. As a result, items 1-3 are all indicative of job migration. In contrast, item 4 is identical to the final reason in the list of reasons for case (a). To the extent that it is a dominant reason for the investment, the investment is not job migration in the standard sense.

It appears that research job migration from the traditional centers of concentration to places such as India and China is beginning to become a significant factor. In particular, quite a few R&D labs have been created recently in these countries. However, it is very difficult to pin down how much research job migration has actually occurred because it is very hard to determine how much of the work done in these new labs is actually research as opposed to advanced development.

An interesting model has emerged for staffing labs in places such as China and India where many of the employees are hired locally at wages determined by the economy of the host country, but the key lead research positions are filled with people brought in from outside. Typically these lead researchers are people who grew up in the host country but who were educated in the traditional centers of IT research concentration and gained key research experience there. (For example, the founding head of Microsoft's research lab in Beijing grew up in China, got his PhD at Carnegie Mellon University in 1988, and worked for ten years in the United States before being hired by Microsoft to start their new lab in 1998.) In addition to the natural cultural and familial attractions of returning to their countries of birth, these people are induced to return in part by offering them salaries that may be low by US standards but extremely high by the standards of the local economy.

Making research pay off for a company is difficult, and there is no doubt that this is made even more difficult when a lab is located far from the main operations of the company. However, for the most part, it appears that companies are satisfied with their overseas research operations. Perhaps the strongest indicator of this satisfaction is the longevity of many overseas labs. This is particularly true for case (a) discussed previously, where many labs have a long track record. Given that it typically takes a number of years before any newly-created lab has a real impact on the company that creates it, much remains to be seen about the labs being created now.

Why Locations Seek to Foster Research Activities

For a country to have companies that are at the forefront of innovation is generally seen as essential for robust economic growth in the long-term. To be at the forefront of innovation, a location must have access to cutting-edge research and have a workforce capable of utilizing it. Fostering research helps both of these prerequisites. It creates cutting-edge technology and it hones the skills of cutting-edge personnel.

The importance of research in and of itself is demonstrated by Figure 14 which shows nine industries, each worth at least a billion dollars, spawned by IT research. Research contributed to each of these fields in the early stages of their development. In these important cases, government funding was critical to funding the research and establishing the industry. (In some other important cases, industry provided the initial funding.) In the cases described in Figure 14, the initial research phase was followed by industrial research and culminated in a new industry in the sponsoring country. It is beyond the scope of this study to untangle the complex interplay between basic research, customer requirements, product development corporate research, and government. The main point is that research is a driver of major economic development, and government funding has historically played an important role in priming these developments.

Creating cutting-edge personnel is probably just as important as creating new technology. Even if a location would be happy just to import research to incorporate into products it makes rather than to import whole products from other areas, importing research is easier to talk about than to do.. To import and effectively use research, you have to have people that understand it fully. One of the best ways to do this is to have a research lab that is participating in the research area because researchers in the area are in an optimal position to find out about and understand what is happening at the research frontier of that area.

Typically, the goal of a location is not research job immigration but rather the positive benefits to be obtained from homegrown research used at home. The end goal is a vibrant local industry fueled by local research rather than being an exporter of research. When a location fosters research, it has an important goal focused on job creation. However, this goal is focused on the many jobs that can be created by a general increase in economic activity that is sparked by research rather than on the relatively few jobs that are involved in the research itself.

What Is Needed to Foster Research in a Country

Quality researchers and the money to hire them are critically important in fostering research. High-quality equipment along with a high-quality communication infrastructure is also required, but, in contrast to many other areas of science and engineering, IT equipment and infrastructure have relatively low cost. Moreover, battles in the marketplace during the dot-com boom led to a world-spanning broadband communication infrastructure that is widely (though not universally) available with costs driven rapidly down because of excess capacity. Without any connection to products or product development, it is hard to visualize good research except in the most academic sense. For example, much of the Xerox PARC work and the IBM work on relational database and RISC technologies, both seminal efforts, were driven by a desire to introduce new products. While equipment, communication infrastructure, and relation to product development are all important to research, we will focus here on the importance of personnel.

To host research, a location needs to produce, retain, and attract quality researchers. To produce quality researchers, a location must have first-class education through IT graduate school. To retain quality researchers, a location must have a good work and living environment, and good opportunities for researchers. To attract quality researchers to move to a location, the location must have a very good work and living environment, and very good opportunities for researchers.

The traditional centers of concentration of IT research have prospered in a self-reinforcing way by being among the world's best places for education, work and living environment, and researcher opportunity. Multiple reinforcing cycles perpetuate this. The presence of good research in universities both improves graduate education and attracts better students. These two factors act to produce better researchers. Researchers have a tendency to stay where they are educated. The more research there is in an area, the more opportunity there is for researchers. Research leads to increased economic activity, which improves work and living environments.

Locations that want to become centers of research concentration need to invest in improved education and infrastructure as well as direct support for research. In some cases they also need to induce foreign companies to open research centers, for example by offering tax incentives or by making it a requirement of doing business there.

As discussed in Newman et al. (2004), many countries are investing large sums in higher education. In addition to this expansion of homegrown universities, some US universities (particularly for-profit ones) are beginning operations in other countries. All told, in the world as a whole, the number of students studying in college and graduate school more than doubled from 40 million in 1975 to 80 million in 1995 and is continuing to grow rapidly.

An interesting aspect of IT research is that the largest traditional centers of concentration are all in English-speaking countries, so English is very much the common language of IT research. As a result, it is of benefit for a location seeking expanded IT research to speak English (at least for work in IT). For instance, some German universities are now teaching all their IT classes in English in order to provide better opportunities for their students.

There are long lead times in the various steps mentioned in this chapter, so the rate of change is slow. Patient application of resources is required over decades before the reinforcing cycles discussed can come into play. However, there is ample evidence that a location can make strong progress given sufficient time and effort. This can be seen, for example, in the experiences of many state university regions in the United States such as the Research Triangle in North Carolina.

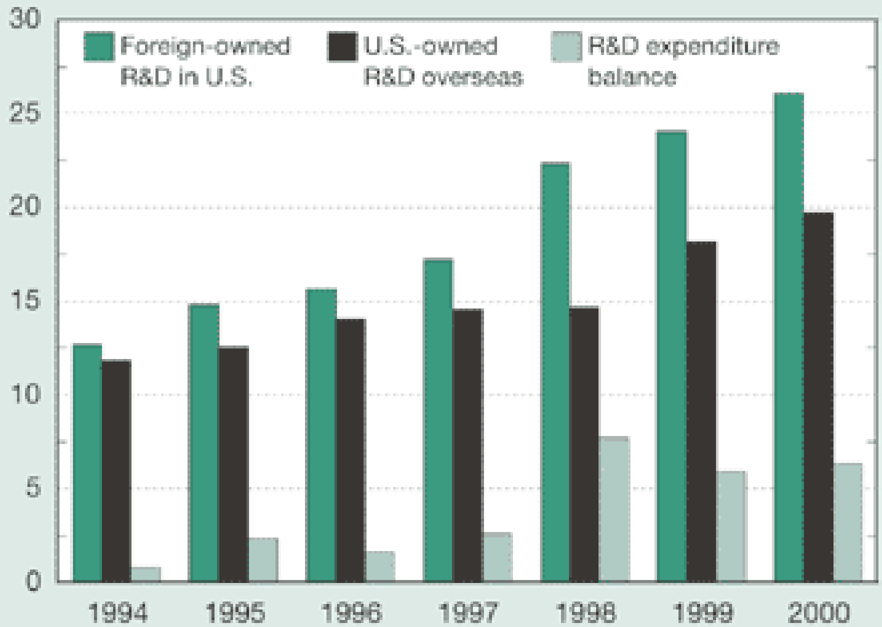
Particularly notable are small countries (including Switzerland, Sweden, Israel, and Singapore) that have historically supported research to a high degree and reaped ample rewards from doing so. For instance, Sweden has consistently provided some of the world's highest per capita levels of government support for higher education (currently 0.8% of GDP, more than twice US levels) and research (1% of GDP, nearly twice US levels). This has yielded consistently high levels of research as demonstrated by per capita publication rates that are among the highest in the world (nearly twice US levels) and other criteria (see Vinnova (2004)).

There is ample anecdotal evidence showing the benefits that accrue to a location that fosters research. Given the large amounts of money and effort being expended by many countries, there is little doubt that they feel that this is very important. This may well be a prime area of competition between countries in the 21st century.

Figure 5-12

Foreign-owned R&D in United States, U.S.-owned R&D overseas, and R&D expenditure balance: 1994–2000

Billions of current U.S. dollars



NOTE: R&D expenditure balance equals foreign-owned R&D in the United States minus U.S.-owned R&D overseas.

SOURCES: U.S. Bureau of Economic Analysis, *Foreign Direct Investment in the United States*, annual series; and U.S. Bureau of Economic Analysis, *U.S. Direct Investment Abroad*, annual series. See appendix tables 4-49 and 4-51.

Science & Engineering Indicators – 2004

Figure 5-13

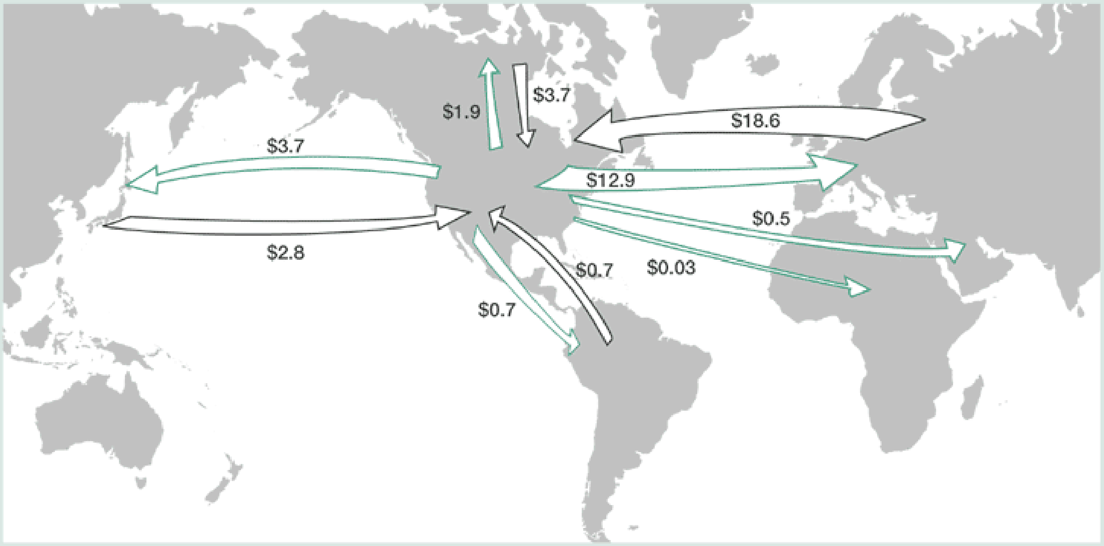


Figure 4-34
Foreign-owned R&D in United States and U.S.-owned R&D overseas, by investing/host region: 2000
(Billions of current U.S. dollars)

SOURCES: U.S. Bureau of Economic Analysis, *Foreign Direct Investment in the United States*, annual series; and U.S. Bureau of Economic Analysis, *U.S. Direct Investment Abroad,* annual series. See appendix tables 4-49 and 4-51.

Science & Engineering Indicators – 2004

Figure 5-14

From *Evolving the High Performance Computing and Communications Initiative to Support the National Information Infrastructure*
Information about this publication can be found at **http://cstb.org/pub_hpcci**
Read it online: http://www.nap.edu/books/0309052777/html/index.html (Figure 1.2, page 20)

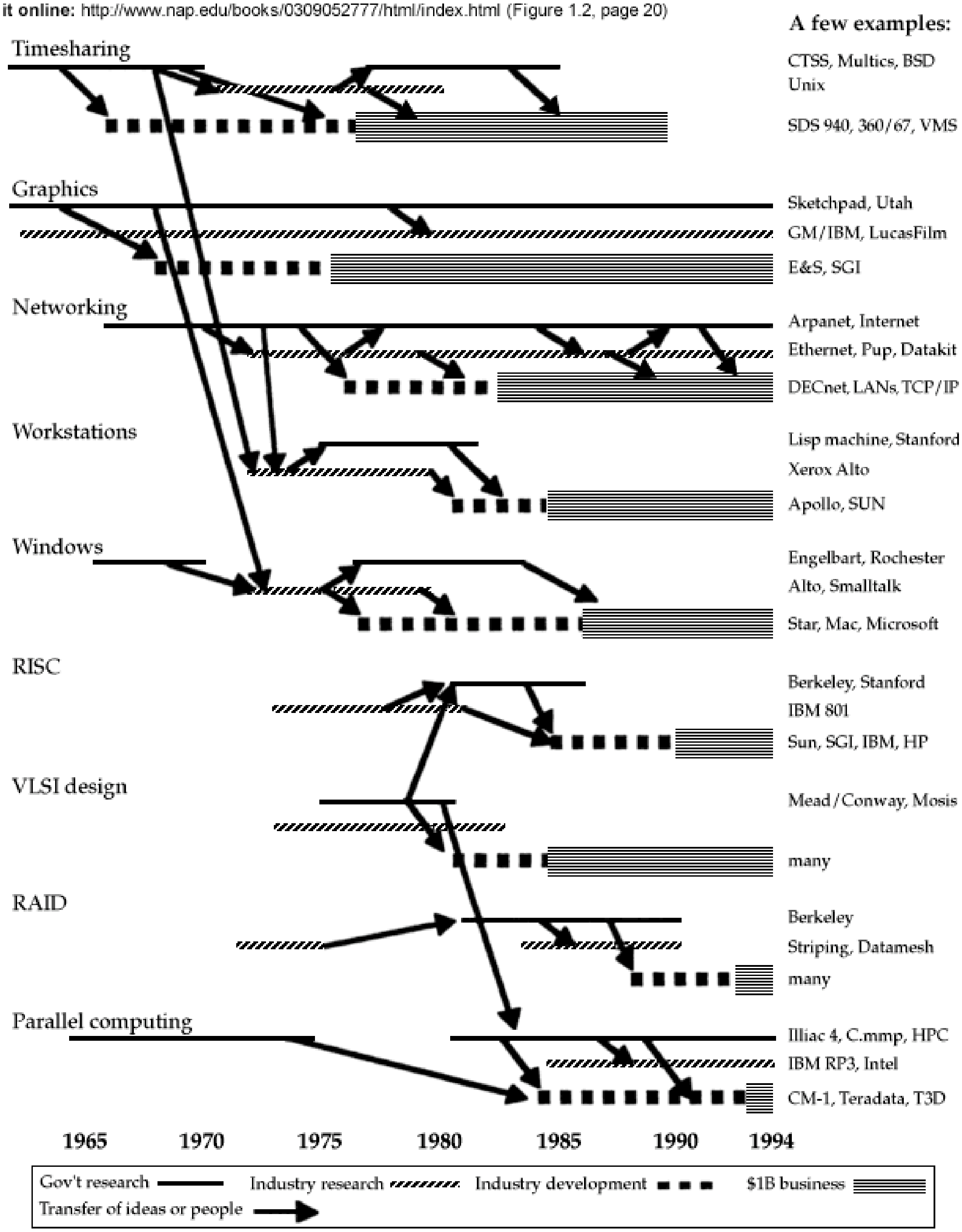


FIGURE 1.2 Government-sponsored computing research and development stimulates creation of innovative ideas and industries. Dates apply to horizontal bars, but not to arrows showing transfer of ideas and people. Table 1.1 is a companion to this figure.

5.5 Conclusion

IT research is steadily, and almost certainly inevitably, becoming more global. This will bring strong advantages to those locations that are now entering the IT research main-stream. Because this is happening in the context of a general worldwide growth in IT research, these benefits will not necessarily come at the expense of the current centers of IT research. However, these current centers are faced with an important choice. They can continue to be strong supporters of IT research and compete vigorously in which case they should be able to continue as influential centers of IT research. However, if they choose to ignore the growing global competition, the world may pass them by and relegate them to second-class status.

5.6 Bibliography

James, J. 2005. Losing the Competitive Advantage? *The Challenge for Science and Technology in the United States. American Electronics Association.* http://www.aeanet.org/publications/IDJJ_AeA_Competitiveness.asp.

National Science Board. 2004. Science and engineering indicators 2004. *National Science Foundation.* http://www.nsf.gov/sbe/srs/seind04/start.htm

Computer Research Association. 2004. *2003-04 Taulbee Survey*. http://www.cra.org/statistics/

Institute for Higher Education, Shanghai Jiao Tong University. 2004. *Academic Ranking of World Universities*. http://ed.sjtu.edu.cn/ranking.htm

Committee on Policy Implications of International Graduate Students and Postdoctoral Scholars in the United States, Board on Higher Education and Workforce. 2005. *National Research Council.* Policy implications of international graduate students and postdoctoral scholars in the United States.

Trajtenberg, M. 2005. Retaining the competitive edge in the era of globalization. *The IEEE International Conference on Software - Science, Technology and Engineering*. Herzlia Israel (Feb.). http://www.iltam.org/SwSTE05

Finn, M.G. 2003. Stay rates of foreign doctorate recipients from US universities 2001. *Oak Ridge Institute for Science and Education*.

Dalton, D. and Serapio, M.. 1993, Foreign R&D facilities in the United States. *Research Technology Management*. www.technology.gov/Reports/report2.pdf.

Newman, F., Couturier, L., and Scurry, J.. 2004. *The New Competition, In The Future of Higher Education: Rhetoric, Reality, and the Risks of the Market*. John Wiley & Sons.

VINNOVA (Swedish Agency for Innovation Systems). 2004. *The Swedish National Innovation System 1970-2003: A Quantitative International Benchmarking Analysis.*

Authors: L. Jean Camp, Seymour Goodman*, Charles H. House*, William B. Jack, Rob Ramer*, Marie Stella

Chapter 6: Offshoring: Risks And Exposures

6.1. Introduction

In June 2005, the news media reported that some 40,000,000 credit card accounts at CardSystems of Phoenix, AZ, had been compromised by an infiltration. "The intruder gained access to names, account numbers, and verification codes critical for committing fraud. A MasterCard spokeswoman said the company was aware of information being removed from the CardSystems database on about 68,000 MasterCard accounts, putting those cardholders at a higher level of risk." Pacel and Sidel (2005). (Also see Computer Security Institute (2005) for a more detailed analysis.)

By mid-year 2005, there was a wave of security breaches and lapses that calls into question the security of electronic financial and commercial transactions. Australian and British press reports identified a black market in India for personal information gleaned from financial offshore processing centers. Consumer complaints led to the arrest of employees at a center processing Citicorp data in Pune, India. Officials at the UK National Infrastructure Security Co-ordination Centre revealed that "hackers, often linked to the Far East, were attacking vital UK government and corporate computer networks, seeking commercially and economically valuable information. The revelations show that computer viruses released via the Internet increasingly are being used to garner confidential information, ranging from personal banking details of consumers to industrial espionage." US investigators concurred, noting that US institutions have suffered similar attacks for "at least a few years . . . mostly from computers in China." (Europe WorldWatch 2005).

Some people suggest that these are simply cases reflecting the true risks of the digital age with the implication that outsourcing and offshoring are minor additions to the mix. This chapter argues, instead, that offshoring exacerbates existing risk and introduces new types of risk by opening more opportunities for incursion, accident, or exposure; and it may greatly complicate jurisdictional issues. This concern does not lead to a wholesale condemnation and rejection of offshoring but rather to the recognition of the inadequate attention so far paid to these risks. We hope that the issues raised here will lead to greater awareness and thus to more prudently cautious, thoughtful, and effective practices in preventing and dealing with these risks.

Offshoring decisions are largely business decisions and are often little influenced by consideration of long-term risks, political consequences, or social impact. Many corporations would argue, not unreasonably, that they do consider some long-term risks such as to reputations, and they should and do consider risks that directly affect their business operations, but that it is not their job to consider the social impact or possible political or larger national security consequences of their offshoring decisions. But somebody, most obviously government, needs to consider these impacts and consequences.

So it follows that the risks examined in this chapter come in three categories. There are risks for companies that engage in offshoring. There are risks to individuals who are innocent and often helpless victims of the kinds of security compromises just described. Much of this is in the form of privacy violations or identity theft. Finally, there are risks to the defense and economic security of nations.

*S. Goodman, C.H. House, & R. Ramer took a leadership position in the writing of Chapter 6.

Given the subject matter and the rapidly growing number of security and privacy violations experienced in cyberspace, this chapter is by its nature inclined to sound alarms and encourage caution. Risks in cyberspace often have to be presented as possible or plausible scenarios, independent of the extent to which they have occurred so far. It is generally impossible to find accurate and comprehensive statistics on attacks and their results, although it is clear that there is a lot going on, and many experts agree that the problem is growing. Given the paucity of evidence, risks are discussed here in terms of the relatively few examples that become public. Those who do not want to deal with these risks for whatever reasons typically argue that the risks should not be taken seriously until there is compelling evidence that the risk is real. The variety and extent of malicious activity in cyberspace has often been underestimated in the past. Unfortunately, many of the forecasted risks have come true. Spamming and phishing, for example, now make up a majority of the traffic on the Internet. One dangerous risk, the use of the cyber infrastructure to launch devastating attacks against national and international physical infrastructure, such as transportation or electric power systems, has not yet been realized. But this does not mean that vigilance is not needed.

Few of the risks to be considered here are unique to offshoring. But, depending on various factors such as the laws in the countries involved, the risks may be significantly amplified by aspects unique to the international nature of the attacks. For example, they may take the form of exposing potential victims to a larger population of possible criminals who are not likely to be held very accountable for the harm done to citizens of another country, or that parts of the lengthened and expanded channels of the operation are under little or no effective control by either the procuring or providing company or their parent countries.

Most of the information used in this chapter comes from US sources. Many experts believe that the risk of cyber attacks is significantly under-detected and under-reported in the United States. These problems of detecting and reporting appear to be far worse in the rest of the world. The reasons for this are not hard to understand and probably reflect that their citizens are not often victims of cyber-crimes, that it is difficult to find and train (and pay) capable people to collect such information and carry out investigations, and that almost any other form of crime probably has higher priority for the limited law enforcement resources available in many populous, poor countries. We were also limited by an inability to obtain and deal with locally published, non-English source material. Thus much of our coverage is about attacks on companies and individuals in the United States. There is some justification for this coverage. In particular, the United States offshores more work than any other country. But it should be clear that individuals and firms around the world, not only in the United States, are vulnerable to cyber attacks, and attackers can just as readily be located in the United States as in some other country. Similarly, all governments that use information technology in their critical infrastructures must face the possibility that this technology can place their national systems and national security at risk.

6.2. Vulnerabilities: Data and Network Security and Beyond

A basic principle of security is that, the longer the supply chain and lines of communication, the more opportunity there is to attack them. The adage that a chain is only as strong as its weakest link often applies as the complexity of securing computer networks is increased by routing through multiple providers. The inherent complexities in international data communications are further compounded by jurisdictional issues regarding regulation and legal responsibility.

Commercial or organizational alliances in the modern world rely on integrating the computer systems of their allies or partners to some degree. Manufacturing companies integrate suppliers into their supply chain systems. The transportation, warehousing, and sales systems of the distributor are linked with those of the manufacturer. These linkages may open up additional vulnerabilities in both systems. Martin Libicki, in a forthcoming book, identifies these as *systems intimacy* issues. He states, "Close relationships in cyberspace, as in real life, can make either partner more vulnerable. A relationship, solely by virtue of the value it brings to its partners, may be attacked by the competitors of both. Third parties can exploit weaknesses in one to get at the other(s)." (Libicki 2006).

Outsourcing in general involves an even greater degree of intimacy because entire business processes may be entrusted to the partner, and this often entails a greater degree of system integration. Software development outsourcing is perhaps the most intimate relationship of all because it constitutes a continuing impact and often access to the procurer's system long after the initial work is complete. Offshoring is an extension of this intimacy across and through multiple national and international data networks under the jurisdiction of multiple parties who may or may not be hostile to the commercial and national interests of both the providing and procuring parties.

Offshoring risks can be categorized into systems intimacy risks and outsourcing risks. They include the following types of vulnerabilities.

Systems Intimacy Risk

- *Data communications vulnerabilities.* Communication channels include multiple service providers of various nationalities. The channels are well beyond the control of either the procuring company or the provider. Usually they are private leased lines, which means that a certain capacity is dedicated to the buyer, but there is no guarantee that the line is indeed private in the sense that others are not listening. These channels are often not encrypted, or encryption is entrusted to the control of the communications service provider. If encryption is provided, it may not include end-to-end transaction encryption, thus leaving data exposed at certain points along the communication path.
- *Loss of control over network perimeters.* A link with an Offshore Development Center (ODC) opens a broadband communications channel directly into the procuring company that could then become dependent on the ODC for user authentication. In one situation, security at an ODC was so notoriously lax that its internal web servers were listed on hacker websites as useful hosts from which to mount denial-of-service attacks. Users at that ODC were also vulnerable to attackers hijacking their sessions to penetrate the ODC's client network (Ramer 2004).
- *Increased network complexity.* Network configuration management in an expanding and ever-changing environment challenges most IT security capabilities. Understanding the flow of critical transactions becomes almost impossible when an ODC is thrown into the mix. If the development center produces software for multiple procuring companies and does not effectively isolate the networks dedicated to each procurer, configuration management approaches the impossible. Validating the security of trusted partners in a multi-client, multi-vendor, mixed environment is a similarly difficult task.
- *Clashing security strategies.* The procuring company and the ODC may take varying approaches regarding known vulnerabilities, intrusion detection, perimeter defense, or other security issues. These discrepancies could create vulnerabilities for both the procuring company and the offshore provider. For example, the procuring company could rely on very strict access control limiting users to only those files that they need. Let us assume that the providing company relies on very strict two-factor authentication but, once the resource proves he (or she) is an authorized user, he is allowed relatively free range

within the system. This situation could present a threat to the provider. A disgruntled employee of the procuring company could access the provider's system and plant malicious code. Or the malcontent employee, such as someone about to lose his job to offshoring, could use the provider's system to launch an attack on the procurer and thus create problems for the relationship that he blames for the loss of his job.

- *Gaps in personnel security.* High turnover in rapidly growing IT industries, such as is occurring in India and the Philippines, leads to administrative stress. Even in India, perhaps one of the better prepared of the offshoring destination countries when it comes to security, many companies still have weak personnel policies (NASSCOM-Evalueserve 2004). There is often a lack of personnel security infrastructure such as searchable credit records or criminal databases (Bhat 2002).
- *Drastically diminished ability to know about and respond to security breaches.* Without strict and enforceable contract provisions, an offshore provider has little incentive to notify its clients that they have had a security breach. Even if it does, the jurisdictional and organizational issues make effective incident response extremely difficult.

Outsourcing Risks

- *Loss of control over security of software development.* When a company has its software produced in an ODC, it defines the performance requirements but relinquishes day-to-day control over software development to the overseas vendor. Clients spend hundreds of thousands of dollars testing software applications to ensure that they meet requirements. Rarely, however, do security departments inspect the code for trojans (malicious software disguised as legitimate software), viruses, or other forms of malicious code that perform threatening or illicit activities. Virus scanners identify and sanitize widely known viruses, but they will not find code specifically designed to sabotage or provide particular information. Viruses are increasingly targeted at obtaining commercially valuable information, ranging from consumer banking details to industrial espionage (Symantec 2005). The risk of embedded malware is enhanced by offshoring due to factors that may include less personal loyalty from offshore contractors than from employees or onsite contractors, increased vulnerability of the supply line, and increased potential for intervention by hostile covert groups such as government intelligence or organized crime. Even when inspections are possible, it may be difficult to find carefully crafted malware hidden in large volumes of code.
- *Loss of control of business processes.* By outsourcing to any location, a procuring company loses a certain amount of control of the business processes that are outsourced. There is a corresponding transfer of control over the information necessary to perform the process. This loss of control may be exacerbated by communications problems, cultural issues, and lines of communication that are more vulnerable when the work is offshored. Depending on the nature and sensitivity of the work involved (e.g., R&D or network management), this information may be of strategic interest to competing nations and their industries.

What seems particularly lacking within many procuring companies is an overall line of authority and responsibility for primary data records as they pass through one, two, or more offshore companies that perform operational tasks. Offshoring decisions are made based on data management strategies and costs, but responsibility for security is often not considered. This kind of hands-off management responsibility cannot be presumed to work in the best interests of anyone concerned with risk attenuation.

The magnitude of risk is summarized in a Symantec Corporation Internet Security Threat Report analysis covering the period from July to December 2004. This analysis is based on the top 50 malcode samples from output of 20,000 sensors monitoring 180 corporations worldwide (Symantec 2004). One alarming finding was that there was a rise in threats designed to compromise confidential information. Malicious code, including the proliferation of trojans and bots (short for robot, a program that automatically searches the Internet for data), created to expose confidential information or compromise systems, represented 54% of the samples. Remotely controlled trojans and bots constituted 33% of the top 50 malware attacks, one of the most serious threats from and to offshoring. 1,403 new vulnerabilities (more than 54 new vulnerabilities per week) were detected. Of these, 97% were considered moderately or highly severe, meaning that successful exploitation of the vulnerability could result in a partial or complete compromise of the targeted system. Malware, allowing attackers to circumvent traditional perimeter security measures (e.g., firewalls), accounted for 48% of all vulnerabilities.

Offshoring is usually done to minimize expense, but assessments should compare total expense for both a given level of performance and a given level of risk or protection. To date, the comparisons have often been at the performance level without due consideration to the risk factor.

6.3. Corporate Risks and Information Security

Corporate Outsourcing Risks

Commercial risk from offshoring is multifaceted; in today's knowledge economy, information security risk should be a critical issue. There are also operational business issues including productivity, efficiency, and quality. Business managers everywhere struggle with costs, delivery times, and product quality. Geographic and cultural spread can adversely affect delivery times and product quality even as costs seem to be reduced. Communication paths become longer and more convoluted; communication is more apt to suffer distortion and error from language and cultural difference. Supply chain networks become more diverse, less centralized, and hence less controlled. Protection from manufacturing sabotage and theft becomes more difficult because of the size and extent of the system. Intellectual property protection becomes more porous as infrastructure expands on an international scale. Legal barriers and costs increase as companies cross international boundaries, due to conflicting regulations, procedures, and practices. Safety issues loom large, exacerbated by decentralized operational logistics.

COMMUNICATION

All business depends on reliable, consistent, and clear communication. Manufacturing processes rely on explicit process steps that companies strive to iterate and perfect. Marketing relies on clear and concise descriptions, as well as emotional appeal. A sales department relies on brand, trust, and perceived value. Contracts between procurer and provider rely on all of these, along with some additional complexities. Disputes inevitably arise, and trust is taxed; quality and deliveries will occasionally be compromised; and legal language will be at best a palliative for a situation suddenly gone awry and not easily remedied.

The effectiveness of each of these communication attributes may be strained by physical and legal distance and by cultural difference. Brand names in one country or language may have an altogether different meaning, even pejorative, in another. Trust in a brand can be damaged by local events that can have much wider ramifications. *Copy exactly* is a terrific concept for manufacturing, but if the instructions are in one language, and the operating crew is literate in another, it may be hard to accomplish.

Sometimes the results can be catastrophic. The Union Carbide process control plant disaster in Bhopal, India was caused by a faulty check valve that likely could have been found by a maintenance team if they had been properly coached, but it killed twice as many people as the September 11 terrorist attacks in the United States and wounded 100 times as many. Many other semiconductor, chemical, pharmaceutical manufacturing, and agricultural processing plants present such risk (Wikipedia). The damage to corporate reputations can quickly outweigh cost advantages.

Companies with daily global interaction, for example, Boeing and Airbus, have a related issue. Whenever a new safety finding occurs, it is imperative to reach the ground support crews at every airport where its planes fly – which is to say, almost everywhere in the world – as soon as possible (Flug-review). Moreover, it must be done with clear, precise, understandable diagrams and instructions. It should not be surprising to learn that Boeing and DuPont each publish more distinct pages of engineering text annually than any other organization on the globe. Only the electrical engineering professional society (IEEE) rivals them. Most companies do not have communication problems of this magnitude, but they lack sophistication in their communication structures. Email, so often relied upon in today's business world, is a notoriously poor mechanism for establishing and maintaining precision. Video and voice conferencing systems lack archival capability, focusing almost completely on the meeting as opposed to the result. Consequently, Deloitte and Touche's recent report on negative experience with offshoring lists *complex governance/management attention* as the leading dissatisfaction issue; this is a clear result of inadequate communication mechanisms (Deloitte and Touche 2005).

Many people have observed that as a company grows linearly in size, its communication paths grow geometrically. From Fred Brooks' observations (1995) about the optimal size of a software development team to Tom Malone's comments (2004) about corporate communication, it has been long established that expanded staff size and extended geography may adversely affect communications, and therefore the effectiveness of human transactions. Communication difficulties are not just due to offshoring; an MIT study found that once people sit in separate buildings (even on the same site), their communication paths seriously erode. This rule also applies to people sitting on separate floors in a skyscraper. What is different in offshoring is that the people on the other end have much less historic cultural alignment and, if they are working for a provider company, perhaps much less allegiance to the procuring company's overall mission and goals as well. Small wonder that the previously mentioned Deloitte report (2005) cites *limited transparency* and *loss of knowledge* among the top five issues.

Manufacturing sabotage and theft

Manufacturing sabotage and theft are not large issues for offshoring situations since their costs are absorbed by the provider. They may affect deliveries, and they will certainly affect ultimate costs, but upfront they are not particularly significant issues. On the other hand, for offshore facilities that are part of a multinational company, sabotage and theft have proven on occasion to be very significant. In order to understand manufacturing or services sabotage, the context must be considered. The question needs to be considered whether this is a problem in general that is merely exacerbated by the corporation's size and breadth, or whether the problem traces specifically to something inherent in the offshoring model. For example, there are instances on record where foreign nationals working on H1-B visas in the United States have stolen intellectual property just as there are instances of American or European workers doing the same thing. Whether there is a higher risk of intellectual property theft if one hires foreign nationals is an open question.

INTELLECTUAL PROPERTY (IP) PROTECTION

IP issues occur at several levels. Many nations do not respect other nations' patents or copyrights; most require that individual patents be filed in their country. The costs of this country-by-country protection are high; the protection afforded is variable. The most notorious countries from a software standpoint seem to be in East Asia and Eastern Europe (Alexandrov 2005).

Loss of knowledge is cited as the fifth most significant issue in the Deloitte report; *vendor employee turnover/training* also is a high concern. These topics are broader than IP protection since they include lore, trade secrets, and company processes. IP protection is a risk with all outsourcing; the broader topics are more apt to become issues with offshoring (Deloitte and Touche 2005). The entertainment industry and the software industry, both groups whose major products are contained in codified, digitized sets of bits easily accessed, purloined, and redistributed on the Internet, are plagued internationally by illegal copying, sometimes referred to as software piracy.

The US Digital Millennium Copyright Act (DMCA) of 1998 is a good example of an attempt to legislate intellectual property protection in a way that was at odds with emerging technical capabilities. Such legal attempts to thwart the pressure of new methods are referenced by many hackers as justification for their actions (Electronic Entertainment Policy Initiative 2005; Gantz and Rochester 2005). Sometimes companies strike interesting partnerships with individual countries, and sometimes countries single out companies for sanctions. Microsoft, as the largest software vendor in the world, often has faced such dichotomies, for example, fighting with the European Union to control source code, while, at the same time, providing source code to the Chinese government and acceding to Chinese rules about use by Chinese citizens and organizations in order to gain entry into the Chinese market (Associated Press 2005).

LEGAL BARRIERS AND COSTS OF OFFSHORING

In order to offshore work, companies face a long list of issues about international trade including trade barriers, tariffs, taxes, import and export restrictions, currency hedges, and transfer of partially completed assemblies versus full products, etc. The hidden costs associated with all of these covenants and requirements can be high. The Deloitte report (2005) focuses on this issue and singles out two topics in the top ten, namely, *cost savings questioned* is sixth on the list and *hidden costs* is eighth.

Legal contracts consume a lot of time for the offshoring company. Terms and conditions, notably recourse available in the event of differences, are often reported as major difficulties requiring time-consuming, energy-sapping activities. Among the issues of consequence is jurisdiction in the event that things go to litigation. Usually, the offshored vendor's country will have jurisdiction with the expected risk issues that follow as a consequence for the purchaser and disputing party (Deloitte and Touche 2005). Some of these business and legal issues associated with offshoring are discussed in Chapters 1 & 4.

OTHER COMMERCIAL RISKS

Executive and worker exposure – personal safety – has escalated as an issue, particularly for locales of turmoil. Hostages are taken and sometimes killed. Specific activities are targeted for disruption: oil production in Iraq, WTO meetings in Seattle or Beijing, software companies in Belfast, and Israeli technology companies are but a few of the targets. When a *Wall Street Journal* publisher can be targeted for execution in Moscow, who can consider himself safe? Such risks are not unknown in the United States; Charles Geschke, CEO of Adobe, and William Hewlett's son were taken hostage in the 1970's in the Bay area. But a foreign setting, especially in tumultuous areas or in areas where law enforcement capabilities are weak, seems to raise the *non-control* element much higher. A particularly noteworthy case for the IT industry was the German Red Army plans in 1986 to target the chief technology officers of the top 16 multi-national high-tech companies. Only one died before the plan was thwarted by international vigilance (absoluteastronomy.com).

Corporate Information Security Risks

Outsourcing software development or other IT-related business processes often leads to large cost savings or quality improvements especially when the work is done in low-wage countries such as India. At the same time, there are greatly increased risks including financial, performance, reputation, intellectual property, and legal and regulatory exposures. For each of these categories, it is necessary to carefully assess the risk, quantify the potential losses, and develop cost-effective risk mitigation strategies, without which there is no effective risk mitigation. Unfortunately, few outsourcing projects include such assessments.

The financial industry has invested heavily in risk assessment and mitigation. Banks have spent billions of dollars on computer security to guard against fraud and theft. International trade risks in commodities are well known, and many risk mitigation methods are in place from payment mechanisms to insurance (a form of risk transference). Information security risks are regularly downplayed, apparently for three reasons: (1) the failures that have occurred are not public knowledge, (2) the exposures have been of relatively low cost to the companies themselves, and (3) breaches are less tangible than, for instance, ships sinking at sea, physical bank robberies, or highway accidents. Some Indian IT outsourcing service providers have been more publicly concerned about information security than the Western companies procuring their services. Numerous leaders of the Indian IT industry have related that they are concerned about security, but, as business managers, they probably will not invest more in security than is required by their clients (NASSCOM; Ramer 2002-2003).

Procuring companies have been conspicuously quiet about security. This apparently curious fact can perhaps be explained by realizing that, when people perceive a security threat, they act to avoid it or protect themselves against it, but if they do not perceive the threat, they do not worry about it. Procuring companies also downplay information security to avoid the threat of negative public opinion and potential regulation. Both of these responses, while rational in some ways, do not often proceed from a concrete analysis of the actual risks involved in the projects. In contrast, leading Indian provider companies have identified client security concerns as an obstacle to growth and, through the Indian software trade association, NASSCOM, have initiated campaigns to enhance security awareness and change perceptions.

THREATS

Risks turn into incidents through two basic kinds of action, accidents and intentional acts. Many are direct, for instance, a computer system fails on-site, a disgruntled employee sabotages the equipment, a well-intentioned employee makes an error, or an external hacker perpetrates an effective denial-of-service attack. There can also be collateral damage where an external incident or accident causes incursion. While accidents can lead to significant damage, this discussion concerns threat actors. These incidents are arguably the most dangerous of anticipatable incidents because they are carefully targeted. Controls against threat actors also help guard against accidents as well. Accidents caused by human error or acts of nature are an essential part of disaster recovery and business continuity planning that are not in our scope.

We briefly discuss six such threats: rogue employees, hackers, organized crime syndicates, industrial espionage, unfriendly nations, and terrorists.

- *Rogue employees.* Citibank customer complaints of fraud led to the arrests in April 2005 of former employees of a call center in Pune, India. They were charged with defrauding Citibank account holders of $300,000. In this case, four rogue employees accessed account numbers and PIN numbers to transfer money out of the accounts (Computerworld 2005). Rogue programmers have installed back doors into code, trojan programs that send out sensitive information, and logic bombs that sabotage operations.

- *Hackers.* The term refers to a special breed of programmer characterized as a person who is simply intellectually curious without evil or financial motivations; increasingly it has morphed to include individuals who may have dark intentions, varying from a self-described desire to thwart e-commerce, in general (e.g., viral attacks), to targeting specific companies for specific vendetta reasons (Electronic Entertainment Policy Initiative 2005).
- *Organized criminal syndicates.* Criminal syndicates around the world regularly engage in identity theft for financial gain. Bruce Schneier, CTO of the security firm Counterpane, has said that there is regular trade in credit card numbers and the only reason that most of us have not experienced fraud is that the thieves have not yet had a chance to use our account number (Schneier 2005). In May 2005, a criminal syndicate in New Delhi sold access information to 1,000 British bank accounts. The information was collected from a network of employees at a call center that the British banks had outsourced to. (The Hindu 2005).
- *Industrial espionage.* Competitive intelligence and industrial espionage are supposedly separated by an ethical wall and a legal structure. But in countries where information theft is not illegal, the dividing line evaporates. Offshoring increases the possibilities and profitability of these activities, while decreasing the cost.
- *Unfriendly nation states.* More than 30 states have been identified as developing cyber warfare capabilities. A number of these techniques have been extensively studied for impact. Offshoring to states that have lasting conflicts of interest with the home state of the procurer, whether in legal jurisdictions or other disputed matters, heightens risk elements (Billo and Chang 2004).
- *Terrorists dedicated to attacking national interests.* Numerous organizations are dedicated to cyber attacks on Indian IT sites. Groups of Pakistan-based cyber-hackers have routinely defaced websites and claimed to have penetrated the perimeters of Indian IT companies. *E-jihad* sites have launched extensive denial-of-service attacks on US, Israeli, and Indian targets (Institute for Security Studies 2003). Indian outsourcing sites came under attack by jihadi groups in Bangalore in June 2005 and in Mumbai in 2003.

Corporate Strategic Risks of Outsourcing

Outsourcing key business functions can create a strategic risk that is often disregarded in the day-to-day drive to cut costs and meet deadlines. In the modern hyper-competitive culture of international business, alliances are critical because markets do not allow time for companies to respond to competitive challenges by developing their own capabilities. Instead, a new product or competitive advantage is more easily challenged by entering into an alliance with an existing company that already has that product or capability. However, as Martin Libicki, a security researcher at the RAND Corporation, points out:

> “Third parties may want to attack a relationship simply because it is the heart of an opposing alliance. Sundering relationships can render opposing alliances less effective.
>
> The logic of sundering mirrors the logic of binding. The ability to form coalitions … is of growing value in competitive arenas. Coalitions, these days, float on the exchange of information; notably the privileged exchange of

> sensitive information (much as personal relationships are ratified and maintained through the exchange of favors) such as inventory data (e.g. Proctor & Gamble's evolving relationship with Wal-mart) or design information (e.g. for new cars). The greater the importance of proprietary and personal information flowing among enterprises, the more important is the ability to protect such information to its cohesion. Thus the more important good security is to the choice of partners." (Libicki 2006, 9, 3)

There is another set of potential problems associated with outsourcing and that is exacerbated by offshoring. These problems relate to the fact that virtually all procurer-provider relations in the domain of interest to us involve connecting or sharing the information systems of the procurer and the provider. This happens to greater or lesser degrees with greater or lesser vulnerabilities, depending on how it is done.

Various security vulnerabilities can result from this relationship. For example, the procurer allows extraordinary and unsecured access to the provider, the procurer may even have the provider at least partially provide security to the procurer's system, or the procurer could become more dependent on the provider. One can imagine how the two systems can be fairly secure in different ways and how connecting them could create a joined system that is less secure than either one. The connection could expose the procurer to security problems from the provider or expose both to security problems from third parties. Both procurer and provider companies must conduct risk assessments to make sure that the explicit ways the systems get connected do not open such vulnerabilities

6.4. Risks to the Individual: Privacy and Identity Theft

A contentious and challenging aspect of offshoring is its risk impact on individuals. Individuals are pawns in many respects in this global restructuring of business, but they stand to bear the brunt of many issues as risks occur: loss of privacy, loss of jobs, loss of property, and loss of security are and will continue to be experienced at the individual level. Some facets affect employees, while other exposures impact customers. Many effects will be borne by the general population within the home country of the procuring companies; some effects will impact the citizens of many countries. Regrettably, for the most part, individuals will have little to say or do to protect themselves.

Section 6.2 dealt with data security. Without data incursion, there is seldom an issue so protection against the risk of data intrusion is the first order of business. Businesses, governments, and military groups understand a wide range of issues pertinent to data security, and they can make decisions and put policies and procedures in place to mitigate risks. Individuals, though, have little impact on data security procedures or policies.

It is therefore fundamental to describe the risks and exposures of offshoring from the point of view of the individual and to suggest some possible mitigation strategies for them. First, note that so much offshoring has already occurred that the risks are in place and must be dealt with. This topic is politically charged. Many people, particularly in the United States and Europe, have an increasing feeling that *THEY* are putting *OUR* jobs, financial records, health records, and privacy at risk. Some people believe that national security is being compromised as well. Such views, to the extent that they become salient, can have significant political impact (Knox 2005).

What are Privacy Rights?

An offshoring issue of great consequence is the differing cultural and legal definitions of privacy around the world. Personal data of tens of millions of individuals are widely available. Individuals who would make illicit use of this data may have vastly different geopolitical, cultural, and legal environments than those whose private data is being used. The goal may be criminal as perceived by the victim and his home country, but not necessarily illegal or punishable from the point of view of the extant government, court, or culture in which the perpetrator lives. Historically, citizens have looked to their own government and its legal system for the protections to which they believe they are entitled.

Consider the issues raised if data about AIDS patients is purloined by an extortion group in a web-based cell in the provider country, followed by a set of threats to expose the diagnoses to employers, insurers, and neighbors. Privacy has certainly been invaded, financial impact could be severe, and the social cost to the individual is incalculable. Where could victims of this kind of action turn? The fact is that provider countries often have a very different set of laws regarding citizen rights than do the procurers. Those laws are interpreted or enforced with respect to theft of data on local grounds rather than with reciprocal rules. Thus, some nations' laws invite certain behaviors that other countries would consider illegal.

Privacy in Some Leading Procuring and Providing Countries

A core function of any nation is to secure its borders, including those less tangible and porous boundaries of the information space. Not all nations seek to protect the privacy of their citizenry. In the United States, when privacy conflicts with free speech, the right of the speaker rather than the subject dominates. In Europe, privacy is protected assiduously by most nations, but even there, free speech is also encouraged in ways that abet privacy assaults on occasion. Other countries, such as Israel, have strong laws governing privacy around medical and other sensitive personal areas, but their governments also have histories of dealing strictly with perceived threats to the public welfare in ways that may trample individual privacy rights on occasion. China, which for years has been a concern of human rights groups, presumes that the Four Cardinal Principles govern the nation: Leadership of the Chinese Communist Party, Marxism-Leninism-Maoism Thought, People's Democratic Dictatorship, and Remaining on the Socialist Road. These principles are not supportive of individual privacy rights.

European companies in the main adhere to strong data privacy protection, ensured by zealous data auditing and control. Swiss banking data privacy is legendary, but privacy of individual data – especially health and financial data – also has a long history of protection across the continent. By contrast, India, China, and the United States have been much more open with personal data; selling consumer lists to advertisers is a good example of a common practice in the United States that could be considered infringement upon an individual's privacy. Because of relatively unique European history, many European countries have been loath to send data to countries where the data is not strongly protected. India has proposed information privacy policies for offshoring company data that square with European data privacy policies, and these policies could provide a potential competitive advantage over the United States for offshoring work originating in the European Union (Peterson 2002).

There is no single directional arrow in terms of privacy and offshoring. In some cases, data are offshored to areas where there is stronger protection, and, in some cases, offshoring creates privacy risk distinct from security and operational risks. In order to examine the general issue of privacy more closely, this section will consider several major locations of offshoring and then discuss a set of possible responses.

The European Union

Europe and Canada have the most comprehensive data protection systems of any countries. Countries that send data to Europe can expect protection equivalent to that of the sending nation because the European Union (EU) harmonized and coordinated twenty-five national regulatory systems under the Data Protection Directive in 1995. Each nation develops its own implementing legislation that complies with the Directive. The Directive was issued both to establish minimum standards on the fundamental right of privacy and to ensure the free flow of personal information between states.

The European Data Protection Directive restricts the data that may be compiled, and it controls data once compiled. There are data that may not be compiled if privacy violations would create human rights violations: sexual orientation, religion, and racial identification. These requirements come from the basis of privacy as a human right, that is, privacy as a right of autonomy. The substantive principles underlying the directive are that data must be purpose-specific in collection and processing, relevant to the reason for processing, accurate, and deleted when the stated purpose has ended. There must be unambiguous consent by the data subject for data collection.

Substantive consent requires notification by the data controller of the identity of the controller and the intended uses of the data. Other information that must be provided before data collection occurs includes the consequences of not providing data, rights of access and correction, and any exceptions for research. The rights of access and correction ensure data integrity by ensuring that subjects can correct, erase, or block inaccurate data.

After the directive was developed in 1995 and implemented by 1998 in most member states, a concern about the lack of data protection in the United States became urgent. Data flow could not simply continue unconstrained to the United States since, from the perspective of the European Union, the United States is an unregulated data haven. The European Union strongly encouraged the United States to harmonize its own privacy regulation with the directive; however, the request was rejected by both the US executive branch and the Congress.

In the 2000 Agreement on Safe Harbor Principles, the European Union and the United States developed a process to prevent an interruption of the data flow from Europe to the United States. The Safe Harbor Act requires American companies to develop privacy policies that align with the Data Protection Directive, inform European customers of their privacy rights under this policy, create easy-to-use complaint mechanisms, register with independent dispute-resolution mechanisms to resolve complaints, and notify customers of any change in policy. However, few companies have signed up for Safe Harbor. At the first anniversary of the Safe Harbor, only 54 companies had registered and complied with the Safe Harbor guidelines (Peterson 2002).

In 2001, the Data Commission approved standard contractual clauses for Data Transfers to Non-EU countries to deal with those nations where neither implementing legislation nor Safe Harbor agreements exist. The Safe Harbor gives EU citizens protection and compliant American companies a relative advantage in obtaining offshoring contracts from EU states. Despite the apparent value in terms of low cost, strategic advantage, and protection from liability, few American firms have taken advantage of the Safe Harbor. Thus, at this point European companies have only a few low-risk choices for offshoring to American firms. Most American and Indian firms to which EU companies offshore must make custom data protection agreements.

The United States

From the perspective of the European Union, the United States is an unregulated data haven. In the United States, personally identifiable data can be accessed by those who assert a legitimate business need even in business sectors where privacy protection exists, for example, finance, health care, and telecommunications. Sectored legislation includes the Driver's Privacy Protection Act, the Video Protection Act, Electronic Communications Privacy Act, and elements of the Health Insurance Portability and Accountability Act (HIPAA, 1996) (Swire and Steinfeld). Similarly, the Gramm-Leach-Bliley Act (1999) was designed to increase individual financial privacy (Janger and Schwartz 2002).

However, the US approach has proven inadequate. Authorities such as Bruce Schneier have criticized the accuracy and integrity of personal data aggregated by commercial brokers (Schneier 2005b). A recent and widely scrutinized example makes the limits of the US approach clear. ChoicePoint, a commercial data broker, was created as a separately owned subsidiary of Equifax, Inc., and a copy of all Equifax data was transferred to the new company (Solove and Hofnagel 2005). As a subsidiary, ChoicePoint was not required to comply with the privacy regulations governing US financial and credit institutions. Consequently, the regulations that prohibit Equifax from selling its data do not apply to ChoicePoint. Indeed, there have been several news reports in recent years alleging ChoicePoint's disregard for accuracy in its data, and it is this exposure of personally identifiable (and often inaccurate) data that places individuals at risk for identity theft.

ChoicePoint acted explicitly to purchase the Mexican voter rolls which are protected under federal Mexican law (Peralte and Ferris 2003). The three Mexican nationals who sold the data to ChoicePoint were prosecuted, but ChoicePoint itself was not subject to Mexican federal law and it still markets the data internationally. ChoicePoint was also subject to scrutiny in 2000 when the listing of Florida felons provided to purge the data rolls was found to have systematic factual biases against African Americans (Pierra 2001). The basic elements of data protection – notification, consent, auditing, and accuracy – are all absent in ChoicePoint processes (Solove and Hoofnagel 2005). The ability to commit a felony in one nation (Mexico) and then use the results of the felonious data collection, illustrates the limits of the reach of national laws in a networked global economy. The inability to identify a basic classification (living in Florida, convicted of a felony) reflects the risk of lack of data integrity when there are no data protection requirements. In mid-2005, the company announced major changes in its policy and approach. How wide-ranging the results will be remains to be seen (Wall Street Journal 2005).

In the United States the approach to privacy has been specific to particular sectors of the economy. When abuses of data in a business sector are identified, they are addressed by legislation directed to that sector. In protecting data, the conflict between autonomy and seclusion is often implemented as a distinction between prohibited data (no one can ask for the data); opt-in (you must be asked for the data); and opt-out (you must pursue the opportunity not to be included). For example, the Gramm-Leach-Bliley Act allows customers to opt-out of data marketing.

AUTONOMY

Privacy as autonomy underlies many of the sectored laws that have been implemented in the United States. Privacy in the choice of health care for women, US postal mail, and personal memberships are all grounded in the right to autonomy. The essential observation of privacy as autonomy is that people under surveillance are not free. Actions taken with knowledge of direct data surveillance will be more constrained than actions taken anonymously. While this is sometimes taken to mean that anonymity is not accountability, the freedom of citizens to interact with government and the anonymity necessary for whistle-blowers illustrate the false dichotomy.

Without anonymity for those with little power, those with power have lessened accountability. Anonymity in a democracy is a critical factor in accountability. Perhaps the classic example is the secret ballot for the voting process. This was a hard-won position in the late nineteenth century that today is seen as an inalienable right. The right of autonomy was first defined in the United States legal system by Justices Earl Warren and Louis Brandeis, who also coined the famous phrase *right to be let alone* that underlies privacy as seclusion.

Seclusion

While the right to be let alone, the right of seclusion, seems at first irrelevant to the issue of offshoring, the changing mores of the web and some of its abuses have brought this segment into sharper focus. The most prevalent violation of seclusion privacy is spam, which frequently originates offshore. In the United States, the CAN Spam Act was seen by many in the anti-spam community as legalizing spam, and by some in the ISP community as providing a uniform legal mechanism for prosecution of spammers. While CAN Spam created a national law, it overrode many stronger state anti-spam laws (Ford 2005). In typical American fashion, specific legislation was enacted to deal with direct abuses, for example, the *Do Not Call* list and the opt-out provision in Gramm-Leach-Bliley.

Property

The United States is a nation with strong respect for individual property rights, although these rights are constantly being tested. The right to property extends to personal data as property. Excluding specific sectored protections, data in the United States are currently regarded as property. Subject rights over data are lost when data are disclosed because property is an alienable right. That is, once sold, there is no longer a personal interest in property any more than one retains a legal right over a house after it has been sold. The property interest in data then becomes entirely the interest of the data owner which is how a data broker is empowered to operate. Thus, the data broker has no direct customer relationship with the subject of the data, and consequently the broker owes the data subject no duty of care. Similar lack of care governs most data considered to be in the public domain. American law even allows for public sector data to be priced and delivered through aggregators and data brokers.

Data Protection

Data protection legislation has much in common with other privacy legislation: *notice, consent, integrity,* and *exercise of rights* are all germane. This commonality is based on the Fair Information Practice Principles (Privacy Protection Study Commission 1977). Notice requires that no compilation be secret. Consent requires that data be used only with the consent of the subject. There is continuing contention between passive consent (i.e., opt-out) and requirements for active consent (i.e., opt-in). Integrity requires that data are correct. The most common citizen interaction with integrity is with credit records. Credit reporting organization must provide citizens with credit reports and the right to redress if data are incorrect. Before the 1970 Fair Credit Reporting Act, credit data were often based on gossip (e.g., investigative credit reports) and other spurious sources. Errors in credit reports could not be corrected by the individuals who were the targets of the reports. Similar errors are found today in reports on individuals prepared by data brokers (Schneier 2005b). *Redress, access,* and *enforcement* are the mechanisms by which data subjects are ensured integrity. Access requires that individuals are able to view data about themselves. Redress requires that there are mechanisms to correct data.

India

India's property model is analogous to that of the United States, allowing authorized use of personal data. Since the 2000 Information Technology Act, strong prohibitions have been in place regarding data theft (Government of India 2000). India is a bastion for freedom of speech and autonomous action. There is no comprehensive government-filtering regime for Internet content. Internet kiosks flourish with resounding condemnations of government policies, and different social groups engage in battles of words without governmental oversight or intrusion. Anonymous posting is allowed. For an Indian youth, the cultural environment is fully conducive to viewing the web as a simple extension of the local mores. Hence, dissent and spamming about one's beliefs targeting another country not only go unsanctioned, but may be endorsed or supported culturally.

On the other hand, India has a significant regulatory structure in medicine, telecommunications, elections, and other industries deemed critical by the government. For example, election equipment is designed not to show public totals, and votes are held to be private. Each of these regulatory or surveillance regimes concerns itself with an individual's privacy. For example, when the Telecom Regulatory Authority received a proposal by the major carriers in India for publication of a cellular phone directory, the outcry could have been lifted from any Western paper. Health care studies examine the physical privacy provided for patients in terms of examinations and discussion of diagnosis under the medical regulatory authority. Thus while there is not specific privacy regulation in distinct sectors in India, the regulatory bodies in medicine, telecommunications, and elections address privacy rights as part of their regulatory function. As a result of India's involvement in long-term struggles against terrorism in Kashmir and elsewhere, wire-tapping and searching public discussion areas for activity in regard to terrorism are not uncommon.

Data are primarily alienable property in India as in the United States. Data are private property so governmental seizure would have to be strongly justified and public in nature. There is no Safe Harbor agreement between India and the European Union. The current intellectual property regime, and lack of corresponding enforcement, suggests that an enforcement regime on data as property might not be effective.

China

China has a communist government and an institutionalized ruling political party, thus the very concept of personal privacy is contrary to the underlying philosophical organization. China is organized on the Four Cardinal Principles, listed earlier in this chapter, none of which have implications that extend protection to individual privacy. Criticism or violation of the Four Cardinal Principles is prohibited. The overall data philosophy is concerned with state control of Internet use rather than citizen privacy. For example, Internet-based discourse in China has a series of disapproved words and a prohibition of criticism of current leaders and the Four Cardinal Principles. Anonymous electronic speech is officially prohibited in China. Speech on the Internet in China is controlled through technical means (filtering of postings, prohibition of websites, and detection of encryption) and political means (punishment of those who receive or transmit unacceptable words, ideas, concepts, or content). Microsoft has recently acceded to the Chinese government on this point with respect to blog management.

In some cultures, privacy includes the right to seclusion or freedom from excessive intrusion. For example, the right to seclusion in Britain includes the right of citizens to ask to be excluded from junk mail where, as in the United States, this only extends to spam and marketing phone calls.. However, there is no right to seclusion in the People's Republic of China. Spam is an approved and active business in China. Asia as a region has had such significant problems with spam that many IT operations blacklist all Chinese incoming mail. For example, both China and Korea have been one-click selections for blocking on Spamcop for years. China is active in hosting websites for spammers and supporting the market for lists for unsolicited bulk email. For example, the Hong Kong-based Fxstyle.net offers, in English, 238 million email addresses for spamming for any business. The information includes more than 10 million AOL, Hotmail, Yahoo, EarthLink, and MSN addresses as well as 1 million personal profiles complete with name, address, email, birthday and country, presumably harvested from the profiles of those advertisers. The target of the web page, the bulk of the email addresses, and the cost of removing that email create costs that are borne by individuals outside of China, yet the laws of their home country pertaining to spam do not apply. Recent research shows that free email accounts receive an order of magnitude more spam than legitimate email from China (Hulten, Goodman, Rounthwaite 2004).

Identity Theft and Credit Card Fraud

Many people are concerned about the ease with which their identity or their credit cards can be stolen. Identity theft can lead to property loss (commonly thought to be only bank account theft, but it can involve property deed transfers or transfer of income allocations) and damaged credit worthiness, and it often involves a long hassle with a multitude of faceless and possibly irresponsible organizations in order to clear a besmirched credit record. It can even lead to a person being labeled a fugitive felon and cause their lose voting rights to be lost when a stolen identity is used in committing a crime.

In the United States where identity theft appears particularly acute, a major factor is that companies are able to sell Social Security numbers tied to names of individuals, complete with addresses, birth dates, and other pertinent information that enables not just invasion of privacy, but also the alteration and use of the data for criminal intent.

Identity theft and credit card fraud are huge problems globally. Given the wave of incidents within the United States in 2005, as described at the beginning of this chapter, it may not be saying much to suggest that consumer data are at any greater risk of exposure in an outsourcing provider country such as India rather than in a procuring country. But it could be more likely that the events will be brought to light and somehow constructively dealt with in the country where most of the victims are citizens. However, privacy is a key issue in the debate over offshoring. *Business Week Asia* ran a story on this in August 2004:

> "186 bills that aim to limit offshore outsourcing are pending in the U.S. Congress and 40 state legislatures. Dozens of those involve restrictions on transmission of data. For example, the SAFE ID Act, sponsored by Senator Hillary Clinton (D-N.Y.), and a similar House bill by Representative Edward J. Markey (D-Mass.), would require businesses to notify U.S. consumers before sending personal information overseas -- and would bar companies from denying service or charging a higher price if customers balk. Although no such bills have been enacted so far, "next year I think all of this legislation will be back and spike up again as a huge issue, especially if the U.S. recovery stalls", says R. Bruce Josten, US Chamber of Commerce, who helped industry fight the legislation." (Engardio 2004)

The particularity of identity theft in the United States is compounded by the fact that the criminal liability and recourse when an American is defrauded is far from clear domestically and is further complicated by offshoring. Theoretically, the US company that farmed out the work is legally responsible. Indian call centers usually sign their contracts in the United States. Thus, both offshoring procurer and provider can be sued in domestic courts by their corporate customers. However, liability for international security and privacy data breaches is unsettled in case law. Americans must often begin with local police to make a claim of fraud. Many local police departments lack the personnel to address individual fraud cases and are ill suited to address complex international technical jurisdictional issues. A problem with privacy risk in the United States is the likelihood that the large organizations that are most able to mitigate risk instead transfer the costs to individuals who are left without jurisdictional recourse especially when the data is offshored.

A number of cases have surfaced, including the situation at MphasiS, one of India's largest call center providers, where Citibank accounts were penetrated and the events were only found by account holders who called the bank to complain. Nonetheless, an Indian official with MphasiS said later that week:

> "While we are unhappy with the incident itself, we are at the same time quite pleased that detection systems worked. While such incidents unfortunately do happen everywhere, timely and exemplary enforcement ensures that no-one needs fear that culprits or potential culprits can get away and the reputation and credibility of the entire system is actually preserved and enhanced." (McCue 2005)

One long-term American consultant to India, when asked to comment on how well the enforcement provisions really work, was quite candid:

> "There is no way that the company itself will be prosecuted. MphasiS is one of the top ten providers and their President is the current president of NASSCOM. The individual perpetrators will be prosecuted under a Government of India act but as is typical with Indian justice, it may be years before it comes to trial. For example, there was a bribery scandal in the 1980's involving Bofors, the Swedish defense supplier, and before the case came to trial in the late 1990's several of the accused had died of old age. NASSCOM advocates strong security to its members but it doesn't really have any enforcement power. The only enforcement provisions that would really be effective . . . would be pushed from the demand side. In my work over there, I heard again and again, that providers will conform to whatever security measures the customers require, with an implied 'but unless they require them we will do the minimum we deem necessary'. Therefore, if US companies aren't acting to protect their clients then the government has to step in and protect the privacy of its citizens." (Ramer 2005)

Not surprisingly, most companies in offshoring businesses assert that these were isolated instances. Other observers are not so sanguine. The day after the MphasiS story broke, TBR News had a follow-up story about 310,000 accounts that were illegally accessed via Lexus/Nexus, coupled with the 145,000 that had been fraudulently exposed at ChoicePoint. These predated the 40,000,000 ostensibly accessed records reported two months later at CardSystems. While offshoring did not figure in all of the reported breaches, the net effect has been unsettling for the data handling industry (Timmons 2005; Rigby and Kolker 2005).

Following the April 2005 incident at MphasiS, many in the Indian IT industry called for serious reforms and security improvements, including calls for a law on data protection as well as more stringent laws on enforcement of contracts (Thiagarajan 2005). However, two months after the MphasiS fraud case, a new scandal broke out. A reporter from *The Sun* of London was able to purchase the account information of 1,000 British bank customers for a price of $5,000. The reporter was told the information came from a network of Delhi call center workers. The contact person boasted that he could provide information on 2,000 accounts a month (Harvey 2005).

Dealing with the Risks and Exposures for Individuals

India's national leadership is seeking data protection legislation to directly compete with US firms for work involving data that are currently offshored from Europe to the United States. Such a change in the competitive landscape would increase the challenges of globalization for the United States in terms of long-term learning, productivity, and employment. The United States has a structural decision to make with respect to international competitive strategy, that is, whether (1) to compete as a high-quality service provider with security and privacy used as competitive advantages, or (2) to compete in the global market as a data haven.

As more and more countries get into the offshoring game, the price pressures on providers of offshored services only increases. According to banking industry sources, effectively securing a transaction can add 15 to 18 percent to the cost (O'Bryan 2003). The real costs of offshoring should include legal, security, auditing, and contingency planning costs, all of which increase when offshoring. A critical but often overlooked issue is that many offshore providers do not perform realistic annual disaster recovery testing. Instead they test with a limited number of client companies at a time. With increased price pressures, the temptation to skimp on security measures strengthens. Thus the need for common and verifiable security standards gets stronger as well.

Outsourced IT-enabled services, whether the service is software development or loan processing or even a call center, involves interaction between the procurer's network which probably is more controlled, known, and trusted, and another network which the client has much less control over, less knowledge of, and can trust less. Networked security will be greatly enhanced if verifiable security standards for offshoring are put in place.

Politicians in a number of US states, as well as in Congress, have begun inquiry into some of these risks and exposures. Of the thirty-six states in 2004 that sponsored legislation that would limit offshoring, only two enacted bills that year. But in 2005, sixteen states had bills introduced in the opening sessions, a clear indication that concern has not abated (Cooney 2005). Given the recent spate of high-profile cases and high number of affected people, much more legislative involvement can be anticipated. This is worth putting into some longer-term perspective. Just as other technologies advanced and enriched the early risk-takers and owners, there were frequently undesired consequences. Pollution from power plants is but one of dozens of examples one could cite. When the undesired consequences rise to impact a sufficient number of citizen's rights (clean air, water, noise), governments generally rise to the occasion to pass laws to protect the citizens. Looking back, the lag time is generally substantial and great harm may occur before citizens acting through their combined power of government set out to seek remedies.

We are now a decade or so into the use of widespread computer networking in which individuals can be brought into harm's way with little to no financial risk to those who actively or negligently inflict harm on others. Just as with sprinklers and fire codes, speed limits and air bags, clean air regulations and smoke stack scrubbers, both legal and technical means can play a role in the information sphere to protect the rights and assets of individuals.

The problem of vetting offshore providers in today's world is complicated. Procuring companies are primarily focused on obtaining the financial benefits of offshoring; most appear to be naive about the risks, or they do not have the time or resources to care. This may account for why this kind of topic so seldom arises in discussions of offshoring. Government vetting in today's world (e.g., by greatly extending the scope and authority of the activities of the interagency Committee on Foreign Investment in the United States) would likely be a nightmare. The best defense is a set of policies that protect against giving providers strong forms of access/control which, in addition to raising the security/privacy concerns, can also make the procurer dependent on, and perhaps hostage to, the provider if it is done foolishly. (Contrary to popular opinion, export controls were remarkably effective for most of their existence for several complex and reinforcing reasons. Industry has often argued against them on the basis that they stifled technological progress, that technology flows were impossible to retard, etc., but those concerns really didn't come into play until the late 1980s.) What can be done in individual jurisdictions is to prevent the transfer of risks to individuals who are the least able to mitigate or recover. Entities that choose a risk should be the ones who pay or profit from the risk premium and any downside. The problem of weak or more seriously compromised provider organizations is considered further in Section 6.5.

It would be highly desirable if economic incentives and competition would be sufficient for companies, both the procurers and providers, to effectively protect the privacy of their customers. So far, as is the case with regard to other forms of cyber security problems, this has not proven to be the case, and it does not seem to be improving as rapidly as the increasing numbers of violations and victims. More generally, the following measures might be considered by lawmakers or regulators and could also be included in offshoring contracts for dealing with situations where there are risks of privacy and identity theft.

For provider companies:

- Providers should have security and data protection plans. They should be required by contract, and work should not be allowed to begin without them. There should be clear requirements for reporting incidents. Breach should be grounds for termination and financial redress
- Providers should be certified in some way, perhaps through adherence to prescribed standards. The risk is that such standards only provide cover for malfeasance and not true protection. A difficult question is: Who would certify the providers and effectively stand behind the certifications? It would clearly have to include government parties in the provider's home country.
- Offshore providers should agree to no indirect third-party outsourcing without explicit approval from the procurer. This should be contractual, with high sanctions, for example, grounds for termination.

For provider countries:

- Provider countries should enact data privacy laws that apply to foreign citizens whose sensitive data is offshored to their country, or agree to recognize the laws of the procuring countries as applying to foreign citizens and make them enforceable in the providing country. Violation of national privacy laws, in addition to breaches of contract, should be covered.
- These laws should be backed by either demonstrated capacity to enforce (e.g., by a good record of enforcement) or by secured assets in order to ensure penalty
- Providing countries should be certified as Safe Harbors as is done by the European Union, but in the more general context of the procuring country and the foreign citizens who are vulnerable to the compromise of their sensitive data.

For procurer companies:

- There should be reporting requirements and stiff fines for failing to protect sensitive information – just like failing health inspections, speeding, or polluting. While a procurer may be theoretically subject to privacy regulations, experience shows that practice is woefully lacking (Ramer 2005b).

For procurer countries:

- They should consider legislation or other strong forms of regulation requiring any of the measures listed here.
- Certain kinds of information about a nation's citizens or businesses may be considered to be particularly sensitive and vulnerable. Consideration should be given to reviewing such categories and banning certain data from being hosted outside of the originating country.

Technical means:

- There should be no mass export of databases or transactions. Databases should be kept on servers in the procuring countries. This would also make it easier to cut off a derelict or abusive provider.
- Data should be used in transactions on a one-record-at-a-time and as needed basis. After one transaction is completed, another should not be initiated until the record for the first is effectively removed from access.

- Databases should be encrypted to help protect data at rest and in transit and prevent unauthorized data mining for purposes not intended by the procuring organization or contrary to relevant laws.
- Systems should be instrumented to facilitate incident discovery, reporting, and forensics.

6.5 Risks for National Capabilities and National Sovereignty

One important aspect of offshoring risks that is often ignored or treated perfunctorily is the impact on national capabilities. Sovereignty is basic to a national government's reason for existence, and effective sovereignty must include national defense, national economy, and national well-being. While individuals and even companies may bear the immediate and visible brunt of IT globalization, including loss of jobs, compromise of data, and loss of intellectual capital, the overall social impact must be evaluated for a full contextual understanding of the impact of offshoring. In this regard, the IT issues that are addressed in this entire report have considerable consequence to the national interests for many countries. Thus this section examines the threats to a nation's sovereignty that are exacerbated or introduced by IT outsourcing.

Effective sovereignty must include a national economy that is able to provide for its citizen's well being and is not subject to arbitrary manipulation by external forces. As economies have moved from bricks and mortar, and rail and road infrastructures, to an information technology-controlled infrastructure, offshoring of IT raises two key risks, namely, the vulnerability of infrastructure or defense systems to remote electronic attack, and the loss of the ability to fix or replace economic infrastructure

Modern economic infrastructure is dependent on an increasingly global IT network and vulnerable to remote attack through inter-networked systems. Operators in Mumbai or Manila help customers with credit card transactions. Programmers in Bangalore or the Ukraine maintain computer operations for European airlines. Railroads, power companies, and defense contractors regularly use global outsourcing to cut costs and deliver services to their clients. Unauthorized hacker access to these systems could, with malicious intent, cause blackouts, air or rail accidents, or communication system shutdowns. Financial fraud or sabotage of financial system through cyber attacks could be more devastating than physical attacks.

Modern defense systems are arguably even more dependent on information technology than infrastructure systems. From fighter aircraft to command-and-control systems to robot-bomb detonators, software is an essential ingredient. Defense systems developed without proper controls significantly increase the risk of weapons systems failure or sabotage. It is in this context that cyber warfare presents a serious threat.

Earlier sections of this chapter identified the mechanisms by which offshoring increases the risks of IT systems development and maintenance. It expands the range of process vulnerabilities and widens the field of potential threats, thus offshoring significantly increases the risk of a successful infrastructure attack or the compromising of weapons systems. In such situations, offshoring can undercut the national capability to repair and replace these critical components of a nation's defense.

Information Technology is critical because it is intimately bound up with technological innovation. The ability to take an engineering advance and create a functioning software system is a critical part of the process of technical innovation. Therefore the future economic welfare of a nation can be put at risk if it is unable to reproduce technological innovation at a sufficient rate to remain competitive with other players. Concern over investment in innovation in developed nations, particularly the United States, is discussed in Chapter 8. The impact of offshoring on infrastructure, defense systems, and national capabilities to remain competitive will be discussed in the rest of this section.

Rising Threats to Infrastructure and Military System

Commercial Off-The-Shelf (COTS) product purchasing strategies have been adopted by the United States and other countries in building their IT-based military systems. These countries have also shared national and international commercial Internet infrastructures to facilitate network-centric warfare (NCW) systems. On the positive side, this methodology reduces costs and delivers a wide range of equipment quickly, thus increasing flexibility and functionality. However, COTS purchases can lower reliability and limit opportunities to verify that the software performs its stated purposes. It is more difficult for the buyer to gain insight into source and application code documentation for COTS products especially if the providing companies are offshore (Gansler and Binnenndijk 2004). Many COTS components, and sometimes entire systems, are developed and maintained by providing companies who may themselves procure development and services from other nations who could have privacy, intellectual property rights, security, diplomatic, and defense policies at odds with the original procuring country. Thus, a COTS strategy increases the possibility that a hostile nation or non-government hostile agents (terrorist/criminal) could compromise the system or services. Regardless of the trust level between the countries and/or corporations, a single person working on military or critical infrastructure software could cause havoc by installing programs that compromise combat zones, military and civil command and control systems, and system access.

Offshoring significantly increases the risks to military systems because many network components are produced and or shipped through countries that may be hostile to the national interests of the procuring military organizations. Eugene Spafford, Chair of the U.S. Public Policy Committee of the Association for Computing Machinery (USACM), testified as follows in October 2005 before the House Armed Services Committee.

> "Our military and government rely on COTS products and contractors to equip and staff our IT infrastructure. Consider that some of those products that are employed in highly sensitive applications are being crafted, tested, packaged and supported by individuals who would never be allowed into the locations where those applications are used because of national origin, criminal history, and/or personal behavior. Furthermore, some of the hardware and software components in use in critical applications are designed and produced in countries that may be adversaries in future military or political conflict. These factors enable "life cycle" attacks where key systems can be compromised during early manufacture, shipping, and maintenance as well as end operation. We do not have the tools or resources to thoroughly check these items to ensure that they do not have "hidden features" or flaws that may be used against us. We need special attention and methods to produce these supervisory systems and critical applications." (Spafford 2005)

In Section 6.2, we discussed a recent Symantec threat assessment that shows rising vulnerabilities and malware designed to compromise confidential information. Tying that to the widespread use of COTS in most countries' military systems, the national security risk becomes clear. The effects of possible critical IT infrastructure breaches include, but are not limited to, the following.

- From a national security perspective, large-scale attacks that manipulate the availability and integrity of military command and control systems can cause malfunction, or in the worst case, loss of life, due to weapon trajectory changes and battlefield misinformation.

- Disruption of IT-based systems and services can potentially increase a loss of situational awareness of an attack, decreasing identification time and time to respond. Not only could these attacks be catastrophic, recovery could be more difficult if the deployed products were developed offshore and the capability to manufacture and develop the hardware and software to replace non-trustworthy or damaged systems is no longer available within the procuring country.
- A significant example of a loss of national capability through global sourcing, though not IT related, is the 2004 closing by UK health authorities of the sole US supplier of a flu vaccine plant. This caused an immediate reaction in the United States especially for citizens at risk. Agreements were obviously not in place between the two countries to supply early warning of the vaccine contamination (Stannard 2004). This experience is especially alarming in the context of growing concern over the predicted bird flu pandemic. The lack of capability to manufacture enough vaccine could lead to major political conflict between procuring and providing countries and, in the worst case, massive fatalities could occur as the virus spread, unabated by an antidote. This example illustrates how technical capabilities can severely impact the ability of a nation-state to provide for its populace.
- Covert access to vital command-and-control systems could undermine military strategies and battlefield success by either exposing or taking advantage of military tactics or distorting data.
- Unauthorized access to confidential records could leave military and civilian personnel open to blackmail and other forms of compromise affecting national security. Compromises causing intermittent failures or loss of integrity of data can also affect loss of life on the battlefield. If failures were deliberately caused, for instance, from built-in malware vulnerabilities such as trojans and bots, an attack such as a buffer overflow or a web-based attack could allow the undetected bypass of security mechanisms such as firewalls or virus scans.
- Allowing access to remotely controlled bots for later attacks could undermine the military and public/private infrastructure of these shared networks as well as those in countries to which they connect.

A broad potential risk, one that could be considerably exacerbated by offshoring, is that the providing organization (or at the least, significant parts of its ownership or management) could be compromised and used by organized crime or foreign governments to the detriment of organizations and citizens in the procuring country. This could serve as a means for bringing about the negative consequences discussed previously. There are many instances of businesses becoming beholden to organized crime interests or fronts for government agencies in nations around the world. Globalization provides substantial new opportunities and reach in this regard.

For such a scenario in an offshoring context, it is easy to imagine the providing organization gaining control over data assets and management (e.g., databases, network operations) that would give it a powerful platform to engage in such activities as unauthorized data mining, intelligence operations, malware planting, attack planning, and money laundering. Given its position as a provider, this might continue for a long period of time, enabling it to do a great deal of damage in a relatively protected way.

In some countries, including Russia, parts of Eastern Europe, and China, among others, where there has been a lack of a well-established rule of law that effectively protects individuals or private enterprises, it may be difficult or impossible for provider organizations to resist overtures by organized crime or government security agencies. Potential providers have very little means (physical or legal) to defend themselves against such overtures.

Critical Infrastructure – Operation and Investment

From a social perspective, attacks such as those described previously can also cause malfunction and destruction of critical civilian infrastructure, for instance, transportation, power, and financial systems, not to mention loss of civilian life, chaos, and loss of public confidence in the national infrastructure and government. From an operational and investment standpoint, it would be difficult to replace the aging backbone of domestic and foreign-built equipment in the procuring countries' infrastructure and also problematic to train maintenance personnel to install, connect, and operate it. Thus, the impacts on nuclear energy, electric, or water purification facilities could be detrimental not only to health but also to the economy.

The UK Financial Services Authority (FSA) issued a report in May 2005 warning that offshoring could damage consumer protection efforts and lead to increased financial crime (Watson 2005). The report highlighted the greater difficulties of implementing strict controls in offshoring. At the same time, the FSA stressed that risks could be addressed with appropriate risk management strategies. The FSA noted that two key risks were business continuity and high staff turnover.

The high turnover noted in the Financial Services Authority report is a security threat because of the gap in personnel security noted in Section 6.2. Staff turnover has been a problem in the rapidly expanding IT sectors of countries such as India because skilled staff members are in high demand (NASSCOM-Evalueserve 2004). The high demand coupled with the absence of searchable credit or criminal databases greatly increases the likelihood of hiring higher risk employees.

Modern technology-based economies are highly dependent on an extensive array of IT-controlled infrastructure. IT-dependent systems include water and electric power, emergency communications, transportation, oil and gas production and delivery, and health care. These systems are vulnerable to hacking, sabotage, and natural disaster. Hurricane Katrina and the New Orleans flood illustrates how quickly a situation can degenerate when infrastructures fail. Supervisory Control and Data Acquisition Network (SCADA) Systems control critical infrastructure facilities such as nuclear power plants, and these SCADA systems are vulnerable to attack. Systems are not only vulnerable to attacks through their non-Internet-based control systems, but through other, outdated control systems as well. "They're designed to be managed remotely and the remote management is not authenticated, meaning you don't know who's managing it," according to Alan Paller, the research director for the SANS Institute." (Simmons 2005).

Offshoring introduces additional failure points into a system, and it also makes these systems vulnerable to concerted attack in the event of hostilities.

Access and manipulation of financial and telecommunication systems could cause long-term national and global economic damage which, if severe or frequent enough, could cause loss of public confidence in infrastructures and the governments' ability to protect the population. More immediately, the economic costs of interrupted finance would likely paralyze many modern societies. Examples are as simple as a local airline computer failure that led to five hours of queuing to board one international flight (British Air Flight 286, San Francisco to London, March 5, 2005) in order to achieve correlation of baggage with passengers. The September 11 terrorist attacks came within an estimated one mile of destroying the redundant backup for the Eastern Seaboard Point of Presence, the hub concentrator for both voice and web-based traffic for 100 million people, and nearly 65% of America's financial transaction backbone. On the other hand, the Internet protocol proved its survivability under the duress of these events. Although NYSERNet's research network ran through Ground Zero with transport provided by Verizon, on lines that were severed when Building 7 of the World Trade Center collapsed, the network never wavered. Moreover, the technology's flexibility helped restore commodity service on Long Island and in Westchester County by remapping onto the NYSERNet network (Lance 2002).

The September 11 terrorist attack was a warning flag to the US financial infrastructure. The damage, as incredible as it was, could have been much worse. US regulatory agencies took steps to increase scrutiny of offshoring of the financial services electronic commerce systems. The US financial system has become a worldwide network, and along with the Security and Exchange Commission, the US Federal Financial Institutions Examiners Council (FFIEC) began requiring audits of offshore providers. FFIEC issued regulations designed to increase the scrutiny of offshore service providers.

National Economic Health, Security, and Outsourcing

For most nations, creating and maintaining a robust economy with adequate jobs is a key to a sound and stable government. Governments are supported because citizens believe their leaders' policies best serve their national defense, economic, and social interests. When confidence in government with regard to these factors falters significantly, instability is usually not be far behind. A country's national security and social policies are influenced by its technological development, natural resource availability and utilization, strength of defense, soundness of financial and operational infrastructure such as transportation and energy systems, trade policies, citizens' ability to create and innovate, and cultural and historic heritage. However, this discussion will focus primarily on issues that may be affected by offshoring.

Offshoring exacerbates some old issues and raises new ones. The rapidly changing technology transfer associated with offshoring has already begun to change country objectives, policies, and cultures for both procuring and providing countries. In recent historical experience, the procuring nation has rarely feared the loss of economic and intellectual advantage to the providing country, yet, as manufacturing industries have shifted jobs away from North America and Europe, that is precisely the concern for those concerned about offshoring.

A key concern for the United States and other developed countries is whether their technological investment and innovation will decline so steeply as to put them into economic decline. The question therefore is how the developed countries that have been technology leaders can preserve their technological capabilities for innovation to maintain successful economies even if they are no longer broadly preeminent over their rivals. There are numerous studies, reports, and commentaries making these points (see, for example, National Summit on Competitiveness 2005; Harsha 2005; National Academies 2005; Lewis 2005).

One example is the testimony given by Nicholas Donofrio, Executive VP for Innovation and Technology at IBM, before the House Science Committee. Donofrio called for a national innovation ecosystem that he said must be fostered by a coherent national policy. In his testimony, he quoted from the December 2004 Report of the National Innovation Initiative and it is worthwhile to review it in some detail. "The push and pull of supply and demand do not occur in a vacuum. They are strongly influenced by public policy and the overall infrastructure for innovation offered by our society. Public policies related to education and training, research funding, regulation, fiscal and monetary tools, intellectual property and market access demonstrably affect our ability to generate innovation inputs and respond to innovation demands. The same can be said of infrastructure – be it transportation, energy, health care, information technology networks or communications. Taken together, the policy and infrastructure environments create a national platform that can accelerate – or impede – the pace and quality of innovation." (Donofrio 2005)

At What Point Does Declining IT Capability Impact National Security?

The United States, which has offshored significant amounts of manufacturing capability over the past half century, is increasingly offshoring its IT capability. Does this really matter? Consumer electronics went offshore without much ill effect on either the national economy or the national security in the 1980s. So did memory chips for computers, and after that, the PC's themselves, plus their displays. Some economists argue that, in fact, this offshoring led to large productivity gains for the United States (Mann 2003, 2004, 2004b).

Many argue that software is different; it does not act as a commodity since the development cycle never ceases. There is often an innovative edge tied to market differentiation that moves well beyond the current frontier of commodity service. This is the uniquely special characteristic of software compared to any other building material. If a country loses control of that frontier, does it risk losing control of its future in both national security systems and in many critical sectors such as financial services, health care, utilities, and industrial controls? Since the critical capability of market differentiation and the agility of systems depend on software capability, the answer is neither easy nor encouraging for US planners.

The future economic welfare of the United States (or other developed countries) could be at risk if offshoring, combined with the absence of appropriate policies, damage the nation's ability to produce technological innovation. It is competitive products and higher productivity that lead most directly to national wealth, but many observers believe that technical innovation is the underpinning for competitive products and higher productivity in the knowledge economy. The concern is that the decline in investment in American research and development and education spending could accelerate to the point where it jeopardizes future reproduction of intellectual capital. This topic is discussed in detail in Chapter 8.

Several popular books explore this issue of national risks from offshoring, one by journalist Thomas Friedman, another by a former trade official in President Reagan's administration, Clyde Prestowitz. These books present visions of the future, though with less than academic rigor. In *The World is Flat,* Friedman explores the results of a highly interconnected globalized world, driven hard by offshoring of IT and its effects on the United States (Friedman 2005). The result, in Friedman's view, is an inexorable and extremely rapid shift of many presumed US advantages, most especially white-collar jobs, to other countries. He predicts a shock wave impact on American politics, business success, and unemployment rates that will likely result in clarion calls for revised educational approaches and tariff legislation as well as much acrimony. But he stops short of saying either that it is a momentum that can be stopped, or for that matter, needs to be

In *Three Billion New Capitalists: The Great Shift of Wealth and Power to the East,* Prestowitz argues that the United States faces such serious fiscal and competitive challenges that it may be headed not only for a declining standard of living but for a 1930's-style depression. The subtitle for Prestowitz's book is telling in itself: *The End of Western Dominance and the Rise of Parity* (Prestowitz 2005). Prestowitz is gravely concerned because the United States is not prepared for the expected economic restructuring driven by globalization. He refers to the mismanagement of the US economy, manifest in low household savings, high budgets shortfalls, and unsustainable trade deficits and foreign borrowing. A deeper problem for Prestowitz is the fact that the United States has no national strategy to protect its industry, skilled workers, and technological leadership. He argues that the United States's laissez faire economic ideology and confidence in its technological and productivity supremacy have prevented Washington from grasping the coming crisis and from developing a programmatic national response.

Dealing with Risks and Exposures in National Capability

The risks and exposures from IT offshoring are great and increasing. They include increasing cyber vulnerabilities, hostile cyber warfare policies, theft and abuse of personal and government sensitive and classified information in all countries, attacks on country infrastructure, and changes in business strategies and investment in research and development. Globalization is likely to continue and so are its international effects. These risks and exposures can never be completely mitigated, but strategies at both the national and international levels can be put in place to help manage them.

Problems cannot be solved until they are defined and accepted as valid by a sovereign entity and its citizens. Frank and open national dialogue regarding economics, trade, outsourcing, education, and research issues that does not focus on a corporate or protective agenda would allow citizens to engage in the dialogue and understand the issues.

One topic that the United States and other developed countries might address are plans to protect their nation's cyber-structure and IT competitiveness. The plan might include not only a strategy to address training and jobs but also strategies for legislation, international agreements, policing, tariffs, Internet policies, and a more equitable tax-structure for companies investing at home. It might address the need for more formal government/commercial agreements and funded research to address data protection and communications between stakeholders involved in homeland defense and critical infrastructure. It might also include a discussion of how to make a country more innovative, specifically in light of offshoring which is discussed in detail in Chapter 8.

The offshoring of homeland security technology development and management systems that send vital information such as biometrics, identification codes, tax and personal information overseas are of critical concern. Until better controls for this information are developed, it presents a high risk to all nations. Sensitive industries should have severe restrictions on offshoring. Offshoring of software and design projects in areas such as defense and the other critical infrastructure industries should be tightly controlled. Further research in methods to secure this data and the development of nation-to-nation and international treatment of both the data and how compromises will be handled is vital, including developing and implementing information security standards for international commerce.

Thomas Homer Dixon, the Director of the Trudeau Peace and Conflict Studies Center at the University of Toronto, has studied the relationship between violent conflicts and various kinds of environmental stress in poor countries. He found that environmental stress cannot, by itself, cause violence. It must combine with other factors, usually the failure of economic institutions and government. He concluded that a central feature of societies that adapt well is their ability to produce and deliver useful ideas or what he calls ingenuity to meet the demands placed on them by a worsening environment. Societies that adapt well are those able to deliver the right kind of ingenuity, at the right time and places, to prevent environmental problems from causing severe hardship and, ultimately, violence. If globalization is to be successful, recognition of the rights and equality of the global citizen has to be accepted and become the underpinning of policies and trade agreements. Dixon speculates on whether procuring countries and providing countries can learn from history and forgive past injustices and whether this might determine if global and worldwide innovation will continue.

6.6. Risk Mitigation and Risk Assessment

A basic approach to information security risk assessment is to analyze three key objectives: *confidentiality, integrity,* and *availability.* The risks to these objectives are greatly increased by offshoring because of inherent vulnerabilities in offshoring, global communications, and international business.

To illustrate, consider the example of ABG, a fictional software company that sells equipment for processing secure transactions. ABG's systems are only valuable to customers if (1) the internal security mechanisms are kept confidential from competitors and potential attackers; (2) the integrity of transactions are ensured (the data cannot be changed by an attacker); and (3) the process is available and efficient, that is, the process does not slow down or interfere with the client's primary business. Outsourcing the development of new features for the product increases the risks of a competitor or a potential attacker learning ABG's proprietary processes. It also increases the risk that the process will not be as reliable (or have as much integrity) due to the loss of control over the development process and a more complicated supply chain network. While any outsourcing increases these risks, developing the software in another country magnifies them significantly for a number of reasons. ABG no longer controls the network security or the process security of the development center. Offshore developers likely have less legal liability to ABG or its clients. The development and maintenance processes (discussion of proprietary designs, transfer of the software, patches, documentation) are conducted over international global networks with a greater potential for interception. A prime motivator for both provider and procurer becomes cost reduction, which tends to overshadow security or other quality concerns

Risks exist at multiple levels – financial, performance, reputation, intellectual property, privacy, legal, and regulatory risks. Therefore, it is imperative to carefully assess the risks, quantify the potential losses, and develop cost-effective risk mitigation strategies. Systematic risk analysis and planning involves the following steps.

- Identify and estimate the value of the assets to be protected.
- Identify the potential threats (things that can go wrong) and threat perpetrators.
- Assess the vulnerabilities in the current systems protecting the assets.
- Develop a plan to protect the assets against the threats by remediation of vulnerabilities.

Too often, providing companies simply hire guards and put expensive firewalls and access controls on their network, and then they declare to the procurers that there is no risk. The managers of the offshoring programs at procuring companies repeat this mantra. However, if the asset being protected is client privacy or corporate intellectual property, all it takes is a disgruntled or dishonest employee to copy the data and walk out of the well-protected offshore data center and sell the information to the highest bidder.

Recognition of higher risks for the procurer is not necessarily an argument against offshoring. Risks lead to innovation, and the free market is based on the principle of taking and overcoming higher risks to obtain higher rewards. The accepted response to a risk is avoidance, transference, or mitigation, responses all found within industry for managing the risk profiles of offshoring. The key is a conscious rational assessment and response to the risks in each situation.

Mitigation Strategies

Effective risk mitigation strategies need to be implemented once a risk assessment exists.

- *Security due diligence.* This should include certification to standards such as BS7799, CISP, or True Secure. (Note that SAS70 is not effective in info security space. Note also that Certification cannot be viewed as a license to ignore security risks.) Legal liability and responsibility for protecting both customer data and intellectual property lie with the procuring company management.

- *Business due diligence.* Does the provider have the technical and security skills needed? Does it conduct effective background checks? Is it financially stable? What relationships does it have with other companies, governments, and organizations?
- *Active risk management.* This requires the development and implementation of an ongoing security plan between the outsourcing procuring company and the provider. The plan should include appropriate forms of monitoring, regular reporting of security metrics, incident response, and disaster recovery mechanisms.
- *Third-party risk assessments.* An independent third party should be responsible for regular security audits of the provider. This should be a professional security firm rather than an auditing firm. Past practice has used the CPA issued SAS70 audit as an acceptable security assessment and audit. However, SAS70 audits are usually produced by the audit firm employed by the provider. The scope of the audit is generally defined by the provider and typically includes a pre-audit that allows the provider to correct any embarrassing failures. Consequently, real risks are often overlooked. Therefore, it is essential that a procuring company ask for an independent security assessment.

6.7 Bibliography

Alexandrov, V.N. 2005. (Ex-Soviet CS Director, today Chief of High-Performance Computing Labs, University of Reading, England). Interview by Charles House July 7.

Associated Press. 2005. Microsoft Censors Chinese Blogs. (June). http://www.wired.com/news/culture/0,1284,67842,00.html.

Bhat, R. 2002. (Manager Efunds BPO) Interviewed by Rob Ramer (Feb.).

Billo, C. and Chang, W. 2004. Cyber Warfare: An Analysis of the Means and Motivations of Selected Nation States. *Institute for Security Studies, Dartmouth College* (Nov.).

Brooks, F. 2005. *The Mythical Man-Month*. Addison-Wesley.

Computer Security Institute. 2005. It's All Fun 'Til Someone Loses an I.D.: This Summer's Big Breach Sheds Light Through Holes in Credit Card Security. Computer Security Alert (Sept.).

Computerworld. 2005. Indian Call Center Workers Charged with Citibank Fraud (April 7). http://www.computerworld.com/printthis/2005/0,4814,100900,00.html.

Cooney, M. 2005. States Target Offshoring – Again. *Computer World* (Network World) (Feb. 28).

Deloitte and Touche. 2005. Calling a Change in the Outsourcing Market. Internal Report, p. 24 (April).

Denning, Dorothy. http://www.cs.georgetown.edu/~denning/infosec/cyberterror.html.

Donofrio, N. M. 2005. Testimony Before United States House of Representatives Committee on Science (July 21).

Electronic Entertainment Policy Initiative. 2005. The Camel Fully Enters the Tent (June 21). http://www.eepi.org/archives/eepi-discuss/msg00109.html.

Engardio, P., Puliyenthuruthel, J., and Kripalani, M. 2004. Outsourcing: Fortress India. *Business Week Online* (Aug. 16). http://www.businessweekasia.com/magazine/content/04_33/b3896073.htm.

Europe WorldWatch. 2005. *Wall Street Journal* (June 20) A13.

Flug Review. http://www.flug-revue.rotor.com/FRheft/FRH9802/FR9802h.htm. (Documents the Boeing / Lauda airline disaster).

Ford, R.A. 2005. Preemption of State Spam Laws by the Federal CAN-SPAM Act. *University of Chicago Law Review, 72*, 355.

Friedman, T. L. 2005. *The World is Flat*. Farrar, Strauss, Giroux.

Gansler, J. and Binnendijk, H. 2004. *Information Assurance: Trends in Vulnerability.* NDU Press, 3-5.

Gantz, J. and Rochester, J.B. 2005. *Pirates of the Digital Millennium*. Prentice Hall, Upper Saddle River, NJ.

Harvey, O. Your Life For Sale. *The Sun*, London, U.K. http://www.thesun.co.uk/article/0,,2-2005280724,,00.html.

The Hindu. 2005. U.K. Police Probing Call Centre Scam in India. (June 24). http://www.hindu.com/2005/06/24/stories/2005062404241300.htm.

House, C. Private Communication with IEEE Vice President of Publications.

G Hulten, J Goodman, R Rounthwaite "Filtering spam e-mail on a global scale", Proceedings of the 13th international World Wide Web, May 2004, NYC, NY

Institute for Security Studies. 2003. Examining the Cyber Capabilities of Islamic Terrorist Groups. *Technical Analysis Group, Dartmouth College (*Nov.).

Janger, E.J. and Schwartz, P.M. 2002. The Gramm-Leach-Bliley Act, Information Privacy, and the Limits of Default Rules. *Minnesota Law Review 86*, 1219.

Government of India. 2000. The Information Technology Act.

Harsha, P. 2005. Lots of News Re: The Case for R&D and U.S. Competitiveness. *Computing Research Policy Blog* (Dec. 5). www.cra.org/govaffairs/blog/archives/000443.html.

Knox, N. 2005. French May Reject EU Constitution. *USA TODAY* (June 27).

Lance, T. 2002. A Vision for the Network: Educause. *NYSERNet* (Draft 12/16)

Lewis, J.A. 2005. Waiting for Sputnik. *Center for Strategic and International Studies* (Oct). www.csis.org/media/csis/pubs/051028_waiting_for_sputnik.pdf.

Libicki, M. 2005. From Intimacy, Vulnerability. *Conquest in Cyberspace.* (To appear).

Malone, T. 2004. *The Future of Work*. Harvard Business School Press.

Mann, C L. 2003. Globalization of IT Services and White Collar Jobs: The Next Wave of Productivity Growth. International Economics Policy Briefs PB03-11. *Institute for International Economics* (Dec.).

Mann, C.L. 2004. Global Sourcing and Factor Markets: The Information Technology Example. *ACM Job Migration Task Force Meeting* (Dec.). Washington, DC.

Mann, C.L. 2004b. What Global Sourcing Means for U.S. IT Workers and for the U.S. Economy. *Virtual Machines 2,* 5 (July/Aug.).

McCue, A. 2005. Indian Call Center Staff in $350,000 Citibank Theft. *TBR News* (April 11). http://www.tbrnews.org/Archives/a1528.htm.

NASSCOM. http://www.nasscom.org/trustedsourcing.asp.

NASSCOM – Evalueserve, "Information Security Environment", Study, May 18, 2004.

National Academy of Sciences, National Academy of Engineering, and Institute of Medicine. Committee on Prospering in the Global Economy of the 21st Century. 2005. *Rising Above the Gathering Storm*. National Academies Press, Washington, DC.

The National Summit on Competitiveness. 2005. (Dec.). Washington, DC. www.usinnovation.org.

O'Bryan, S. 2003. Lecture at Management Information Systems Research Council. *University of Minnesota*.

Pacelle, M. and Sidel, R. 2005. Security Is Breached at Card Processor. *Wall Street Journal* (June 20), A2.

Peralte, P.C. and Ferris, S. 2003. Mexico claims ChoicePoint Stepped Across the Line. *The Atlanta Journal-Constitution* (April 27).

Peterson, A. 2002., EU Report Reveals Holes in US Safe Harbor Agreement. *Privacy Laws & Business* (Jan.).

Pierra, R.E. 2001. Botched Name Purge Denied Some the Right to Vote. *Washington Post* (May 31) A01.

Prestowitz, C. 2005. *Three Billion New Capitalists: The Great Shift of Wealth and Power to the East*. Basic Books.

The Privacy Protection Study Commission. 1977. Personal Privacy in an Information Society.

Ramer, R. 2002/2003. Interviews with Directors of Tata Consultancy Services, MphasiS, Tata Infotech, and Sonata Software (Feb. 2002, Jan. 2003, May 2003, Dec. 2003).

Ramer, R. 2004. (Based on interviews with security personnel at ODC site serving British and US clients.) *Communications with Risks and Exposure Sub-Committee* (April).

Ramer, R. 2005. TerraFirma Security Corporation. (Private Communication, April 25).

Ramer, R. 2005B. Correspondence with peer reviewers.

Rigby, B. and Kolker, T. 2005. LexusNexus Uncovers More Security Breaches. *Reuters*, Amsterdam (April 12). http://www.tbrnews.org/Archives/a1528.htm.

Schneier, B. 2005. Testimony to Minnesota State Senate Commerce Committee (April 6).

Schneier, B. 2005B. Accuracy of Commercial Data Brokers. *Schneier on Security 7* (June). http://www.schneier.com/blog/archives/2005/06/accuracy_of_com.html.

Simmons, G. Mission Critical Systems Still Vulnerable to Attack. http://www.foxnews.com/printer_friendly_story/0,3566,172787,00.html.

Solove,D. and Hoofnagel, C. 2005. A Model Regime of Privacy Protection. *GWU Law School.* Research paper #132 (March).

Spafford, E. 2005. Testimony before the House Armed Services Committee Hearing on Cyber Security, Information Assurance and Information Superiority (Oct. 27).

Stannard, M.B. 2004. U.S. ill-Prepared to Handle Bioterrorist Attack, Experts Warn Flu Vaccine Crisis Called Symptom Of Far Wider Problem. *San Francisco Chronicle* (Nov. 1).

Swire, P.S. and Steinfeld, L. Security and Privacy After September 11: The Health Care Example. *Minnesota Law Review*. (To appear).

Symantec Internet Security Threat Report. 2004. Threats for Jan- June 2004, 3.

Symantec Internet Security Threat Report. 2005. Threats for Jan- June 2005.

Thiagarajan, K. 2005. Wake-up Call in Order. *Hindu Businessline* (April 18). http://www.thehindubusinessline.com/bline/ew/2005/04/18/stories/2005041800200300.html.

Timmons, H. 2005. Security Breach at Lexus/Nexus Now Appears Larger. *New York Times* (April 12).

Watson, J. 2005. UK Report Highlights the Risks of Offshore Outsourcing. *VNUNet.com* (May 15). http://www.crmbuyer.com/story/43085.html.

Wikipedia. http://en.wikipedia.org/wiki/Bhopal_Disaster.

Wikipedia. http://en.wikipedia.org/wiki/Data_haven.

Authors: Alok Aggarwal, Fran Allen*, Steve Andriole, Ashish Arora, William Aspray, G. Balachandirane, Arndt Bode, Martin Kenney, Goran Marklund, Frank Mayadas, Peter Mertens, Robert Schnabel*, Stuart Zweben

Chapter 7: Education

There are a variety of ways in which a country can attempt to shape its destiny in the face of offshoring. One is to address the issue through a policy and regulatory approach. For example, a country that is sending software work across its national borders could introduce protectionist tariffs, reform tax law, build a safety net for workers who lose their jobs, or promote innovation through increased research budgets. This policy and regulatory approach is the subject of Chapter 8. Another way to address offshoring at the national level is to adjust the educational system to provide the basis for the labor pool for the employment needs of the country especially in light of the international marketplace. For a developing country, this generally means building up the size and quality of its workforce in order to expand its software export business. For a developed country, this generally means finding ways to educate a workforce that either enables it to compete against low-wage countries or take advantage of partnerships with the low-wage countries.

This chapter addresses education as an enabler and as a response to offshoring. The chapter identifies some challenges, describes the educational systems in four locations (India, China, the United States, and the European Union), and ends with some proposed educational responses. The focus is primarily on higher education, both undergraduate and graduate, but there is also discussion of training opportunities outside of the traditional degree programs.

7.1 Prospects and Challenges of an Educational Response to Offshoring

The educational system must address both new workers who need an initial education to enter the IT field, and incumbent workers who have to keep their skills and knowledge current to do their work effectively in a world that is rapidly changing due to globalization. Most of this chapter focuses on the new workforce, but some of the topics discussed here also apply to the incumbent workforce such as courses on particular technologies, certificate programs, or people returning for a higher degree after working for some years. Chapter 8 addresses another issue related to the incumbent workforce, providing them with retraining if they lose their job through trade.

The educational system for information technology is complex, and it is difficult to determine the most appropriate steps for a country to take if it wants to prepare for a globalized software industry. This is true for countries sending software work as well as those receiving it. There are at least ten reasons why this educational response is so complex and difficult. This is not to suggest that a policy maker should give up trying. Indeed, the final section of the chapter suggests some actions that one might take. But it must be recognized that the issues are complex and no easy fixes are likely to be found.

1. *Many different occupations*. In the medical profession, there is not just one occupation of doctor, but many different kinds of doctors (general practitioners and many different kinds of specialists), nurses, medical technicians, physical therapists, and so on. Each of these occupations has its own set of requirements in terms of skills and knowledge to be able to do the job in a professional manner. The same is true of the IT profession. There are many different IT occupations, ranging from web designer or programmer to

*F. Allen and R. Schnabel took a leadership position in writing Chapter 7.

research computer scientist or computer system architect, and they vary widely in their requisite skills and knowledge. Each occupation is affected differently by globalization.

2. *Multiple degree programs*. Several of the computing professional societies have mapped out model curricula for IT academic degree programs (computer science, computer engineering, software engineering, information systems, and information technology), and these model curricula are followed in many countries. There are numerous variations on these five types of programs and also various kinds of educational experiments with new kinds of degree programs such as information schools. Thus there is a need to consider not one but many different curricula in order to address offshoring.
3. *Multiple non-degree training and education opportunities*. There is a large range of choices in non-degree training and education. These include corporate universities, individual courses and suites of courses from traditional and for-profit universities, and programs of study leading to certifications in various specific technologies.
4. *Multiple career paths*. There are many different career paths to become, for instance, a beginning programmer. One might take an undergraduate degree in computer science, enroll in a few computer science courses while taking a major in another science or engineering discipline, take an associates degree or study in a certificate training program in a particular programming language, learn on the job, and so on. Few physicists have a career path that does not involve formal training in physics; however, the majority of IT workers do not have a formal degree in computer science or information technology.
5. *Multiple application domains*. IT is used in virtually every application domain, from the entertainment industry, to science and engineering, to government, to business. Many IT workers need to know something about the application domain in which they work; for example, many IT workers in drug companies need to know something about the pharmaceutical business not just IT if they are to work effectively. IT workers might also need to learn about how IT systems are integrated into the company's business functions and operations. In contrast, workers in an IT research or development lab might be able to focus more narrowly but be required to draw more deeply on a technical IT education.

All of these complexities make it impossible to give simple prescriptions about what changes to make to a national educational system in order to provide good service to the country in the light of offshoring. But there are also some other features that make it difficult to implement an educational response to offshoring.

6. *Transformation pace*. Traditional universities, at least in the United States and Europe, have been slow to change. This is caused in part by taking a long-term view of education and in part by organizational structure (long-term labor contracts, decentralized power, management by consensus, entrenched bureaucracy). The deliberate approach to curricular reform is one of the strengths of the university system, but it can also be a weakness in a field where technologies becomes obsolete in a year or two and where the demand for workers can rise and fall significantly in a short period of time.
7. *Centralized planning of supply and demand*. While universities in most countries make their own decisions about the number of IT students they enroll, these admission decisions are shaped by national policies and government support in the form of computing equipment, infrastructure funds, research funds, fellowships, and internships. If a government believes that it has a shortage of IT graduates to fulfill its work needs and does not have direct control over university enrolments, it might act indirectly by

increasing funding to universities. Unfortunately, governments do not have a strong track record in their ability to predict trends to match supply to demand. For example, some argue that in the United States, there was a glut of scientists in the mid-1990s after the scientific community convinced Congress there was an impending shortage of scientists, and Congress ramped up support for fellowships and other means to increase the number of scientists (Teitelbaum 2003).

8. *Competing goals of education*. In many cases, preparation for the IT job market is not the only reason for an educational program. It may be designed, for example, to give the student a liberal education or to stretch the student's mind. With competing objectives for a degree program, it is harder to make changes that maximize the training provided for a single one of these objectives such as preparing students to be effective IT workers.

9. *The changing nature of offshoring*. Offshoring is not a single fixed phenomenon. The Indian offshoring industry, for example, includes programmers and system analysts who do software maintenance, testing, or development; workers answering phones in call centers; workers doing accounting services and other back-office business work; workers doing knowledge processing such as reading digitalized X-rays; workers doing research and advanced development; and so on. In India, the growth field of offshoring was once programming to fix Y2K problems. A year later, it was call centers. Two years later, it was IT-enabled services. Today, there is a push towards high-end activities where profit margins are higher such as systems integration and research. Who knows what the growth area will be next year? All of these kinds of offshoring co-exist in India today. Other low-wage countries might have one kind or another of offshoring work today, for example, there are mostly call centers in Africa, mostly programming shops in China, but the mix of tomorrow is uncertain. The type and mix of work is constantly changing, so how is an educational system to plan since one kind of education is needed for someone working in a call center and a very different kind of education is needed for someone working in a research lab? Perhaps it will be possible to build an educational system that takes into consideration the dynamism of the world, but this is a challenge.

10. *Lack of data on the relationship between education and career*. We have no good data on the kinds of careers that people pursue with a given IT education, how successful they are, what the progression of jobs held is, or how long they persist in the IT field. It would be useful to have this data for each of the different degree programs so that they could be compared with one another and against careers in other science, engineering, and professional disciplines.

In a sense, the issue for every country, whether high-wage or low-wage, is the same: to provide an education system that will form the basis for the labor pool for the employment needs of that country. But this is too facile a statement. There are important differences from country to country. Low-wage countries such as China and India, which have rapidly expanding software export industries, need to ramp up their educational systems to meet the rapidly increasing demand for educated workers. Companies in these countries need to hire well-trained employees so that clients have confidence in the quality of the work, and they have to hire enough of them so that clients will give the company large-scale projects. India has an educational system that has been increasingly privatized. The educational system has been agile at adapting to industry's needs, but India faces problems of quality control outside of a few elite institutions, and the education and lucrative careers in IT are out of reach for most of the population. China faces issues about how well central planning will work. Some people in the United States fear that most of the low-skill IT jobs will leave the country. For these people, the question is how to train people for the high-skill IT jobs and what kind of career ladder is possible to get there. Other people believe that the United States will stay strong by increasing its level of innovation. For these people, the question is how to introduce a curriculum that teaches students to be innovative. In Europe, the Bologna Declaration, a joint declaration of the European ministers of education in 1999, is trying to facilitate the movement of labor within Europe. The educational challenge there, in part, is to move from national-style educational systems to a new higher education system that has some uniformity and transportability across Europe. Moreover, Europe is very different from the United States in not having a large global software products industry.

We do not yet know, for any country, how difficult it will be to offer an adequate educational response to the challenges and opportunities of offshoring. Globalization is here to stay, and offshoring looks like it will be a growth industry for at least a few more years. Thus an educational response seems critical if a country is to thrive in the globalized software world. But, to take an example, the United States has faced a stream of knotty educational issues relating to IT. From the first days of the US computer industry in the 1950s, the United States has faced issues concerning computer education. At a national conference in 1954, science policy leaders wrung their hands over how they would find enough PhD. mathematicians to staff the scientific computing projects that existed. In the 1960s, the country struggled with finding adequately trained personnel to teach in their newly formed computer science departments, how to define graduate and later undergraduate education, and what curricula to teach. As business computing emerged beginning in the late 1950s, and as computing filtered down to smaller and smaller businesses as computing price-performance improved in the 1960s and 1970s, there were new educational challenges over forming new academic disciplines (e.g., information systems) to meet business's computing needs. In the early 1980s, doctoral production remained stubbornly low and there were concerns that there would not be enough faculty members to teach the expanding number of undergraduate majors and other computing course-takers.

More recent times have seen new challenges including dealing with rapid spikes and rapid drop-offs in undergraduate enrolments in the face of the dot-com boom and crash, revitalizing a research agenda and graduate education core that was largely formed in the 1960s and 1970s, enriching research vitality through an interdisciplinary approach to research and greater attention to applications, finding means to handle growing national IT workforce needs especially to accommodate people who did not take the traditional path of formal technical degrees, and handling revolutionary changes in the ways in which IT is used in American business. Generally speaking, the US educational establishment has not been as quick to meet these challenges as some policymakers would like, but they have succeeded well enough to maintain the world's strongest software industry.

Because the IT educational system is so complex and what is happening with offshoring is changing so rapidly, it is impossible to be prescriptive about what any country should do with its educational system. In the next four sections, we describe the current IT educational systems in India, China, the United States, and Europe and the changes taking place in them. In the final section, we draw some conclusions about the educational response to offshoring.

7.2 Indian Education

Higher education is one of the crucial enablers for India to become a powerhouse in offshoring. The higher education and training system continues to be one of India's strategic advantages together with a large English-speaking population, a British-style legal system, and close ties to the English-speaking world through both its colonial roots and the contact of its scientists and engineers with Western Europe and the United States.

Brief History of Education and Trends

In the initial decades after independence in 1947, India tilted its educational investment priorities in favor of higher and technical education in order to realize Nehru's vision of a state-regulated production and distribution machine. This was a period of planned economic development, designed on a Soviet model of modernization. In the first twenty years of planning, higher and technical education received much higher priority than primary education due to the predicted labor requirements of heavy industries. In the next fifteen years, the percentage of India's resources spent on technical education declined, higher education growth stabilized, and elementary education gained a higher percentage of the state investment. In the first twenty-five years after independence, the number of universities in India quadrupled, and the number doubled again over the next twenty-five years.

The Increasing Importance of Higher Education for India

The role of knowledge in economic development has become critical in the last decade and, concomitant with this worldwide trend, the role of higher education has assumed increasing significance. Higher education is underdeveloped in terms of quantity and quality in India. A vast demand was generated for various kinds of human capital, brought about by the opening up and integration of the Indian economy with global markets. The real income level of a sector in Indian society has gone up, enabling people from this sector to participate in higher education. Two factors ultimately raised the demand for higher education: the increasing role of the knowledge economy that requires higher skills, and the globalization trends that opened up new avenues to high-skill jobs. As The World Bank observed, "Higher education has never been as important to the future of the developing world as it is right now. It cannot guarantee rapid economic development - but sustained progress is impossible without it." (World Bank 2000, 19).

India tried to meet the higher education demand through both public and private means. One reason that government has not invested more in higher education is that the resources available to the Indian government are finite, and there is competition for these funds for higher education from other public investments that also have high social return such as clean drinking water. Another reason that the Indian government may not have invested more public funds in higher education is because there has been strong private interest in making these investments since the early 1990s (Jha 2005; Tilak 2002, 2004; Carnoy 1999). During the liberalization of the 1990s, privatization in the higher education sector advanced rapidly. One estimate is that private sector education today accounts for close to 2 percent of Gross Domestic Product (Lall 2005). The private sector accounted for just 15% of the seats in engineering colleges in 1960, while today it is 86.4%.

There seem to have been some problems with the quality of instruction in a number of the private institutions, and the government has been lax in establishing and enforcing accreditation and other quality standards. However, there are some excellent private institutions, such as the Indian School of Business at Hyderabad that provides high-quality executive business education.

The tuition of even the state colleges and universities is beyond the reach of many Indian citizens, and this is part of the reason why only 6% of the population enters higher education. The cost in the private schools is much greater. The Indian School of Business in Hyderabad, for example, charges about US$30,000 for a one-year course of instruction which is five times the per capita income in India. However, there are other more affordable choices of business schools for students of lesser means.

As is discussed later in this chapter, the Indian universities have not made great contributions to scientific and engineering research which goes hand in hand with graduate education. Doctoral training in engineering has dropped significantly in India just as undergraduate capacity has increased. It is likely that the private institutions will be better at producing commodity products (masses of undergraduate engineers and MBAs) than specialized niches such as doctoral-level researchers. Perhaps this is another role for the public universities.

Financing and Demographics of Education

The expenditures in India on education as a percentage of the Gross National Product has risen from about one percent half a century ago to nearly 3.5% today. The average spending on education in the 1950s was 1.8% of GNP, 2.8% in the 1960s, 3.1% in the 1970s, 3.3% in the 1980s, and about 3.5% in the 1990s. The world average is 4.8% with the industrialized countries spending about 5.1% of their GNP on education and the developing world spending about 3.6%. Breaking down the data further, Sub-Sahara Africa is spending 5.4% of GDP on education, Eastern Europe 4.6%, and Latin America and the Caribbean 4.6%. Thus India's spending on education is low compared not only to developed countries but also to a number of developing countries.

In the year 1953, there were 25 universities and 565 colleges in India; in 2004, those numbers were 311 and 15,600, respectively. The number of students in higher education rose during the same period from 230,000 to 9.28 million, while the teaching staff rose from 15,000 to 462,000. Over 2.5 million graduates are produced in India every year. There are serious class, regional, rural-urban, and gender inequities in the demographics of higher education.

Despite the rapid expansion of higher education, enrolment in higher education in India is just 6 percent of the relevant age group (18-23). In comparison, countries in North America are in the 60 to 70 percent range, those in Europe are in the 40 to 60 percent range, while the Asian Tigers (Hong Kong, Singapore, South Korea, and Taiwan) are in the 33 to 55 percent range.

In 2000, the engineering colleges in India were not evenly distributed geographically. Just four states, Andhra Pradesh, Karnataka, Maharashtra, and Tamil Nadu, accounted for 64% of the engineer-degree intake with just 28% percent of the population. In the state of Tamil Nadu, there were over 40 engineering colleges for every 10 million people, while it is less than 1 per 10 million people in the state of Bihar. However, response to market forces by private organizations has begun recently to even out the distribution.

In 2000, India produced 11,100 PhDs of which 5300 were in the sciences and engineering. The total number of engineering institutions as of 2002 was 1215; 253 more were to be added in 2003-04.

Higher Education: Its Development and Present Status

Some excellent centers of higher education have been created in India. The foremost and best known are the five Indian Institutes of Technology (IIT). Other strong educational institutions include the Indian Institutes of Management (IIM), and the Indian Institute of Science (IISc). There are other institutions of academic and research excellence which come under the ambit of the Council of Scientific and Industrial Research (CSIR). In addition to these public sector institutions, the private sector has contributed the Indian Institute of Science, Tata Institute of Fundamental Research, and the Birla Institute of Technology and Science among others.

Most of the graduates of these institutions found there was a paucity of good jobs for them in India, at least in the years from 1953 until 1998. The economic growth rate that the original planners envisioned did not come about so many of these graduates could not find good, full-time employment in the profession for which they had trained. Because of this lack of opportunity at home, many of the IIT graduates started migrating to the Western countries, particularly the United States. Over one-third of the graduates of the

IITs have settled outside India, mostly in the United States. Thus the vastly qualified human capital created at considerable cost to India has remained underutilized until recently.

Development of the IT Sector

When circumstances changed in the mid-1980s and particularly in the 1990s with the onset of the IT boom and the Y2K problem, the major investments made in the higher education sector started paying off for India. This investment enabled the rapid maturity of India into a significant IT player in the world. With this background, let us consider the higher education system in place in India today.

The key driver for the Indian IT industry has been the availability of skilled computing professionals who are inexpensive (relative to other countries) and fluent in the English language which is the language in which most systems and applications software is written. In the last fifty years, the annual growth rate in science education in India has been 11 percent in terms of number of graduates and 9 percent in terms of institutions. The number graduating annually in science and engineering, including computing, has been in excess of 150,000. The polytechnics annually produce about 200,000 diploma graduates; these polytechnic colleges provide technical training that is vocationally oriented. In addition to this, there are the thousands of private training institutions that offer both short- and long-term courses in programming and software engineering.

As far back as the late 1970s, information technology education received attention in India based in part on a belief by the government that this technology would become pervasive and require large numbers of qualified workers (Maheshwari 2004). The government planned a three-year MCA (Master in Computer Applications) program. The engineering colleges were encouraged to start the B.Tech (Bachelor of Technology) programs in computer science and engineering. Private initiatives in functional training in the use of software packages also began at this time.

In the late 1980s and early 1990s, the rise in software exports caught the imagination of people and various estimates of the anticipated shortages in the availability of skilled workers were publicized. Personnel planning for IT was similar to an emergency operation, with large shortages foreseen in skilled workers. Most universities either started or expanded their degree-level programs in IT in this period. There was a major expansion of the certificate and diploma courses offered by private organizations. Soon IT education was a massive industry, including both public and private initiatives.

Where does IT education stand in the country today? Out of the 700 plus engineering colleges, about 500 run B.Tech programs in electronics, computer science and engineering, or IT. The MCA program is found in over 300 universities or colleges. The BCA (Bachelor of Computer Applications) and BIT (Bachelor of Information Technology), which are three- or four-year programs, have been introduced recently in a number of universities. These B.Tech, BE, and MCA programs together can produce around 75,000 graduates per year. This number falls short of meeting the national demand for IT workers. As in other countries, however, employers who are seeking technical IT workers do not restrict themselves to graduates with IT degrees. They are also likely to hire students who majored in other scientific or engineering disciplinesand who learned a significant amount about IT as part of their degree program. Thus the number of technically-trained graduates is higher than 75,000 but hard to count exactly.

Formal technical degrees and the demand for them is only part of the story. There is also a large demand for workers familiar with IT who have done courses less rigorous than the formal degree programs mentioned. These less highly-trained workers can fill the demand for workers in call centers and back office/IT-enabled services. This sector has over 5000 training institutions, and its growth rate is around 20% per year. Major private players include NIIT Technologies and Aptech, as well as the DOEACC Society, an autonomous body set up by the federal Ministry of Information and Communications Technology. These institutions offer a large number of courses and provide short-term, skills-oriented programs. They enable university students who could not get admitted to degree programs in IT to pick up IT skills while doing some other course of study unrelated to IT at the university. It is believed that as many as 500,000 students are getting some sort of IT training through these non-formal channels each year.

There is competition for trained IT workers from other IT fields in India. There are at least two important areas that require IT workers. The first is the growing hardware sector. One estimate puts the demand by the hardware industry for trained workers with university degrees or diplomas at 180,000 by 2008 (NASSCOM 2005). The second is the large number of workers who will be required to teach IT in the schools. There are about 100,000 secondary schools teaching about 28 million students today. One of the ways that IT education will be promoted is through the teaching of computer science as a formal subject which will require an additional 100,000 qualified teachers. Estimates for 2008 place demand at 1.4 million formally-trained degree holders in an IT discipline, and an additional 1.1 million workers for the IT-enabled services (ITES) area (NASSCOM 2005).

What are the pressing problems for the IT education sector today? Even with the vast initiatives in both the public and private sectors, some policymakers are concerned that supply may not be able to cope with the demand, which is expected to balloon. (But one study by NASSCOM, discussed later in this section, disagrees.) The second problem is the quality of the tertiary sector of computer science and IT education. One study estimates that 70 percent of the workers with formal post-secondary training are not up to par as far as industry's requirements are concerned (Balatchandirane 2004). The third area of concern is that PhD enrolments in computer science are practically nil which could seriously impair the prospects of India moving up the value chain in IT exports. An alternative to indigenous production of computer science doctorates would entail an effort to attract Indian and other students who received their IT doctorates in another country, most likely the United States or the United Kingdom. There has been a recent increase among Indian students taking doctorates in the United States in the number who return to their homeland, but there are still questions of compensation and working conditions to consider if the Indian universities want to attract these people as faculty.

Around 290,000 engineering degree and diploma holders enter the workforce annually. Most of them enter the IT industry. Most have received their education in English. Table 1 summarizes the pool of graduates in India.

Table 7-1: Graduate Pool in India, FY 2003-04

(nos)	Engineering Degree Holders	Engineering Diploma Holders	Arts Degree Holders	Science Degree Holders	Commerce Degree Holders	Total Graduates
Graduates (through 2003)	1,200,000	1,750,000	11,500,000	4,985,000	5,933,000	21,986,000
2004 graduates (estimate)	155,000	130,000	1,150,000	540,000	480,000	2,460,000

Source NASSCOM (2005)

The number of IT and ITES professionals employed in India has grown from 284,000 in 1999-2000 to an estimated 813,500 in 2003-04. Most of the new recruits are recent graduates with various academic backgrounds. Turning to the worker demand and supply for the IT sector, NASSCOM estimates that the supply of IT professionals will in fact outstrip demand by 48,000 in 2008. The number of professionals who would be joining the IT workforce from various academic disciplines is given in Table 2.

Table 7-2: Indian IT Sector; Labor Supply

(in '000)	**2003-04**	**2004-05**
Number of engineering graduates *Degree (4-year course)* *Diploma (3-year course)*	215 112 103	284 155 129
Number of IT (Computer Science, Electronics, Telecom) Professionals *Engineering IT graduates (Degree)* *Engineering IT graduates (Diploma)*	141 95 46	165 100 65
Number of IT professionals entering the workforce *Engineering IT graduates (degree)* *Engineering IT graduates (diploma)*	80 55 25	94 58 36
Number of non-IT engineers entering the IT workforce	40	40
Number of graduates (other disciplines)	30	30
Total fresh IT labor supply	150	164

Source NASSCOM (2005)

Training Programs

Even though there is a large population available to enter the IT workforce generally, there may still be shortages in particular IT occupations such as programmers or web developers. Different people in the work pool have different training and not all of them are prepared for all the IT occupations. By and large, engineering graduates are prepared for many technical IT occupations. However, some of them need to take a few software courses after they enter the workforce in order to be able to function more efficiently in the IT industry. Students from other disciplines, such as the sciences and arts, often need rigorous training in software development. Some Indian educational policymakers are advocating that software-related courses be added to these other curricula, even if the software courses are not fundamental to the principal subject of study, for the specific vocational purpose of preparing students concentrating in these other disciplines for IT sector entry.

English-language skills are a problem for many students in Indian graduate and vocational schools. The image of India churning out a large number of graduates fluent in the English language is not really accurate. Students are entering the IT job market with a wide range of skills in the English language, but the IT industry expects fluency. Some of these graduates need additional language training. This is particularly so in the ITES industry that requires skill profiles that are different from those for the software industry. Those employed in the ITES industry need not only language skills, but also familiarity with the particular functions and domains of knowledge of the field to which IT is being applied.

It is ultimately the quality of the human capital that determines the growth of the Indian offshoring industry. Without the creation of high-quality human capital, other advantages are not going to be of much help. Education is important, but training may be even more important. Preparing workers for this career involves more than a one-time investment effort; it involves a dynamic, ongoing process that is flexible and quick to respond to market signals, while at the same time incorporating an overall philosophy of matching the basic human capital to the additional incremental skills that are demanded by the market.

Thus the training programs need to be innovative and dynamic with course curricula designed on the move. This differs markedly from the curricular reform process used by universities where it can take years to design a course that is solid and can stand the test of time. The nature of the training that is expected in the IT industry is difficult to predict since it is based on ever-changing demands for particular new skills in the international marketplace. Like most universities and governments around the world, Indian public-sector universities are not well suited to this kind of flexibility and rapid change. In fact, it has been the private sector that has been by and large responsible for most of the meaningful training programs in this industry. The biggest training institution in Bangalore today is not in a university, however, but at the company, Infosys. The company is setting up a huge facility at Chennai, where as many as 10,000 of its computer professional employees can be given specialized training each year. Another industry leader, Wipro, also has a large training facility. These companies are two of the largest training institutions in Bangalore today. As many as 33 percent of the world's SEI-CMM Level 5 companies (the Software Engineering Institute Capability Maturity Model of Carnegie Mellon University), the highest level of international quality certification, are to be found in Bangalore today, a fact made possible by the high-quality training of its professionals (NASSCOM-KPMG 2004).

There are also a number of courses or institutions created for industry. IIM Bangalore runs courses intended to meet the need of the hour. There is a specialized program in Masters in Business Administration designed especially for IT professionals. The interesting aspect is that, while IIM Bangalore interacts with industry and accepts large donations from industry, it retains its autonomy. Private industry cannot control or decide on the kind of course that will be run or how to run it. IIM Bangalore decides completely on its own about the form and content of its courses, and yet the program remains highly sought after. Similarly, the Indian School of Business at Hyderabad, funded by private sector initiative, is turning out to be a world-class institution for training managers with additional skills. Both these institutions fall outside the regular university system in India. They do not receive certification from the University Grants Commission (UGC), the autonomous body of the government of India that monitors, certifies, and funds institutions of higher learning in India. These institutions and others, such as the Indian Institute of Information Technology (IIIT), are of very high quality and brand equity.

Another model is the scenario where some companies pay large sums of money to a university or other educational institution for a specific course to be started. The company gets to place some of its managers in the program every year, but the course content is controlled by the educational institution. For example, Wipro has made large contributions to Birla Institute of Technology and Science for this purpose.

There are other industry/academic interfaces. In a number of engineering/IT courses, the student is expected to do project work that involves studying and collecting data from an industry over a period of three to six months. This gives the student a first-hand opportunity to get to know about the industry, even before graduation. Companies that encounter bright students in this way let the students know informally that opportunities are available for them on the completion of the course. A number of companies recruit on campus. They visit campus to meet students a semester or two away from graduation and explain to them about their company and career opportunities for the students, and they make offers to promising students after interviewing them. Faculty members are present to advise the students. In this way, students can receive job placements before they complete their study, and the companies are assured of good quality computer specialists. Another area of cooperation is in providing foreign language skills to qualified IT professionals. Many companies are turning towards the Far East market. Since fluency in Chinese, Japanese, or Korean is essential for the Indian IT professional who works in the Far East in order to communicate and write software, these companies have interacted with universities to provide special courses in these languages for its professionals. Alternatively, they have selected bright foreign language students and given them IT training in their own companies and then placed them in their offices abroad.

Some of the pertinent points about training to emerge from a study done by NASSCOM and Hewitt Associates are listed in the Table 3 (NASSCOM 2004). They indicate the importance attached to training by the Indian IT companies.

Table 7-3: Training by Indian Companies

1. **Nearly all companies (95%) have a formal development and learning needs analysis program.**
2. **The most commonly used mechanisms to support continuous learning and development for employees are organizational libraries, assessment of skills/knowledge/abilities, and job postings/internal transfer systems.**
3. **The median number of training hours per employee per year is 40. The distribution of training hours across behavioral and technical training programs varies with level of employees. Senior employees get more behavioral training, up to 60% of the training is either on managerial topics or in interpersonal skill enhancement.**
4. **98% of the companies have a formal training feedback mechanism.**

Source: NASSCOM and Hewitt Associates (2004)

Observations

Using the previous discussion as background information, here are some observations and recommendations about IT education in India.

1. It is ultimately the quality of the human capital that determines the growth of this industry. Without the creation of high-quality human capital, other advantages are not going to be of much help. One advantage of India is that it has adapted very rapidly, if not perfectly, to this need. A country that wants to be a significant IT player has to have a strong higher education sector. Recently, in India the private sector has predominantly played this role. The demand for a strong higher education system presents a great challenge for India. For example, for India to bring its total investment in education up to 4.8%, which is the level of developed nations, would require almost US$9 billion additional annually. If every penny of the extra funding was spent on primary education, it would still not be enough to give all Indian children an eighth-grade education. Thus there is tremendous demand for funding even within public education itself which competes with the called-for investments in higher education.
2. Training courses for IT professionals have to be continually created to keep abreast of market demands. The private schools are more motivated and better positioned to do this, but the public universities could improve at this as well.

3. There are bound to be gaps between the supply and demand for IT professionals. Any projection of supply and demand is at best an approximation of the present understanding of future realities. The future reality could be drastically affected if there are some changes in the international economic or political environment. New IT players could rise, displacing others who have dominance now. Since a country cannot control the external environment, and since changes in IT occur rapidly, the demand for IT products and services can change very quickly. Along with this risk are great opportunities in that the international market for IT products and services is huge and expanding. How responsive each country's education and training systems (both public and private) are and how quickly they adapt and exploit these opportunities will separate the winners from the also-rans.

4. Despite advantages of location, cost, and time-zone differences, what ultimately matters is quality. One reason why India could succeed is the fact that it has the largest concentration of IT companies with the highest level of quality certifications in the world in Bangalore and Hyderabad.

5. The low level of R&D investment and shortage of R&D workers in India leads to a low level of technological innovation. India employs just 150 R&D personnel per 1 million people. Among these, those holding doctorates represent just 13 percent, while graduates are 17 percent, and the remaining 70 percent are still undergraduates or diploma holders (NASSCOM 2005).

6. The quality of the Indian university system is a concern. There is not a single Indian university among the top ten Asian universities. While 280,000 engineers are produced in India every year, only 10,000 (less than five percent) are of top international quality (NASSCOM 2005). If one were to remove the well-known Indian Institutes of Technology and Indian Institutes of Management, the average quality of the remaining higher education institutions drops steeply.

7. The demand for higher education in India will balloon due to a number of factors. First is the rising need for skilled labor due to globalization. Second is the large increase in the number of young people in India and the large rise in people with primary and secondary education. An increasing share of them are moving on to higher-education levels, raising the demand for higher education.

8. With the developed world constantly raising the stakes by pushing the knowledge frontier further, India will have to constantly raise the quality of its higher-education systems to prevent the widening of the gap. This might mean greater investment in the public universities, but it should also mean greater quality control through government regulation of the private education providers who now provide a majority of the educated workers.

9. Salary levels for university teachers are low. It is typical for students who graduate from the top institutions to receive a compensation package that is greater than what a teacher receives. The best of these teachers are tempted by jobs abroad as well as by jobs in the private sector. It is becoming increasingly difficult to get bright people to enter the academic profession. It may be that the private sector is better positioned to provide adequate salaries to attract quality faculty, but the public universities could also improve the salaries and working conditions of their faculty.

10. Various documents of the World Bank of late have focused on the importance of the knowledge society and how post-secondary education needs to rapidly grow in the developing world (World Bank 2002). As the higher education systems are inadequate in the developing countries, they are open to selling by the developed countries who are moving in to sell education in countries such as India.

11. In most universities, there is a resources crunch for research. In many universities, salaries alone take up 95% of the total allocations, and there is a tremendous infrastructure shortage as a result.

7.3 Chinese Education

During the last two decades, the Chinese economy has grown rapidly (compound annual growth rate in excess of 7%), while shifting from a largely agricultural country to a major industrial power. China has developed a substantial technological base, although Chinese industry is still dependent upon imports of advanced production equipment, technology in the form of licenses, and the uncompensated usage of intellectual property. Chinese performance in innovation is improving dramatically. For example, in 1986, in terms of patents filed at the US Patent Office, China was 57th globally; by 2003, it had advanced to 18t and, by all accounts, continues to improve its global ranking (Pluvinage 2005). This section draws heavily from Chen and Kenney (2005).

A Brief HIstory of Chinese Higher Education

In China, respect for education is rooted in Confucianism. When the Communist Party came to power, it was committed ideologically to education and the use of science and technology for economic development. The new government also massively increased its investment in basic education, creating a broadly educated public. With the establishment of the People's Republic of China in 1949, the Western powers pursued a policy of isolating China; a by-product of this was China's adoption of the Soviet Union's model of comprehensive and specialized universities and a large network of research institutes. In 1978, the Chinese university model was again reformed to one that more resembled that of the United States and emphasized comprehensive universities (Pepper 1996; Wang 2000). However, the government research institutes are still enormous and have an important role in graduate education. Despite these changes, until recently only a very few universities undertook research; their most important priority was pedagogy.

When the Chinese economy opened to overseas investment, the earlier investment in elementary and secondary education provided a pool of literate and capable factory workers. For those seeking further education, national examinations identified the most capable students, and these students were allowed to continue for massively subsidized post-secondary education. This meant that even children from impoverished backgrounds could, in theory, receive higher education. The result has been enough educated people in the general populace, together with a well-educated elite, to provide an adequate supply of trained engineers and scientists for the country. After the opening to the West in the 1980s, the final element of the Chinese education system was put in place: going abroad, preferably to the United States, for post-secondary education. As with the IITs in India, graduates in engineering or the sciences from elite universities, such as Peking or Tsinghua, are nearly certain to be able to secure admission and financial support to a foreign university.

The Current Chinese Higher Education System

As in the case of India, Chinese universities graduate a large number of students every year. For example, in 2001 (the most recent date for which data was available from the US National Science Board), 567,000 students received their first degree. In total, there were 337,000 graduates in science and engineering; of these, 219,000 were in engineering (National Science Board 2004). The quality of these graduates varies dramatically, but the sheer volume means that China has a large reservoir of technically- trained individuals.

Since the educational reforms of the 1980s, Chinese universities and research institutions (URIs) have developed an unusual mode of interacting with industry. Chinese URI personnel have established firms that are, in effect, university subsidiaries. These firms undertake a variety of activities, ranging from serving meals in university cafeterias to technology development. Lenovo, which recently bought IBM's PC business (Lan 2005; Eun et al. 2005), is an example of such a firm. Chinese universities are also willing to undertake mundane technology development for firms that US universities are generally unwilling to do. This general pattern of university/industry interaction is true for the software industry as it is for other industries.

There is disagreement about the size of the Chinese software workforce. Joseph (2001) reports that there were 30,000 to 35,000 high-level software professionals in China and about 400,000 workers employed at the various levels of the software industry. Pollice (2005), on the other hand, reports that in 2002, only about 250,000 people were employed in information technology jobs in China. He expected this number to increase five to tenfold during the next few years. Universities and research institutes provide 71 percent of all the software engineers in China, with training organizations as the next most important source (12%), followed by professional schools (7%), on-the-job training (6%), and overseas-trained Chinese (4%) (Liu 2004). Liu also states that foreign firms, such as IBM and Microsoft, have established training facilities in China. The Indian for-profit firm, NIIT, has established 100 software training centers in China and developed partnerships with various Chinese institutions (Menon).

Although there had been earlier interest in hardware engineering, Chinese universities largely neglected software studies as an academic discipline until 2001 (Pollice 2005). At the end of the 1990s, the Chinese government recognized that it had a shortage of trained software personnel. The Tenth Five-Year Plan called for a dramatic improvement in Chinese software capabilities. In response, beginning in 2001, 51 Chinese universities established Masters degrees in software engineering. The degree quickly attracted students. For example, beginning in 2002, Peking University Software Institute had an enrolment of approximately 1,000 students. "This is in addition to the number of undergraduates and programmers trained in other trade school curricula . . . [and it] brings the yearly entry total of … employees [trained for some kind of IT occupation] to more than 100,000." (Pollice 2005)

Even though Chinese universities have become interested in software training only recently, the Chinese software industry has benefited from URI and government spinoffs in the formation of some of the more recent software firms (Tschang and Xue 2005). Under government prodding, they have rapidly increased the numbers of software engineers they are training. Although the shortage of software professionals is starting to be addressed, problems remain in educating these professionals to be creative and innovative. Most Chinese technology start-ups appear to be "me-too" firms that clone a Western business model for the Chinese market or use fairly unoriginal technology. For example, of the 24 Chinese technology start-ups that have listed on the NASDAQ Stock Exchange, all appear to be copies of firms that already exist in developed countries (Kenney and Patton 2005). According to Xielin Liu (2004) of the National Research Center for Science and Technology for Development, the education and training of software engineering in China is still "very weak." The courses emphasize "theoretical knowledge" and do "not offer the students a good operational experience." Liu concludes that "both professors and Chinese business engineers are not familiar with international standards" and "lots of Chinese are good in textbook learning and poor in practical learning." Whether or not this rather dismal assessment is fully justified (and a more recent survey in People's Daily 2005 appears to confirm it), given the rapid growth in the economy, there are shortages of qualified and innovative software engineers.

Chinese Research and Development Parks

Even as the central government strives to increase the number of software engineers, local and provincial governments are also actively pursuing software as part of their economic development priorities. Local universities are central to these efforts. For example, Dalian, a large city on China's northern coast, is establishing itself as a center to supply software services to Japan and the rest of the Asia Pacific. The Dalian Software Park (DSP) advertises itself as located in the Higher Education and Culture Zone of Dalian and surrounded by numerous universities and research institutes (DSP 2005). These universities appear to have begun developing a curriculum geared toward providing well-educated employees for the software services industry.

The centrality of Chinese URIs in the development of Beijing and its Zhongguancun Science Park, in particular, has been remarkable (Wu, Yan, Wang 2004). (Although Zhongguancun Science Park is termed a science park, it is more properly a technology park, as few firms within it are doing cutting-edge science like that undertaken by U.S. biotechnology firms.) For example, a number of Beijing's high technology and software firms can be traced directly to elite educational institutions such as the Chinese Academy of Sciences (CAS) and Peking and Tsinghua Universities (Chen and Kenney 2005). Lenovo, a CAS spinoff, experienced its first success by commercializing a Chinese-language word processing system (Lu 2000: 66-68). (For further discussion on the importance of science parks to offshoring, see Chapters 3 and 8.)

Conclusions About the Chinese Higher Educational System

The Chinese educational system has provided a well-educated population and a large and well-trained cadre of engineers that have been important to the growth of Chinese industry. In the software field, the record by Chinese universities has been more mixed, but this is largely because the Chinese government did not see software as a priority until recently. Since 2001, the Chinese government's attitude has changed drastically, and it is emphasizing software as an area for growth. As a result, the university system has responded, although there remains the issue of teaching workers to be innovative.

There are open questions about the most desirable relationship between Chinese universities, firms, and society (Chen and Kenney 2005). Is it desirable for universities and their students to do mundane development work for firms? Should universities own and even manage private sector firms? As the Chinese economy develops and matures, how should universities evolve?

In summary, the Chinese educational system has experienced rapid change as the country industrializes and embarks on an effort to become more knowledge based. In the process, there is a massive effort underway to transform the elite universities from emphasizing teaching to a greater balance between teaching and research. For example, Peking University, in an effort to become a global-class research university, has reorganized its personnel processes to emphasize research and publications and ensure more rigorous standards for promotion and tenure (Yimin and Lei 2003). China has an enormous asset in the form of Chinese engineers and scientists who went abroad, and their return or involvement in the maturation of the Chinese educational system can contribute significantly to the continuing development not only of the Chinese software industry, but also to the Chinese university system. These efforts will be important for China, and will position the country to increase its contributions to the international science and engineering community.

Much of the effort to develop the Chinese software industry is directed at serving the emerging domestic market which is expected to be enormous. Nevertheless, China has participated in and will continue to develop an export market as well, especially to Japan but also to the United States. It is not yet clear how these multiple goals of domestic and export markets will play outso far as education is concerned. Large efforts to localize international software, for example, may call for skills that are not readily transferable to export market work.

7-4 US Education

The US IT educational system is complex and regularly changing. Because the IT market is so large and varied, the United States can support a number of different types of educational programs. There are, for example, five major types of undergraduate degrees alone. More traditional baccalaureate degrees in computer science, computer engineering, and information systems have been joined recently by degree programs in software engineering and information technology. A number of universities are experimenting with new interdisciplinary programs at both the graduate and undergraduate levels. For-profit universities, corporate universities, and certificate programs also play important roles in this complex educational system.

Mainstream Education

Educational programs at many levels prepare graduates for computing jobs. Terminal associate degrees are typically vocationally oriented, often leading to certification in the use of particular technologies. At the other end of the spectrum, doctoral programs prepare graduates for research careers and advanced development. Masters degree programs run the spectrum from the vocationally oriented to serving as a precursor to doctoral study. But in the United States, a baccalaureate computing degree is the typical preparatory program for entry into the computing profession, producing the largest number of graduates. Therefore, we focus most of our attention on these programs.

In 2001-02, the last year for which comprehensive degree production statistics are available, there were 47,299 bachelors degrees conferred in computer and information sciences, a category that includes mainly computer science degrees but also degrees in other computing areas (Zweben 2005). During the same year, there were 30,965 associate, 16,113 masters, and 750 doctoral degrees conferred.

Baccalaureate computing degrees exist under many different titles. The different names frequently invite confusion among students, employers, and the general public. These can be boiled down to five major types: Computer Science (CS), Information Systems (IS), Information Technology (IT), Software Engineering (SE), and Computer Engineering (CE). The computing professional societies have drafted influential model curricula for these five undergraduate degree programs, which have some commonalities, as indicated in Table 4. Accreditation criteria related to computing are in general accord with the model curricula.

While Table 4 shows the similarities of these baccalaureate programs, Table 5 compares their distinguishing features. We can see that there are overlaps between these five programs but each has its own distinctive characteristics.

Table 7-4: Common Skills and Topics in Computing Baccalaureate Programs

- A foundation in both concepts and skills related to computer programming (understanding of the concept of an algorithm, an ability to implement an algorithm, basic software engineering principles);
- An understanding of the possibilities and limitations of computing technology (what current technologies can and cannot accomplish, limitations of computing, impact of technology on individuals, organizations, and society);
- The concept of the life cycle of a computing system; the relationship between quality and life cycle management;
- The concept of process, both computing process and professional process involving human resource deployment;
- Development of interpersonal communication skills, team skills, and appropriate management skills;
- Exposure to an appropriate range of case studies and applications;
- Attention to professional, legal, and ethical issues;
- A capstone project experience.

Source: The Joint Task Force for Computing Curricula (2005)

Table 7-5: Characteristics of Different Baccalaureate Computing Programs

Type	Definition	Emphases	History	Number in US
Computer science	Define and implement software, devise new ways to use computers, develop effective ways to solve computing problems	Algorithms, complexity, programming languages, mathematical foundations, programming fundamentals	Began in 1960s. Commonly emerged out of math or electrical engineering, occasionally out of business schools	At almost every college and university (more than 2,000 accredited)
Information systems	Integrate IT solutions and business processes to meet the information needs of businesses and other enterprises	Information, incorporating technology as an instrument to generate, store, and distribute information; business processes related to information	Began in the 1960s. Most emerged from business schools.	1,000

Computer engineering	Design and construction of computers and computer-based systems	Hardware, software, communications and their interactions; computer architecture, computer systems engineering, circuits and systems, electronics	Originated in the 1970s and 1980s. Emerged typically from electrical engineering departments	175 ABET accredited departments
Software engineering	Development and maintenance of software systems so they behave reliably and efficiently, and are affordable to develop and maintain	Programming fundamentals, software design, software modeling, software validation, project management	First departments in the 1990s. Emerged typically from CS departments.	30 (6 accredited)
Information technology	Meeting the needs of end users with business, government, healthcare, schools, and other organizations	Technology, societal and end user context, practical issues of operating computing systems	Most departments formed since 2000.	70 (just beginning accreditation process)

Sources: The Joint Task Force for Computing Curricula (2001; 2004a; 2004b; 2005), Gorgone (2002), ABET (2004), CAC and CSAB Criteria Committees (2005), Zweben (2005)

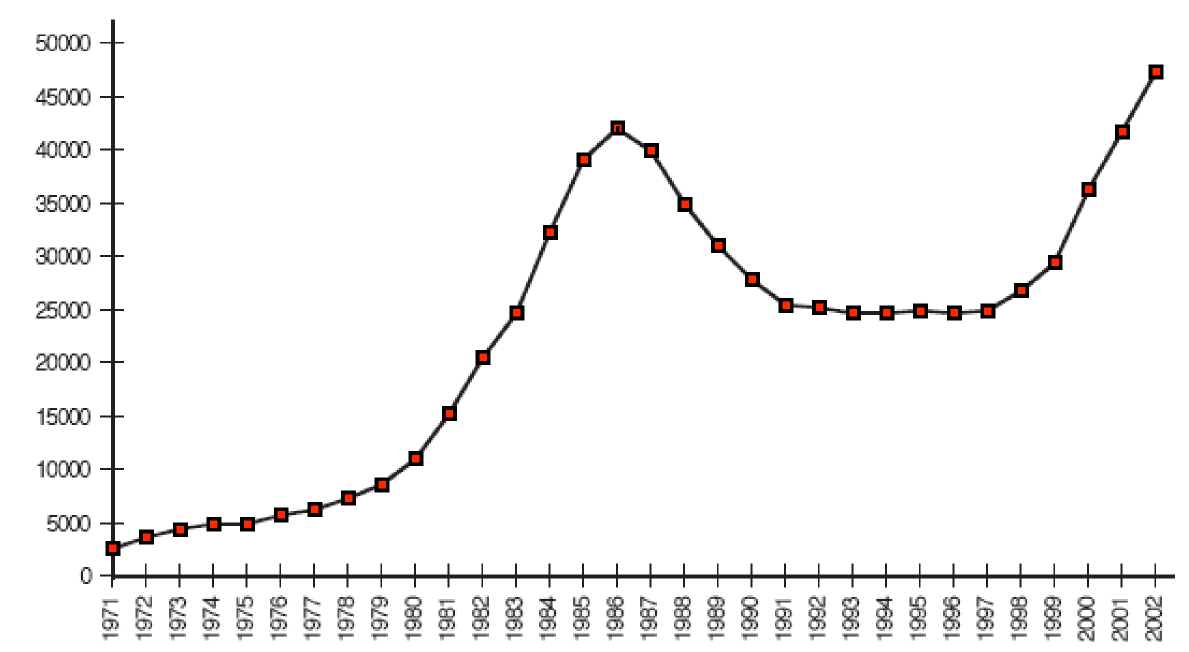
How well do these programs keep up to date with current needs? Individual computing programs undergo regular change within their respective institutions. Annually, programs incorporate new areas and update course content in existing areas of their curricula. These changes tend not to change the overall character of the program, but they do keep the program up to date with technical developments.

Model curriculum updates have been less frequent. These model curricula, prepared by committees of the computing professional societies (e.g., Association for Computing Machinery, IEEE Computer Society, Association for Information Systems), have been updated about once a decade. The updating process typically takes several years of work and involves scores of people. The process contains many review points. Input is solicited not only from the academic community but also from industry. International input has also been provided in most of the more recent curriculum efforts. Nevertheless, the updating process is largely driven by members of the US academic community and, when completed, reflects mainly the concerns and interests of that community. Curriculum updates tend not to change the fundamental character of the programs. The most recent update adds two new program areas, software engineering and information technology. It also incorporates newer topic areas into the three existing programs. The review process results in many useful changes that address both content (such as new emphasis on networks and databases and reduced attention to compilers) and pedagogy (such as a new emphasis on breadth in the introductory course). These changes help to keep the curriculum more up to date, but the overall structure of the program areas tends to bear great similarity to their predecessors. That is not to say the process is broken. It seems reasonable that many fundamentals remain unaltered from one update to the next.

The most recent updates to the model computing curricula began just before 2000. The computer science curriculum was revised in 2001, information systems in 2002, and computer engineering in 2004. The first software engineering model curriculum was introduced in 2004, and the first IT curriculum is currently under review. Thus a lot of progress has been made in the past few years. However, during this update period, the job market has changed considerably. For example, the dot-com boom ended and the offshoring of jobs became a public concern during a period of economic recovery that was creating new jobs at a historically low rate (the so-called jobless recovery). These updated curricula do not directly address the offshoring issue.

Perhaps the most notable change has been the serious drop-off in student enrollments in undergraduate computing programs in the United States. Figure 1 shows national enrollment data for computer and information science bachelor degrees from 1971 through 2002 (the most recent year for which this data is available). It is apparent that there were periods of rapid growth in the first half of the 1980s and again in the late 1990s, while the late 1980s had a significant drop-off in computing bachelor degrees awarded.

Figure 7.1: Baccalaureate degrees in computer and information science.

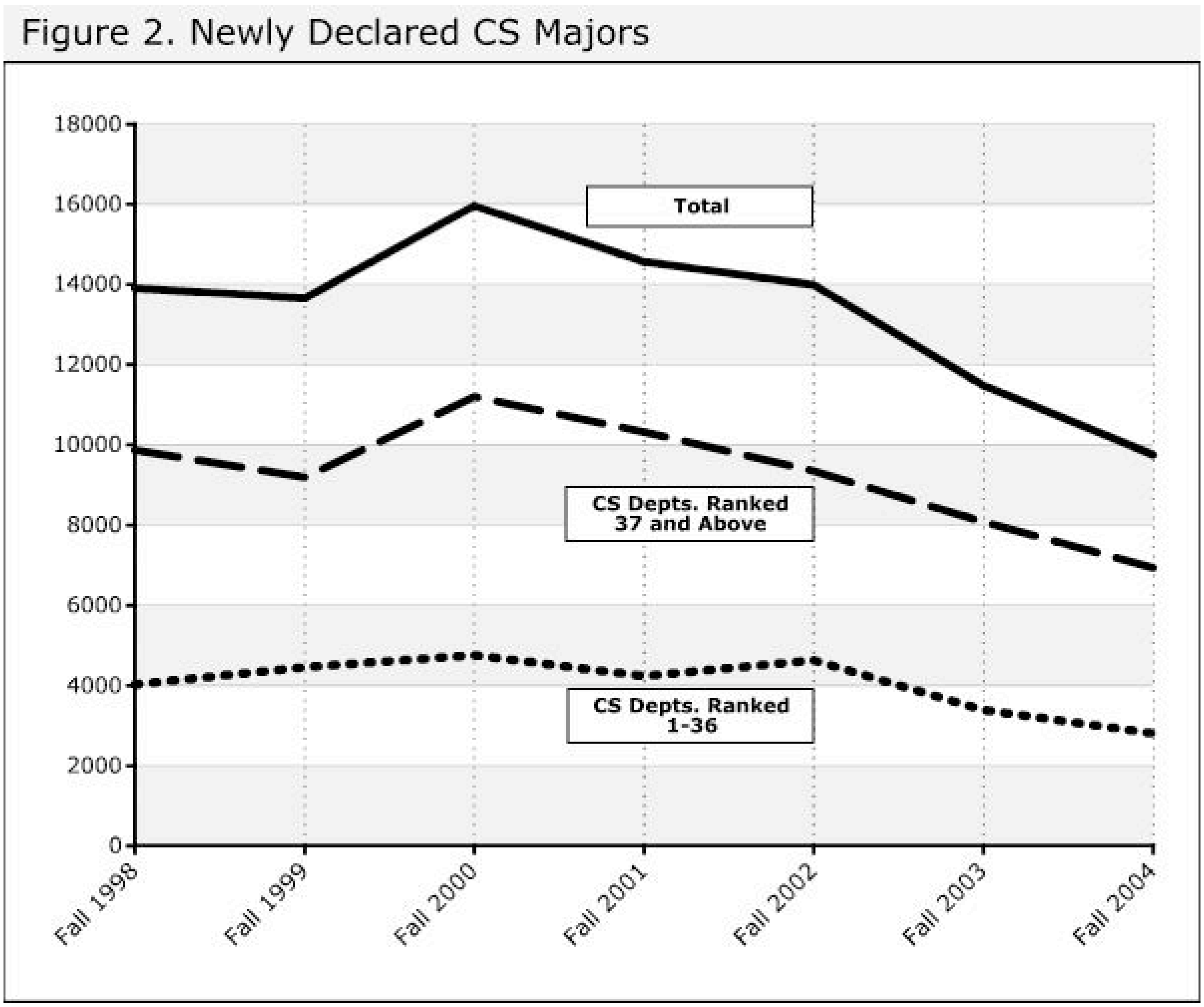


Source: National Center for Education Statistics, *Digest of Educational Statistics 2003*, Table 252.

To gain an idea of what has happened more recently, one needs to consider a different data set. The Computing Research Association Taulbee Survey provides data on baccalaureate degrees awarded by PhD.-granting computing departments in the United

States. A historical comparison of national (NCES) and Taulbee data shows that the numbers reported by the Taulbee survey closely match the up and down paths of the national data over time, with the Taulbee numbers amounting to approximately one-third of the national numbers; thus one would expect trends in one would be mirrored in the other. The advantage of the Taulbee data is that it is more up to date. The recent Taulbee data, as presented in Figure 2, shows a serious decline in students entering US computer science baccalaureate programs at PhD-granting Institutions from Fall 2000 to Fall 2004.

Figure 7.2: Newly declared CS majors.

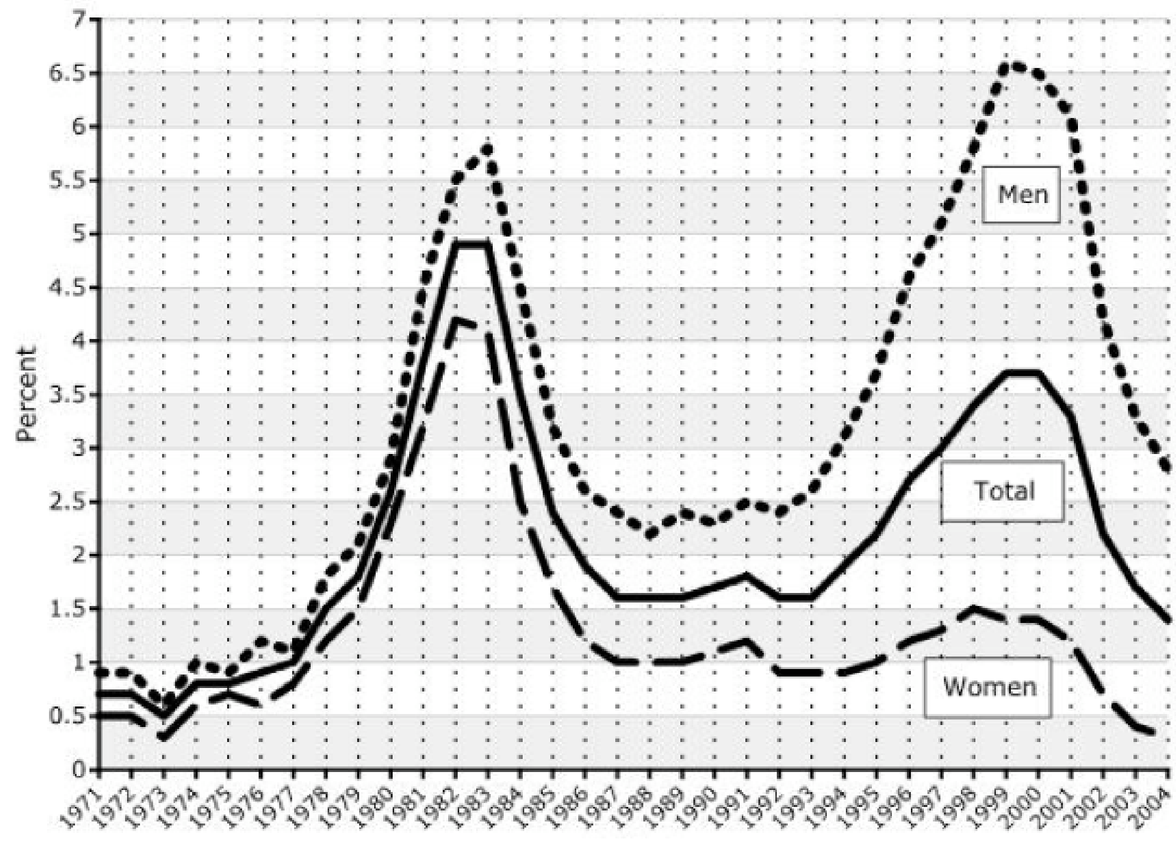


Source: Computing Research Association

Further evidence of the loss of student interest in computing careers is shown in a national survey of college freshmen that is regularly conducted by UCLA, as reported in Figure 3. It shows a precipitous drop in interest among freshman in selecting computer science as their major.

The data in Figure 3 is principally about computer science programs. Less reliable reports indicate that information science and computer engineering undergraduate enrolments grew in the late 1990s and fell in the past several years. Software engineering and information technology programs have not witnessed such declines as far as we know, but they are recently created and still in the process on growing in number and size.

Figure 7.3: Freshman intention to major in Computer Science.



Source: Higher Education Research Institute at UCLA, as cited in Computing Research News, May 2005.

Rapid increases or rapid decreases in enrollment are difficult for most universities to handle because of the long-term employment contracts to faculty and the sunk costs in infrastructure and laboratories which are overtaxed/underutilized in times of rapid student enrollment growth/decline. Students receiving computing degrees represent only one part (estimated at about a third) of the IT workforce in the United States (Wardle 2002, chart: Employment as a Function of Training and Area), but they are the most important source of IT workers because they not only represent the largest single source of these workers but also overwhelmingly fill the high-skill technical jobs.

Because of the importance of rapid undergraduate computing enrollment shifts (either up or down) to university planning and national worker supply, a number of groups have studied the causes for these rapid changes (Freeman and Aspray 1999; NRC 2001). The rapid growth in student enrollment in the early 1980s and late 1990s has closely followed the rise of the personal computer and the commercial Internet. Thus it might be that students' personal knowledge of and enthusiasm for these technologies drove the steep ramp-up in student enrollments.

Another possible explanation is that many of the students are vocationally motivated in their choice of major, and the increase in enrollment in the late 1990s was tied to the possibility of a good job, or the lure of wealth through stock options during the dot-com era.

We hear various anecdotal reports of high-achieving students claiming there are better opportunities elsewhere than in IT, for example, in law, finance, entertainment, medicine, or some other professional field. The vocational reason works better than the knowledge/interest reason at explaining the drop-off in enrollments between 2000 and 2004. There are at least two possible reasons why students would believe their vocational opportunities in IT are not strong and, therefore, would not choose a computing major. One is the highly publicized dot-com crash that gives students and parents the impression that there no longer are jobs available in high tech start-ups. Another possible explanation is the press reports of Americans losing their jobs through offshoring.

The evidence about why students perceive a lack of career opportunity in IT is not strong. A 2004 survey of over 1000 high school teachers by the Computer Science Teacher Association revealed that teachers believe offshoring is the biggest reason for student disenchantment with a computing career. But this is the teachers' perception of student beliefs not a survey taken of the students themselves. A report by Andrea Foster in *The Chronicle of Higher Education* (May 27, 2005) states that "undergraduates blame the field's anemia mostly on news-media reports of the technology jobs moving to developing countries." However, Foster seems to have based this claim on the UCLA (HERI) report cited (see Figure 3) which reports intentions but not reasons for them, and on some anecdotal remarks, not on solid research.

Another reason sometimes put forward for the low undergraduate computer science enrollments is the response from computer science departments to rapid enrollment growth in the late 1990s. Departments had trouble coping with the higher demand and, in response, set higher grade point averages for admission, made introductory courses more demanding, or established other filters or barriers to enrollment. These barriers are still in place in many departments, despite lower demand.

One final possible explanation has to do with the quality of teaching and the nature of the material that is taught. High school curricula have changed in the last decade to focus on languages (primarily Java) and paradigms (object-oriented programming). The introductory college computing course also typically focuses on teaching the more modern object-oriented style of programming such as Java, in part because students who mastered these tools could readily find employment (at least in the 1990s). However, these tools are somewhat difficult for faculty to teach and students to learn especially compared to tools and skills taught in introductory courses in other science and engineering disciplines. The preparation of high school teachers who are teaching computer science has been an issue for many years, but the complication introduced by these new programming languages has made the quality of instruction even more problematic. Many high schools have eliminated computer science courses perhaps because it is so hard to teach, but there may be other reasons as well such as not being part of the performance canon under the No Child Left Behind initiative, and not being sanctioned as part of the core college preparatory curriculum.

We do not have good data to sort out how significant these different reasons are. It is likely the reasons vary from student to student, and that multiple reasons are in effect as students make decisions about their college major and career. As we showed in Chapter 1, this perception of decreasing job opportunities in IT does not match the actual numbers of jobs existing between 1999 and 2004, nor is it consistent with the Bureau of Labor Statistics projections for job growth over the coming decade. The BLS data suggests strong job opportunities now and in the future.

Bill Gates, in his tour of several universities during the past year, expressed concern about the future availability of skilled workers in the face of these declining enrollments. Companies such as Microsoft that are developers of computing technology used throughout industry have an ongoing need for workers with strong technical skills. Computing programs that are strong on the technical side such as those in computer science, software engineering, and computer engineering are likely to continue to be of interest to such companies. Jobs in the IT sector account for only about ten percent of the IT jobs in the United States. There are, however, numerous technically oriented jobs in IT departments in companies in other sectors of the American economy.

Innovative Approaches to Computing and IT Education in the United States

The previous section discussed the traditional courses of study in computing in US higher education. Beyond these academic departments, a variety of new academic units at the school or college level that are related to computing and information technology have begun to emerge in the United States, largely in the last decade. A wide range of motivations exists for the formation of these units. Two primary motivations seem to be:

- Structural. This includes computer science departments that have become sufficiently large or diverse enough to evolve into schools or colleges, as well as existing schools or colleges with a different mission (particularly library schools) that transform themselves into something more oriented to modern information technology.
- Innovation. This generally involves creating a new unit to meet new educational and research needs.

In almost all cases, however, whether curricular innovation or meeting new educational needs were the initial driving factors behind the formation of these new units, they are turning out to develop new curricular approaches which are impacting the breadth of computing and information technology education in the United States.

The remainder of this section presents a simple categorization of these new academic units related to computing and information technology in the United States. For each category, we list a small number of examples, and briefly mention curricular programs that characterize some of them at the undergraduate and/or graduate level. The categorization used here is arbitrary and others are possible. The point of this material is not the categorization but the examples of new educational approaches that are contained among them.

1. Schools and colleges of computing, computer science, computer and information science, and related names that include the degree programs in computer science as one component. In a number of cases, these units evolved directly from departments of computer science that either grew large enough to become separate colleges or had a vision to broaden their scope. Among the major US research universities, leading examples include the School of Computer Science at Carnegie Mellon University, the College of Computing at Georgia Tech, the Faculty of Computing and Information Science at Cornell, and the Donald Bren School of Information and Computer Sciences at the University of California, Irvine. Many additional examples exist, some of which are motivated by collaborations with local software and data processing industries, such as the College of Information Technology at the University of North Carolina, Charlotte, and the College of Information Science and Technology at the University of Nebraska, Omaha.
2. In all of these units, either initially or over time, the curriculum and undergraduate or graduate degree programs have expanded beyond traditional computer science offerings. For example, the School of Computer Science at Carnegie Mellon, in addition to its Department of Computer Science, contains a number of institutes and centers in areas including robotics, human-computer interaction, language technologies, and entertainment technology. Each of these centers offers academic programs, including an undergraduate major in human-computer interaction, a masters in entertainment technology, and masters and doctoral programs in robotics, language technologies, and

human-computer interaction. Georgia Tech's College of Computing includes (beyond computer science degrees) an undergraduate major in computational media offered jointly with the School of Literature, Communication and Culture, a Masters degree in information security, a Masters degree in human-computer interaction, and a doctoral degree in human-centered computing. The School of Information and Computer Sciences at UC Irvine includes undergraduate degrees in informatics and in information and computer science, in addition to computer science, and computer science and engineering. At the graduate level, beyond the standard computer science degrees, it includes a large set of specialized masters degrees: in arts, computation and engineering, embedded systems, knowledge discovery in data, and network systems, and a doctoral degree in network systems. The College of Information Technology at UNC Charlotte offers degrees at all three levels in computer science and in software and information systems. These examples are indicative of the breadth of curriculum that is emerging from these types of academic units.

3. New schools and colleges that are separate from computer science (and information science) programs and fill an additional need in the computing and information technology space. Two examples of recently formed units at major research universities include the School of Informatics at Indiana University's Bloomington and Indianapolis campuses, and the School of Information Sciences and Technologies at Penn State University. The School of Informatics at Indiana includes an undergraduate major in informatics that combines core courses in informatics or computer science with the study of a cognate area chosen from a broad range including biology, communication and culture, fine arts, psychology, and many others. It also includes masters programs in bioinformatics, chemical informatics, human-computer interaction design, and music informatics, and a PhD. in informatics that includes these and other areas of research including cyber security, social study of information technology, and health informatics. Penn State offers an undergraduate major, as well as masters and doctoral degrees in information sciences and technology that are aimed at blending technology, applications, and human, social, and organization factors.

4. Information schools which, in almost all cases, evolved from library schools. Many major universities have transformed or converted a previous school of library science, or a similarly named and focused school, into a school that studies information, information and library science, or the like. There are over a dozen examples in the United States, including the School of Information Management and Systems at the University of California, Berkeley, the College of Information Science and Technology at Drexel University, the School of Information and Library Science at the University of North Carolina, the College of Information Studies at the University of Maryland, the School of Information at the University of Michigan, the School of Information Studies at Syracuse University, the School of Information at the University of Texas, Austin, and the Information School at the University of Washington, simply to demonstrate both the geographic scope and the range of names.

   Many of these programs had a heritage of offering masters degree programs and are evolving to offer a broader range of curricula and degrees. Two examples give some sense of the scope and areas these academic units cover. Generally speaking, these programs tend to cover library and information science and management, and other areas including human-computer interaction, information retrieval, and social study of information and information technology. The University of Michigan's School of Information offers a masters in library and information services; archives and records management; information economics, management and policy; and human-computer interaction. It also offers a PhD that allows research specialization in any of these areas as well as on topics including digital libraries and digital publishing. The Information

School at the University of Washington has developed an undergraduate major in informatics and a PhD degree in information science; these supplement masters degrees in library and information science, and information management.

5. Campus-wide multidisciplinary information technology institutes aimed at fostering collaboration of faculty and students across departments, and complementing students' traditional educational programs. Examples include the ATLAS (Alliance for Technology, Learning and Society) Institute at the University of Colorado, Boulder, and the Renaissance Computing Institute at the University of North Carolina at Chapel Hill, operated jointly by Duke University and North Carolina State University. The ATLAS Institute offers a certificate in Technology, Arts and Media that is available to students in all majors, and is developing an interdisciplinary PhD in Technology, Media, and Society.

It is premature to know what impact, collectively, these new or transformed academic units and their new educational programs will have on the software and information technology industries. As a gross generalization, these programs represent an approach to educating students at the cross-section of information technology, a wide range of applications, and human factors. The typical student in these programs does not receive as much technical training as the typical student in computer science or computer engineering, but the mix of skills and perspectives they contain appears likely to produce students well-suited for upper-level jobs involving the application of IT to a business or some other application area. Thus, they are likely to become a useful educational option from the perspective of both students and employers.

It is interesting to consider why this educational innovation could not take place in the traditional departments. While there is some of this kind of innovation in traditional academic departments, they are usually organized to reflect disciplinary boundaries that have as much to do with methodology and approach as with the problem domain. Computer science departments that emerged from engineering or mathematics departments typically retain a preference for quantitative methodologies based on well-established theoretical underpinnings. Such departments find it hard to understand, much less evaluate, the work of faculty whose disciplinary traditions involve human factors (such as human-computer interaction) and where the underlying methods are from design and social science more than from engineering or mathematics. Thus, people who work in areas such as human-computer interaction or the more business-oriented side of IT have difficulty getting hired and promoted by those departments, reducing the level of breadth and flexibility those departments can achieve. Introducing larger structures such as schools of computing in which this large dynamic range of methodologies can be accommodated offers institutions a strategy for getting beyond this problem. Nevertheless, it should be noted that some computer science departments have embraced the broader view of computer science and have welcomed faculty members in human-computer interaction and other less traditional areas of computer science.

Alternative Education

Degree programs in traditional colleges and universities are not the only kind of IT education in the United States. There are non-degree courses offered by traditional colleges and for-profit organizations, certificate programs, training associated with specific technologies, and corporate training programs, for example. There are also degree programs offered by for-profit universities. These alternatives to traditional degree programs appear to be growing rapidly, but it is difficult to quantify their extent or growth. Students enroll in these non-traditional programs to achieve many different goals: training for a specific IT career, career advancement within the IT field, move from a non-professional to professional IT job, continuing education to keep technical skills current, or gaining specific product information or usage skills. For more information on these programs, see Freeman and Aspray (1999, chapter 6).

The success of these institutions clearly indicates a demand for technical education that the more traditional higher education system is not meeting. That these programs have had strong success in technical areas presumably is due to at least the following four factors.

1. The short-term return on technical training is easy for potential students to recognize. The DeVry University web page claims that "for the 10-year period ending June 2004, 91 percent of DeVry graduates who actively pursued employment or who were already employed when they graduated, held positions in their chosen fields within six months of graduation." In terms of immediate employment prospects, this record presumably seems good in comparison, for example, to graduates in the humanities from an Ivy League college. Particularly in an economy that seems increasingly focused on maximizing short-term gains, the fact that students do the same is not surprising. There are questions, however, about whether that short-term focus is likely to bolster the development of the kind of knowledge and habits of mind that are useful over the full expanse of a career.
2. There is high demand in industry for people with the skills these institutions provide. The for-profit universities could not survive in the marketplace unless there were jobs available for their graduates. The growth in the marketplace and the projected growth over the coming decade is discussed in Chapter 1.
3. Traditional institutions lack the capacity to meet the demand for technical training. The niche that the for-profit universities occupy in technical areas certainly emerges in part from the inability of universities and other components of the traditional educational system to keep up with the demand. It also comes from a university culture that discourages programs whose main goal is the development of specific skills whose value is likely to be short-lived.
4. These institutions are able to respond more rapidly than traditional universities to market demands, both in terms of numbers of students (whether the numbers are increasing or decreasing) and also the demand for new topics to be taught. Most of these non-traditional education providers do not have long-term fixed labor contracts, for example, nor do they have time-consuming review processes for new courses.

There are more than 1,000 corporate universities in the United States. They help provide life-long learning to their employees and to their suppliers and customers. Offerings of the corporate universities differ from the basic training offered by traditional universities; instead they provide education and training in the skills that the company believes these people need most at that particular time. It might be technical training, background information about the company or its industry, or core competencies such as learning skills, communication and collaboration, creative thinking and problem solving, global leadership, or career self-management. Sometimes the corporate universities offer courses themselves, sometimes they arrange for approved vendors (specific universities or private training companies) to offer courses on their behalf, often online through the company intranet. For more information on this subject, see Meister (1998).

A recent study by the American Association for the Advancement of Science and the Commission on Professionals in Science and Technology (Malcom et al. 2005) provides useful information about non-traditional educational pathways to an IT career, including the for-profit universities such as Strayer University, DeVry University, and University of Phoenix. Their study cites one report that as many as 1.5 million higher education students, 1 in 12 students now studying, are in for-profit universities rather than traditional colleges and universities although only about one-sixth of the students in these for-profit institutions are enrolled in four-year-degree programs. The for-profit universities are growing in enrollment about three times as fast as traditional colleges and universities. In 2001, six of the ten schools that produced the most bachelor degrees in information technology and computer science in the United States were for-profit universities. This is completely unlike the situation in other science and engineering disciplines; the largest producers of baccalaureates in physical science, biological science, or engineering tend to be the large, research-oriented state universities.

The for-profit universities have a different profile and mission than the traditional universities. For-profits are usually accredited by regional higher education organizations, attesting to the fact that the institution meets minimum standards for university-wide infrastructure and practices, but not by technical accrediting bodies such as ABET which check on the minimum standards of quality for particular degree programs. There is more of a focus on technical training than on broad-based education, but many do offer four-year information technology or computer science degrees. Instead of retaining a full-time faculty, the for-profit schools generally hire faculty on a course-by-course basis. There is no tenure system and no research conducted. The previously mentioned AAAS-CPST study quotes a New York Times article describing what the students seek in attending the for-profit schools: "quick-and-to-the-point coursework, customer service, small classes, convenience, and an education that leads to employment."

The for-profit universities advertise heavily for non-traditional students. According to the Department of Education (as described in the AAAS-CPST study), non-traditional students have one or more of the following characteristics: delayed enrollment, part-time attendance, full-time employment, dependents, and six or more years to complete a degree. These programs have higher percentages of women and minorities than the traditional programs do, and the student population tends to be older, more mature, and have attended at least one other college or university previously. Statistics show that the students at for-profits tend to work for companies that are not in the IT sector. Students with this profile often used to matriculate at two-year public community colleges but competition for admission to the community colleges is getting stiffer with traditional students trying to save money by completing the first two years of their baccalaureate degree there.

Although it is difficult to get good data, certification training is an important and growing part of the IT education and training marketplace. Certification indicates that an individual has achieved a certain level of proficiency in a narrowly-defined technology area. It became popular with employers during the dot-com boom because it was a way to provide training within a focused area at lower cost and in a shorter time compared to traditional education. Many individuals enroll in certification training programs for the training, not the credential, and in fact, in 2000, only about one quarter of those who were trained ended up being certified (Gartner survey as reported in Prometric 2001). As of 2002, there were approximately 100 vendors, offering at least 670 separate certifications in information technology according to the National Research Center for Career and Technical Education (Moncarz 2002). There are also numerous community colleges and four-year colleges offering certificate programs. National Center for Education Statistics data shows that awards for study lasting less than one year grew almost 400 percent between 1990 and 2000.

Certification tends to be of two types. Most commonly it is focused on a particular vendor's product, but sometimes it is focused on a technology area or occupation such as network administrator. While companies that employ IT workers occasionally do their own certification, it is generally left to the vendor (for example, Cisco providing Cisco certification), a third-party company offering specific vendor technology, or a professional or industry group offering certification in a technology area. Programs of study leading to a certificate are sometimes offered by two-year colleges but seldom by traditional four-year colleges or universities. Certification in various Microsoft products is by far the largest area of certification. As of summer 2002, there were more than one million Microsoft Certified Professionals and 450,000 Microsoft Certified Systems Engineers. Some of the other vendor companies whose products are subject to certification include IBM, Sun Microsystems, Hewlett Packard, and Apple. One professional group that has a popular technology certification program is the Computing Technology Industry Association (CompTIA) which has awarded more than 100,000 certificates in it's A+ certification program for computer service technicians where they are tested on basic computer hardware and software.

There are sometimes complaints about certification training especially from employers who pay the cost for their employees (Moncarz 2002; Prometric 2001). Common complaints are that:

- certification does not substitute for practical experience,
- costs have become exorbitant,
- it is more important for the employees to learn about the products they actually sell than about the technical details of the tools or infrastructure embodied in a Microsoft or Cisco product,
- the certification programs do not guarantee the certified employee has good problem-solving skills involving the technology,
- certification courses take employees away from too much work time, and
- certification can make employees more attractive to other employers and confident of their own abilities and thus encourage employee turnover.

Individuals tend to enroll in certificate training programs to learn a specific technology, get career advancement in their current workplace, find a job, or increase their salary. Certification seems to be most successful for career advancement in the areas of technical support and network administration (ITAA 2004). Salary with the same employer and job typically increased only 5 to 7% after completing the certification; however, median compensation for a certified employee averaged 25% higher than for a non-certified employee (The Association of Support Professionals 2001).

7.5 European Education

Traditionally, the European education systems (except for perhaps the United Kingdom) are quite different from those in the United States. Changes under the Bologna Declaration which is an attempt to unify the educational system across Europe has a target that is similar to American higher education, but there will nevertheless continue to be important differences between the US and European educational systems. After discussing the changes that are taking place across Europe as part of the response to the Bologna Declaration, this section presents a brief account of IT education in one European country, Germany, as it exists today, and draws some comparisons with degree programs in the United Kingdom.

It is not our intention to claim that we give a complete account of German IT education, that IT education in other European countries is carried out just like it is in Germany, or that these different countries are experiencing the same enrollment trends. For example, computer science enrollments are continuing to grow in Spain by an estimated 4% annually, presumably because the educational system, which historically did not have sufficient capacity, is continuing to expand, while in most of Western Europe, traditional computer science enrollments have dropped steeply over the past several years, though there have been modest gains in enrollment in newer IT disciplines such as telecommunications and bioinformatics. Nevertheless, we believe that the reader can gain an appreciation for some of the differences between European and American IT education as they relate to offshoring from this brief account. The German model is an important one for Europe, for the German-speaking countries which have similar IT educational programs, represent approximately a quarter of the European population.

The Bologna Declaration

The Bologna Declaration is aimed at coordinating university education across countries, especially the graduation process, by adopting the consecutive structure of the bachelor's degree (3 to 4 years) and the master's degree (additional 1.5 to 2 years), followed by doctoral studies (2 years or more) and lifelong-learning initiatives. Thus the plan is to adopt a system already well known worldwide. The Bologna Declaration was driven primarily by the European governments, but it was a bottom-up initiative, coming mainly from university management and education ministers responsible for research and education. It has been adopted by forty countries, mostly European, and has relatively strong support from university management in these countries. The process is to be completed by 2010. Today, nearly all of the universities in Europe are in the process of changing their educational systems to follow the regulations of the Bologna Declaration (some more rapidly than others). Here are the main goals.

(i) Introduction of a compatible graduation scheme across the European countries that supports the mobility of students and graduates (workforce), and attempts to conform to worldwide standards for the degree and graduation sequence (a consecutive scheme with a bachelor's degree followed optionally by a master's degree), also to support mobility. In the past, European countries had many different incompatible schemes. To further support mobility, a unique scheme to regulate student workload, known as the European Credit Transfer System (ECTS), has been introduced across Europe. Accreditation agencies have also been established to insure the quality standards of the programs at the participating universities.

(ii) The introduction of a bachelor's degree that would provide students with a formal graduation after three years of study and be recognized by all institutions that follow the Bologna Declaration. This contrasts, for example, with the current German system in which a student receives the Diplom after no less than 4.5 years of study, but more typically after five or six years. There is an examination part way through the course of study in the German system which results in the Vordiplom for students who successfully complete it. However, institutions in other countries do not recognize the Vordiplom as a formal degree that qualifies the student for the next level of education.

(iii) The bachelor's degree, followed optionally by a master's degree, is seen as an entry point for international students especially from developing countries where it is common for bachelor courses but no master courses to be available. Before Bologna, these students were often forced to begin their studies anew, in the first semester of a diploma course. A growing number of European universities today use English as their language of instruction. This and perhaps other factors have led to a steady growth in the percentage of foreign students enrolling in these programs.

The Bologna Declaration stimulated other reforms in European education. These included, for many schools, reducing the length of time required to receive the first degree; a new system of continuous examinations (mid terms and finals) for every course instead of concentrated examinations after several years; and support for e-learning.[1]

[1] The goal of e-learning is to use electronic devices (personal computers, CD-ROMs, digital televisions, PDAs, and mobile phones) to provide learning wherever the student is located. E-learning can provide not only Internet and

The Bologna Declaration's greatest impact on computer science has been to start new interdisciplinary and specialized studies within European universities. The initiative has been directed in part at preparing an international workforce for the knowledge economy, and many universities are responding to the need for a growing number of computer science graduates with domain-specific knowledge.

As in the United States after the end of the dot-com boom, the number of students in traditional computer science programs decreased. It is typical in Europe that much software development is carried out in the context of embedded systems, for example, in the automotive or aerospace industry sectors, but there is also software development in the biomedical, chemical, life science, and telecommunications areas as well as in the banking, finance, and insurance industries. Many job opportunities, therefore, require domain-specific knowledge in addition to computer science knowledge.

Because of this, many universities have started to include application-specific courses into computer science or offer combined degrees such as bioinformatics, medical technology, computational physics, computational chemistry, and computational science and engineering. These new programs have attracted some students away from traditional computer science where enrollment numbers have typically been down over the past few years.

However, there is some dispute over the Bologna Declaration. Critics argue that the traditional homogeneous model of university education leading to a diploma after nine semesters has considerable advantages over having separate curricula for the bachelor's and master's degrees. The TU-9 initiative, representing the nine leading and largest technical universities in Germany, takes an opposing position to the Bologna Declaration, doubting that it is possible to provide the students a professional qualification for an IT job within a three-year bachelor program. It is unclear whether there will be modifications in the Bologna Declaration over time.

What are the possible impacts of the Bologna Declaration on offshoring? It may be that Bologna will lead to more uniformity in the content as well as the formal structure of degree programs across Europe. If education in Eastern and Western Europe become more similar, the short-term effect is likely to be an increase in the amount of near-sourcing as a result of the wage differential. (There are, however, good reasons to believe that there will continue to be national differences in education after the Bologna Declaration has been completely implemented as the example of the United Kingdom and Germany that follows illustrates.) However, economic theory suggests that, over the long-term, wage rates would even out somewhat between Eastern and Western Europe, eventually making near-sourcing less attractive.

German IT Education

At the moment, even in the presence of the Bologna Declaration, there is considerable variation in IT study programs across Europe, and it is difficult to compare them. In the United Kingdom, for example, courses in information systems were offered as conversion courses for graduates whose first degree was in a discipline other than computing; this is now referred to as *vertical integration.* The aim of these programs was to provide a competence in computing disciplines and in the business applications of information technology. In general, they did not provide a deep knowledge of either the computing discipline or the engineering aspects of information systems. With the acceptance of benchmark standards for masters degrees, this situation has changed but the concept of

---

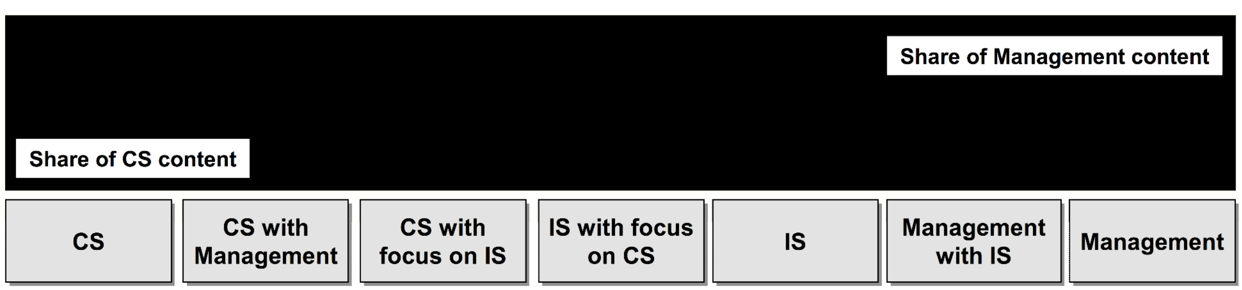
email delivery of instruction but also more interactive learning through collaborative software, online discussion forums, and team learning systems.

vertical integration of certain kinds is still accepted and seen as desirable (and is much discussed). In contrast, the German programs, both before and after the Bologna Declaration, tend to have an integrated structure that anticipates that the master's students will have studied the same subject (often at the same university) in their bachelor's program. Having this integrated structure enables the German system to go into greater technical depth, but it makes it more difficult for students from another undergraduate major, or even the same major from a different university, to enter into the master's program.

To take one other example where the UK and German degrees are different, consider business informatics (in German, Wirtschaftsinformatik). The German degree has a strong focus on mathematics, logic, operations research, and statistics, and focuses mainly on information system architecture. Graduates are expected to be able to actively and systematically design business information systems. The German course of study includes detailed modules on such business topics as accounting, logistics, marketing, production management, and human resources. In contrast, the UK course of study in business informatics focuses more on the alignment of business strategies and information technology. The UK programs tend to include more electives, giving the students more opportunity at the master's level to specialize their education (Helfert and Duncan 2005).

Information systems programs in German-speaking countries have a longer tradition than information systems programs at US universities. Graduates of these programs in Germany are typically well prepared for development work on commercial software packages. This characteristic is often regarded as one of the advantages of the German education when compared to those in developing or low-wage countries. In recent years, more and more computer science programs have been enriched by elements of information systems, and more and more management programs have been combined with parts of computer science and information systems. At a number of German universities, for example, the job descriptions for academic positions in computer science departments have been modified in this direction in recent years. By choosing the electives, students can flexibly position themselves along a spectrum of different preparations, ranging from pure computer science without any components of management education to management without computer science elements (see Figure 4). So they may adapt to the actual requirements of the job market in the last part of their studies (real-time specialization).

Figure 7-4: Combination of computer science and management contents in university education.



CS: Computer Science IS: Information Systems

There has been a shift in enrolment from computer science to information systems in Germany. Between 1998 and 2003, the computer science enrollments declined by 20%, while those for information systems climbed by the same percentage. Nonetheless, today three times as many German students study computer science as study information systems. Many European countries, including France, Italy, and Spain seem to be following this same enrollment trend away from computer science and towards information systems especially in the business computing programs (informatique de gestion) in France.

Table 6 shows how educational programs relate to skill requirements of software production as they are practiced at the German software company SAP. (We omit the selling of the systems from this discussion.) Many graduates of German universities take jobs with SAP or its customers, and because of its sheer size, growth, and leadership, many economists and educational policy leaders in Germany pay close attention to SAP's employment practices including its policies about near-shoring and offshoring.

Table 7-6: Education Needed for IT Work at SAP

Departmental-level Activity	Educational Training
BASIS (basis technology): build transaction mechanisms, data bases, data warehouses, cache memory optimization, knowledge warehouses, generic expert systems, human-computer-interaction, etc.	Typically a computer science degree
Software development - organized along economic sectors or industries (e.g. automotive, construction, pharmaceutics/chemicals, banking, public administration ...) or functions/processes (human resources, logistics, accounting, Strategic Enterprise Management ...).	Typically an information systems degree
Development of special algorithms such as Advanced Planning Systems, genetic algorithms, neural networks, optimization of production, production planning or transportation.	Typically a math, operations research, or management science degree
Development of architectures such as NetWeaver or Business Process Platform.	Typically requires teams of people with computer science, information systems, and business administration degrees
SAP Consulting: customizing and regulating the manifold of interdependent parameters (e.g. selection of priority rules, forecasting procedures, service delivery levels, safety stocks, Available-to-Promise-mechanisms in Supply Chain Management, etc	Typically requires information systems and business administration degrees

Both computer science departments and management schools within universities frequently cooperate with large software houses that produce business application systems. The tight cooperation of software companies such as SAP and universities has a manifest influence on computer education in Germany. It enables the universities to organize a curriculum in which computer science, information systems, and management specialists can collaborate with practitioners. Through this kind of collaborative education, Germany seems to have an advantage over low-wage countries such as India and China, and maybe even over the United States.

The European education systems provide the opportunity to learn a second and often third foreign language. The majority of management, computer science, and information systems students tend to participate in internships in English-, French-, or Spanish-speaking countries, and, increasingly, they take internships in China. In this way, students are prepared to take part in projects of firms located in countries with cultures and languages different from the one they grew up in.

Educational Implications of European Near-Sourcing

The Western European countries such as Germany, Austria, and France send a lower proportion of their offshoring to India than the United States does because of the presence of near-shore alternatives in Eastern Europe. (See Chapters 1 and 3 on near-sourcing.). As a result of the geographic proximity, and because of language and cultural affiliations, cooperation on larger projects between software producers in Austria, Germany, and Switzerland and software companies in Eastern Europe (or between France or Spain and countries in North Africa, e.g., Tunisia) are entirely possible. Convenient train service between Western and Eastern Europe minimizes travel time to between one and six hours, depending on the particular cities in question. The actual migration of workers from Eastern to Western Europe where many of these Eastern European computer scientists have received their education also reduces the need to send work across national borders. Nevertheless, a number of large and medium-sized German software producers choose to send components of their projects to Eastern Europe. Thus specialists and managers in the industrialized countries cooperate with those in Eastern Europe or North Africa instead of with India or China. Figure 5 depicts a typical model of labor division as it exists today. This partition of labor evolved in a kind of trial-and-error process through the efforts of Germany's leading producer of individualized software, sd&m (software design & management). Since this model can be applied to many different projects, the German IT Association (BITKOM) recommends it as a kind of reference model (BITKOM 2005; Taubner 2003).

Figure 7.5: Division of labor between industrialized and offshore/near-shore countries.

What? / Where?	Industrialized Country			Offshore/Near-shore Country		
Specification	✗	✗	✗	✗		
Construction	✗	✗		✗	✗	
Coding	✗			✗	✗	✗
Implementation and Integration	✗	✗	✗	✗		
Service and Maintenance	✗			✗	✗	✗

✗ Share of work

Figure 5 represents the current situation. It would probably be difficult today to find a sufficient number of firms in Eastern Europe that have sophisticated application systems that could be used for the practical education of students during their internships. This implies that the Eastern European educational systems are, at the moment, best prepared to train students for jobs in lower-value work such as coding and maintenance, while the Western European countries are better prepared than the Eastern European countries to train their students for jobs involving higher-level tasks such as specification and implementation. This division in occupational preparation (and IT career opportunities for their citizens) is likely to change over time because of the ambitions of the low-wage countries to climb up the value chain.

One of the reasons for the near-sourcing relationship between Eastern and Western Europe is the presence of Eastern European (and North African) workers who speak Western European languages. If there were greater emphasis on learning English-language skills, Eastern Europeans would be able to compete more effectively for offshoring work from the United States, the United Kingdom, Australia, and other countries that conduct their business in English; and the English-speaking countries represent the majority of offshore software work that is outsourced. Similarly, better English-language skills in the Western European workforce would give them access to the large population of offshoring firms in India, Malaysia, the Phillipines, Mexico, and some other places.

Small and medium-sized firms have difficulties with near-shoring and even greater difficulties with offshoring. A new kind of service provider is addressing these difficulties. These providers work as a kind of intermediary between the firms and the vendors in lower-wage countries. In order to do their jobs effectively, they need workers who have not only IT skills but also a set of business skills, including:

- software engineering
- project management
- contract negotiation
- contract development
- finding, evaluating and controlling service providers (sourcing)
- assessment of local business conditions, e.g. taxation, costs, education, non-tariff trade barriers, security, fluctuations, labor legislation, data protection, power of unions
- assessment of cultural conditions, e.g., attitude towards quality

7.6 The Educational Response to Offshoring

As we described at the beginning of this chapter, the question of how best to educate students to become professionals in a field that is evolving as rapidly as computing and information technology is a challenging one. Offshoring aside, the rate of change in the computing and information technology profession may be as great or greater than in any other area that universities prepare students to enter. Determining how to respond to this change is a difficult problem for educational institutions particularly because they must balance the need to be responsive to the evolution of the field with the needs to provide a firm foundation and not to overreact to trends. Factoring in the additional evolution and change in the profession as practiced in any given country due to the dynamics of the global economy, that is, the segments of software and IT work that a particular country emphasizes and wishes to emphasize in the future, only increases the challenge for educational planning and delivery. Both the basic content of the IT field and the portions emphasized in the profession in each country can change quickly.

This chapter has discussed the current state of higher education in computing and IT, and how it is responding to a global software/IT economy in which offshoring is a major factor. It has done so from the viewpoints of India, China, the United States, and Western Europe. It has considered both how computing and IT education is responding to the fundamental changes in the field, and how offshoring is further impacting this education from the perspectives of countries that play different roles in the global software/IT economy.

Although the educational needs and issues may look different from different national or individual perspectives, six overarching principles emerge from the discussions of this chapter.

(1) There is a need to consider the levels of IT work that are predominant in the national or multinational economy being served by the educational institution and which are likely to be predominant in the future. The software and IT industry can be characterized by a series of skill levels, ranging from the more routine to the more complex, strategic, and innovative. For example, Andriole (2005) defines a five-tier system of IT work in business applications, consisting of support, infrastructure, enterprise business technology architecture, strategic business applications, and business strategy. This classification is based in part on a series of interviews with technology managers and leaders conducted between 2001 and 2004. He draws a distinction between operational technology which can more readily be treated as a commodity and is prone to offshoring, and strategic technology which is a competitive differentiator and less likely to be offshored. The first two tiers are in the commodity category, the final two in the strategic category, the middle tier is a combination of the two. His analysis applies best in the business context, and in a world where low-wage countries are more prone to take on low-skill rather than high-skill work. But his analysis shows that, in the context he considers, certain kinds of jobs are more likely to be sent to low-wage countries and other kinds of jobs are likely to remain in a high-wage country. The educational consequences of this point of view are discussed under principle (5).

Another point, emphasized by Drezner (2004) and others, is that work that has been made routine and commoditized is also work that is most likely to be subject to automation. It has not happened to a large degree yet, but routine programming might be handled in the future with automated software tools. It does not matter whether a job is lost to a person in another country or to a machine as far as the worker is concerned. Certain kinds of jobs are less likely to be automated as discussed in detail in Chapter 1. Although the wage rate affects the equation, it can make economic sense to automate in low-wage as well as high-wage countries.

For software and IT work, in general, an analogous concept to that defined by Andriole for business IT exists. That is, software and IT work can be thought of as consisting of a spectrum from the more routine (e.g., system and computer maintenance and support, basic programming) through the more advanced (e.g., application programming that requires knowledge of IT and specific applications whether business, science, engineering, media or otherwise, or sophisticated systems programming and IT architecture development) to the advanced strategic level (development of approaches that utilize IT to advance the organization strategically and provide it with a competitive advantage).

As computer science and IT curricula are developed, particularly at the national and global level, it is important to consider these levels of software and IT work and identify which levels the curriculum is intended to prepare students for. In procuring countries, it may be desirable to focus the curriculum more heavily on the lower levels. This may vary, however, as the roles played by IT professionals in these countries evolve, and the provider companies aim to perform higher-level work. In countries that are sending their commodity IT work offshore, it will be desirable for the curriculum to prepare students for the middle and upper levels of IT work where the ability to merge computer science and IT with applications and strategy are important. This is likely to lead to an increased emphasis on application knowledge and conceptual understanding and a reduced emphasis on routine programming skills. It should be stressed that, in all cases, however, the predominance of a certain level of IT work in a certain country or region is just a generalization; all levels will exist in all countries, and students will be needed to move into all of these levels. It is the distribution that will vary.

(2) There is a need for computing/IT education to evolve whether due to globalization or not. The skills and talents needed by software and IT professionals have evolved over the past decades independent of the issue of offshoring. In general, IT professionals are more likely to work in an application-specific context than previously, and conversely, less likely to work in computer-specific areas such as compiler or operating system development. They are more likely to work on large software applications in teams that include applications specialists, and, depending on the organization, may also collaborate with sales and marketing staff. They are also more likely to work in an environment where they are expected to be masters of certain software platforms and interoperability standards and know how to reuse code. Thus in general, it will be increasingly important that a computer science or IT education involve training and conceptual material that enables the student to work on large-scale software applications; understand important business, scientific, or other application areas; and be familiar with the tools and platforms that are increasingly the standards in the international marketplace. It also is increasingly important that the education emphasize teamwork and communication skills especially as they are practiced in a geographically distributed fashion. In order to develop and implement good planning concerning how to update IT education, it would be good to collect data about the relation between various educational choices and career outcomes. Given the importance of the model curricula prepared by the professional societies and the rapid changes in IT, it is worth considering a process that updates the model curricula more than once a decade and that has more industry input to balance the academic input into the curriculum revision process.

(3) There is a need for education to begin to prepare students for a global economy and its possible impacts on their careers. It is increasingly likely that an IT professional will be working in a global context. This may include being part of a multinational team or collaborating with customers or suppliers from other parts of the world. Thus, it will be increasingly important that an education in computer science and IT help prepare students for this global workplace. Education that acquaints students with different languages and cultures, whether through courses, study abroad, or other means, will be increasingly beneficial. One possibility is international internships for students so that a student from a developed country could spend a summer or a year working in an IT environment in a developing country or vice versa. Finally, to the extent that English is the universal language, the ability of countries to educate their IT professionals to be fluent in English will be a major factor in determining their success in the outsourcing economy and in multinational endeavors

If one had a crystal ball and could determine the changes that offshoring and, more generally, globalization will make to the software industry, it would of course be much simpler for everybody involved to figure out what action to take. One of our reviewers suggested the following scenario: "One perspective that goes beyond 'move up the value chain' is really to think 50-100 years ahead and imagine a world in which barriers to knowledge work are low but cost-of-labor disparities have largely equalized. What would drive value then? I would suggest it consists of specialization, clustering, the ability to leverage the global system through cooperation, and the ability to connect capabilities with results. Education and policy can affect these." (anonymous review, edited)

*(4) Educational systems that help prepare students to be creative and innovative will create advantages for those students and their countries***.** As the lower tiers of software and IT work become more commoditized, creativity and innovation will become even more important, particularly in countries that experience the loss of support and programming work. The creation of new products and new businesses will continue to lead to the greatest commercial and scientific successes, and even more, will serve as the differentiator between organizations and between countries. Historically, some educational systems are

seen as fostering creativity in students more successfully than others. One crucial differentiator in fostering a creative mentality in students is the research component of the educational system and the participation of students at all educational levels in research activities. Another differentiator is the degree of rote learning versus more open problem solving. Countries that currently have an advanced research enterprise in their university systems may increasingly see this as their greatest competitive advantage in educating computer science and IT students for the higher tiers of the IT workforce. Countries that do not include a research component in their university systems will need to consider whether strategically the investment in developing this component and culture is needed to attain their goals for the IT economies in their countries. Teaching research and innovation should not be left to the research universities alone. In the United States, small liberal arts colleges with limited research efforts prepare a disproportionately high number of the country's scientists and engineers. There is a place for innovation and research in the undergraduate curriculum.

(5) Educational systems that not only pay attention to current business and industry needs but also provide a core foundational knowledge will create advantages for those students and their countries. To cite two national examples, the Indian educational system has been particularly good at teaching the latest technology that is needed in business and industry today. In contrast, the United States has been particularly good at teaching foundational knowledge that is likely to serve a student through most of his or her career. Foundation skills help students remain current and not become obsolete as the technology changes rapidly around them. Although the particulars of a new technology in the workplace may be different from what a student was taught in school, a basic understanding of computing principles and ways of addressing problems will remain current even as the particular technologies change.

There needs to be a balance between fundamentals and currently relevant technologies in the student's education. In order to prepare students to be productive workers when they enter the job market, it is important not only that the educational system teach fundamentals but also pay attention to the reality of life-long learning and to the current needs of business and industry, and that it select carefully the particular technologies it exposes students to in order to address these needs. Andriole (2005) argues, for example, that all IT students need to learn more about business, particularly about business strategy, business applications, and enterprise architecture for higher-end jobs, or about infrastructure and support for lower-level jobs. This could perhaps be done by spending a term at a business through a university cooperative program, for instance.

Placing the right balance and right materials in the curriculum is tricky and may vary from institution to institution, but it can be achieved through respectful interchange between people in the academic and industrial/business worlds. No IT education can possibly fulfill all of the student's educational needs for an IT career, however, and IT workers should expect to have to engage in life-long learning in order to keep up with the rapid pace of technological change and the rapid changes in the way that organizations employ information technology. This is particularly true in the US higher education system where baccalaureate students are required to study a breadth of courses and not spend all their time studying IT. To give further emphasis to a point made earlier in this section, what constitutes fundamental knowledge also changes over time and can change in response to such exogenous factors as offshoring.

(6) A good educational system requires the right technology, a good curriculum, and good teachers. Fortunately, personal computers are relatively inexpensive, software for them has been commoditized, and fast broadband communication is readily available at low cost in most places in the world. Thus, the technology for training an IT workforce is within reach of much of the world. The model curricula that have been designed by the professional

societies have been and should be used as important reference points in many places around the world. There is probably value in developing a process by which these curricula can have greater business and industrial input and react more rapidly to changes in the way that IT gets used in the world. Although adopted around the world, the model curricula have been designed primarily for degree programs in the United States. If the professional societies really aspire to be world bodies and develop world curricula, they should pay attention to the needs of other countries and their degree programs as well. These might include a wide variety of IT jobs, including purely technical jobs but also including jobs enabled by the use of IT such as business or knowledge process outsourcing.

The teacher problem may be the most difficult one to address. For example, in India, critics complain that the general quality of the IT faculty is poor, salaries are low, and there are no funds to enable research by the faculty members or their students. In the United States, there are serious problems with the preparation of high school teachers who introduce students to IT, and several times in the past (in the late 1970s and again during the dot-com boom), American universities had difficulty recruiting and retaining quality faculty because of the lure of industrial IT positions and the inadequate number of students obtaining doctorates which are required to become faculty members. If the curriculum is to change to contain more business knowledge or knowledge of other application domains, it will be that much harder to find faculty members with the right combination of technical and domain-specific skills, or to manage an academic enterprise that has people with different disciplinary backgrounds. Certainly academic teams and cooperation between faculty members is part of the answer but not the whole answer. Inducements to improve the quality of the faculty would be helpful in India, the United States, and other countries. Inducements include not only good salaries and working conditions, but also funding for research and access to good doctoral programs for training the next generation of faculty members. The United States has attracted a large number of faculty members in its computing departments from developing countries, such as India and China. As IT globalizes, there will be more and more competition for this talent. Thus, the United States and other developed nations will be in a position where they must compete harder to attract talented faculty.

7.7 Bibliography

Accreditation Board for Engineering and Technology (ABET). 2004. Criteria for Accrediting Engineering Programs, Effective for Evaluations during the 2005-2006 Accreditation Cycle (Nov. 1).

Andriole, S.J. 2005. *The 2nd Digital Revolution.* IRM Press.

The Association of Support Professionals. 2001. Certification and Support Salaries. Watertown, MA. http//www.asponline.com.

BALATCHANDIRANE, G. 2004. Education and Training. In *Development of IT Industries and Regional Innovations in BRICs - The Case of India*, Asian Institute for Regional Innovation, South Korea (Nov.).

BITKOM 2005. Leitfaden Offshoring. Berlin, Germany. http://www.bitkom.org/files/documents/BITKOM_Leitfaden_Offshoring_31.01.2005.pdf

CAC and CSAB Criteria Committees. 2005. Draft General and Program Criteria for Accrediting Computing Programs (June 11).

Carnoy, M. 1999. Globalization and Educational Reform: What Planners Need to Know. *International Institute for Educational Planning, UNESCO*, Paris, France.

Carr, N. 2003. IT Doesn't Matter. *Harvard Business Review* (May) 41-49.

Chen, K. and Kenney, M. 2005. The Role of University/Research Institute-Industry Linkages in the Technological Development of Beijing and Shenzhen. *BRIE* Working Paper 168.

Chen, L. 1999. Reform: China's New Engineering Obstacle. *Prism* (Sept.). http://www.prismmagazine.org/sept99/lastword.htm. (Accessed Sept. 2005).

Cutter Consortium. 2004. *Trends in the Acquisition, Deployment, Support & Management of Information Technology*. Arlington, MA.

DREZNER, D. W. 2004. The Outsourcing Bogeyman. *Foreign Affairs 83,* 3 (May/June) 22-34.

DSP. 2005. DSP Home Page. http://www.dlsp.com.cn/english/About%20Dlsp/aboutdlsp.asp. (Accessed Sept.).

Eun, J.-H., Lee, K., and Wu, G. 2005. Explaining the "University-run Enterprises" in China: A New Theoretical Framework and Applications (Jan.). www.ciber.gatech.edu/workingpaper/2005/019-05-06.pdf (Accessed Sept.).

Freman, P. and Aspray, W. 1999. The Supply of Information Technology Workers in the United States. *Computing Research Association,* Washington, DC.

Gomolski, B. 2004. What to Tell the Kids. *Computerworld* (Oct. 18).

Gorgone, J. et al. 2002. IS 2002: Model Curriculum and Guidelines for Undergraduate Degree Programs in Information Systems. *ACM, AIS, AITP*.

Grimshaw, D. and Miozzo, M. 2004. High-Tech Business Services and Innovation in Germany and the UK: The Case of IT Outsourcing. *Anglo-German Foundation* (June). http://www.agf.org.uk.

Helfert, M. and Duncan, H. 2005. Business Informatics and Information Systems – Some Indicators of Differences in Study Programmers. *Proceedings of UK Academy for Information Systems (UKAIS)* Newcastle, UK.

Hoffman, T. 2003. Job Skills: Preparing Generation Z. *Computerworld* (Aug. 25).

Information Technology Association of America. 2004. Adding Value…Growing Careers: The Employment Outlook in Today's Increasingly Competitive IT Job Market (Sept.). http://www.itaa.org.

Jha, P. 2005. Withering Commitment and Weakening Progress: State and Education in the Era of Neoliberal Reforms. *Economic and Political Weekly* (Aug. 13) 3677-3684.

Joint Task Force on Computing Curricula, Computer Curricula. (2004). Overview Report (Including A Guide to Undergraduate Degree Programs in Computing). *The Association for Computing Machinery (ACM), The Association for Information Systems (AIS) and The Computer Society (IEEE-CS)* (Nov.).

Joint Task Force for Computing Curricula. 2001. Computing Curricula 2001: Computer Science, Final Report (Dec.).

Joint Task Force on Computing Curricula. 2004a. CE 2004 – Curriculum Guidelines for Undergraduate Degree Programs in Computer Engineering (Dec.).

Joint Task Force on Computing Curricula. 2004b. SE 2004 – Curriculum Guidelines for Undergraduate Degree Programs in Software Engineering (Aug.).

Joint Task Force for Computing Curricula. 2005. Computing Curricula 2005: The Overview Report (April).

Joseph, M. 2001. China Threatens India Eminence. *Wired* (Feb. 23). http://www.wired.com/news/business/0,1367,41656,00.html (Accessed Sept. 2005).

Kenney, M. and Patton, D. 2005. Analysis of the Chinese High-Technology IPOs on the NASDAQ. Unpublished working paper.

Lall, M. 2005. The Challenges for India's Education System. Briefing Paper. *Asia Programme, Chatham House.*

Liu, X. 2004. Technology Policy, Human Resources, and Chinese Software Industry. *Conference on Strategies for Building Software Industries in Developing Countries* (May) Hawaii. www.iipi.org/Conferences/ Hawaii_SW_Conference/Liu%20Paper.pdf.

Longwell, J. and Roberts, J. 2005. Beefing UP on Training. *CRN* 1160 (Aug.) 18-24.

Lu, Q. 2000. *China's Leap into the Information Age*. Oxford University Press, Oxford, UK.

Malcom, S., Teich, A., Jesse, J.K., Campbell, L.A., Babco, E., and Bell, N.E. 2005. Preparing Women and Minorities for the IT Workforce: The Role of Nontraditional Educational Pathways. *American Association for the Advancement of Science and the Commission of Professionals in Science and Technology.*

Maheshwari, S.N. 2004. IT Education in India – Incorporation of Quality. In Verma, S.P., Ed. *Information Technology and Indian Administration*. Indian Institute of Public Administration, New Delhi, India.

McGrath, S.T. 1998. The Future of IT Certification. *Training and Development 52*, 6 (June) 19-23.

Meister, J.C. 1998. *Corporate Universities: Lessons in Building a World-Class Work Force* 2nd Ed. McGraw-Hill.

Menon, P. NIIT Draws Up Strategy to Strengthen Its Presence in China. http://www.niit.com/ILB/India/asp/articles/NIIT-China-article-prakash-menon.rtf (Accessed Sept. 2005).

Mertens, P., Grosse-Wilde, J. and Wilkens, I. 2005. Die (Aus-)Wanderung der Softwareproduktion – eine Zwischenbilanz. *Arbeitsberichte des Instituts für Informatik der Friedrich-Alexander-Universitaet Erlangen-Nuernberg 38,* 3. Erlangen, Germany.

Moncarz, R. 2002. Training for Techies: Career Preparation in Information Technology. *Occupational Outlook Quarterly* (Fall) 38-45.

National Association of Software and Services Companies (NASSCOM). 2004. Strategic Review 2004; The IT Industry in India.

National Association of Software and Services Companies (NASSCOM). 2005. Strategic Review 2005: The IT industry in India.

NASSCOM-KPMG. 2004. Study Choosing a Location for Offshore Operations in India.

NationaL Research Council, Committee on Workforce Needs in Information Technology. 2001. Building a Workforce for the Information Economy. Washington, DC.

National Science Board. 2004. Science and Engineering Indicators 2004. http://www.nsf.gov/statistics/seind04/front/nsb.htm. (Accessed Sept. 2005).

People's Daily. 2005. Survey on China's Software Employees. (May 8) http://www.china.org.cn/english/scitech/128010.htm (Accessed Sept.).

Pepper, S. 1996. *Radicalism and Education reform in 20th-Century China.* Cambridge University Press, Cambridge. UK.

Pluvinage, V. 2005. IP and Economic Development in Emerging Markets: Historical Perspectives and Controversial Views. Unpublished presentation (June).

Pollice, G. 2005. Software Engineering in China: The Next Big Thing. (May) http://www-128.ibm.com/developerworks/rational/library/may05/pollice/. (Accessed Sept.).

Prometric. 2001. 2001 Training and Certification Study. *Thompson Learning*. http//www.prometric.com.

Ray, C.M. and R. McCoy. 2000. Why Certification in Information Systems? *Information Technology, Learning, and Performance Journal 18*, 1 (Spring) 1-4.

Taubner, D. (2003) Effizientes Software-Engineering: Vorgehen für wirtschaftliche Projekte. *Fachzeitschrift für Information Management & Consulting 10*, p. 14-18.

Teitelbaum, M. 2003. Do We Need More Scientists? *The Public Interest, 153* (Fall) 40-53.

Tilak, J.BG. 2002. Privatization of Higher Education in India. *International Higher Education* (Fall).

Tilak, J.BG. 2004. Are We Marching Towards Laissez-faireism in Higher Education Development? *IAU Sao Paulo Conference: The Wealth of Diversity* (July).

Tschang, T.and Xue, L. 2005. The Chinese Software Industry. In A. Arora and A. Gambardella Eds. *From Underdogs to Tigers* Oxford University Press, New York, NY, 131-169.

Verton, D. 2004. Anything But IT. *Computerworld* (Nov. 29).

Wang, C.. 2000. From Manpower Supply to Economic Revival: Governance and Financing of Chinese Higher Education. *Education Policy Analysis Archives 8,* 26 http://epaa.asu.edu/epaa/v8n26.html. (Accessed April 2005).

Wardle, C. 2002. Diversifying Computing: Three Perspectives. *CRA Conference at Snowbird*. Snowbird, UT.

The World Bank. 2000. Higher Education in Developing Countries: Peril and Promise. *The Task Force on Higher Education and Society*. Washington, DC.

The World Bank. 2002. Constructing Knowledge Societies: New Challenges for Tertiary Education. Washington, DC.

Wu, G., Yan, L., and Wang, Y. 2004. Beijing Regional Innovation System: History, Dilemma and Solution. *The 2nd Annual Globelics Conference 2004 on Innovation Systems and Development: Emerging Opportunities and Challenges.* Beijing, China (Oct.).

Xue, L. 2005. University-Market Linkages in China: The Case of University-Affiliated Enterprises. iis-db.stanford.edu/evnts/4097/ LXue_UniversityMarket_Linkages_in_China.pdf (Accessed Sept.).

Yimin, D. and Lei, X. 2003. An End to Business as Usual? *Science 302* (Oct. 3) 43.

S. Zweben. 2005. 2003-2004 Taulbee Survey: Record Ph.D. Production on the Horizon; Undergraduate Enrollments Continue in Decline. *Computing Research News (*May) 7-15.

Authors: William Aspray*, Goran Marklund

Chapter 8: Policies and Politics of Offshoring: An International Perspective

The purpose of this chapter is to examine how nations address the problems and opportunities of offshoring through policy. For each of the nations studied in this chapter, we consider such topics as the policy issues of offshoring, how they fit into other national policies and political issues, the principal political players, and positions they take. We do not recommend policies that an individual nation should hold.

We are interested in gaining an international perspective on the politics of offshoring. There are too many nations involved in offshoring as suppliers or receivers to consider them all individually, and these countries resist grouping into neat categories based on their national policies of offshoring. Instead, we have taken five countries for investigation: the United States and Sweden as examples of countries that send significant amounts of work offshore; Australia, which both sends and receives software-related work across its national boundaries; and China and India as examples of countries that are major recipients of offshored work. These five case studies provide an impression of the national policies, and to a lesser extent, of the national politics of offshoring, but they do not give a complete international picture.

8.1. US Policy

Public policy debate about offshoring began in the United States as a result of the wide news coverage of the report in November 2002 by Forrester Research that 3.3 million US jobs would be lost by 2015 as a result of offshoring. Television commentator Lou Dobbs of the Cable News Network (CNN) has, for example, regularly taken corporations to task for sending IT and IT-enabled jobs offshore with predictions that this movement would only compound the pain to middle-class America that had experienced a loss of millions of manufacturing jobs to Asia over the past decade. The 2004 US presidential debates made offshoring an issue with every major Democratic presidential candidate proposing legislation to save American jobs. The Republicans were mostly believers in comparative advantage through free trade but downplayed their position during the elections because it was a message that did not play well in critical swing states such as Ohio and Michigan where many of those manufacturing jobs had once been located. When President Bush's chief economic advisor, Gregory Mankiw, expressed support for unrestricted offshoring, he was lambasted by Speaker of the House Dennis Hastert (R-IL), and President Bush distanced himself from Mankiw's remarks.

Let us digress briefly to consider the situation in Europe in order to better understand that policy action (as taken in the United States) is not the only possible response to job loss through offshoring. Public policy debate in Western Europe came later and has been more muted than in the United States. In Germany and France, the labor unions were strong enough to limit offshoring, and labor laws included provisions requiring companies to compensate laid-off workers who lost their jobs because their company moved their jobs to another country. Also, there are limited numbers of German- and French-speaking educated workers in low-wage countries prepared to take on this offshored work. It was in the United Kingdom where the greatest amount of offshoring occurred in Europe, and also where there was the greatest backlash although Prime Minister Tony Blair twice came out with public statements in favor of offshoring. The public awareness of the potential job loss

*W. Aspray took a leadership position in writing Chapter 8.

through offshoring was heightened in the United Kingdom through a follow-up to the US report by Forrester, projecting the loss of 750,000 UK jobs to offshoring by 2015. Recently, public sentiment against offshoring has begun to heat up across Western Europe as the amount of work sent offshore by companies in these countries begins to rise. For example, in response to public sentiment, the French government has set aside a one billion Euro fund for motivating French companies to keep jobs at home.

One difference between the United States and the United Kingdom has been the response of organized labor. Perhaps the harshest labor criticism of offshoring in the United States has come from the Communications Workers of America especially against IBM. This criticism seems to have modified the way in which IBM went about its offshoring, but it has not deflected them from doing so. Although organized labor continues to have the ear of the US Congress, and it has supported most of the legislation placing restrictions on offshoring sent to Capitol Hill, these bills have not been passed into law. Part of the ineffectiveness of organized labor in the offshoring debates may be that workers in the software and services industries are not all that well represented by American labor unions. In contrast, there have been threatened strikes (e.g., Bank of Ireland) and actual strikes (e.g., at the financial conglomerate HSBC) in English-speaking Europe, and labor unions seem to have a powerful say in public debates.

Instead of labor actions, the United States has seen actions by the executive and legislative branches of the state and federal governments trying to control the loss of jobs through offshoring. More than 20 federal bills have been introduced. About three quarters of the states either introduced bills or recorded executive directives from their governor. For example, John Kerry (D-MA), the unsuccessful 2004 Democratic presidential candidate, introduced a bill in the US Senate that would require call center workers to disclose their location at the beginning of each session with a caller. This bill had the rationale of giving the caller information that would help him to decide how much private information to divulge to the call center employee in Mumbai or Manila, but presumably it was also intended to encourage customers to put pressure on companies not to use non-US locations for call centers. Senator Hillary Rodham Clinton (D-NY) introduced legislation paralleling the European data protection laws that limit personal data that can be shipped across national borders. Some state bills and executive orders preclude foreign-owned companies from bidding on contracts paid for with public funds, require all workers on these contracts to be US citizens or hold green cards, or tilt the contracting process in favor of companies located within the state.

Most of these laws have not been passed or tested in the courts. One exception is the Thomas-Voinovich Amendment. The Bush administration introduced a new policy, through the Office of Management and Budget Circular A-76, to encourage greater competition and outsourcing of federal work to private contractors. Senators Craig Thomas (R-WY) and George Voinovich (R-OH) introduced an amendment to appropriations legislation that the Bush administration modified slightly, and it passed into law (with a one-year sunset clause) in January 2004 as part of the Omnibus Appropriations Bill. The amendment stated that work contracted out under the rules of Circular A-76 may not be performed by contractors outside the United States to any greater extent than it had been in the past. This law remained in effect for the 2004 fiscal year only. The extent to which it limited offshoring is unknown.

There are reasons to question the legality and efficacy of such restrictions. Some legal scholars believe that most proposed state laws and executive orders will be ruled unconstitutional because of the Commerce Clause of the Constitution that leaves control of international commerce agreements in the hands of the federal rather than the state governments (see Klinger and Sykes 2004). These legal scholars also believe that proposed federal legislation on offshoring may break existing international agreements. There is also a risk of retaliation by other countries to protectionist American legislation. In fact, it may be the risk of retaliation that is most persuasive in limiting available legislative and regulatory actions.

Tax law is another approach that received significant attention in Congress and in the 2004 presidential debates especially from the Democrats. The goals were to change US tax law so that there is no tax incentive to move jobs overseas, and to normalize tax rules between the United States and other countries so that US-based multinationals would have incentive to repatriate earnings to the United States earned in other countries. The United States taxes revenues of companies operating in the United States no matter where the revenue is earned (giving a tax credit to the company for taxes paid in other countries on this same revenue). Many companies reduce US taxes paid by keeping revenues overseas until they have an operating loss in the United States against which they can offset this foreign revenue. Democratic presidential candidate John Kerry recommended a change in the law that would require companies to pay US taxes in the year the revenue was earned, not the year when the revenue was brought into the United States. Another kind of change that has been proposed is to place greater US government control on organizations such as the Overseas Private Investment Corporation which helps the Federation of Indian Chambers of Commerce to encourage American companies to relocate to India and which helps to encourage investment in Indian banking and computer companies that are possible competitors of US firms.

Another place where debates have arisen over protection of jobs for American workers has concerned US visa policy. Ron Hira, a public policy professor at Rochester Institute of Technology and vice president of Career Activities of IEEE-USA, has been a driving force in the IEEE-USA's efforts to protect jobs and wage levels for American engineers. He has made a detailed study of the strategic use of H-1B and L-1 visas by Indian offshoring companies (Hira 2003; 2004; to appear). The companies use a blended strategy of placing some workers on site at their US client's facilities and other workers back in India to make offshoring more amenable to the client and make the work flow and work management more convenient. Sometimes these visas are used simply to replace a US worker with a lower-paid Indian worker who works in the US office alongside the client's other employees. Hira argues that the current visa policy reduces the competitive advantage of physical presence in the United States that the American worker would otherwise have, and he suggests that this use of visas by Indian companies may constitute dumping (the selling of goods at less than fair market value), in violation of US international trade agreements. Several laws have been introduced in Congress to curb this practice. None has passed, and many of them are broad-sweeping and may have unintended consequences that harm US interests such as reducing the creation of new jobs for Americans or weakening US technological competitiveness. Hira admits that some proposed legislation has these problems but argues that legislation that more carefully limits use of these temporary visas, such as that co-sponsored by Senator Christopher Dodd (D-CT) and Representative Nancy Johnson (R-CT), can protect American workers, while still allowing temporary visas for legitimate reasons such as skilled specialty work when US workers are unavailable (H-1B) and legitimate intra-company transfers (L-1).

There have been several side issues related to these temporary visa programs in the United States. Since the H-1B visa program began in 1991, there has been an annual cap on these visas, typically 65,000, but much higher for several years during the dot-com boom because of pressure exerted by the American business community. The US immigration service (USCIS) has a poor track record for accurately counting the number of H-1B visa applications granted each year. IEEE-USA has been a watchdog of the USCIS, for example, sending out a press release in March 2005 that USCIS has exceeded its 65,000 visa quota for the year by 10,000. In a related issue, under pressure from the business community in December 2004, Congress allocated for this fiscal year an additional 20,000 H-1B visas specifically set aside for workers holding advanced degrees from US universities. However, critics argue that USCIS has used stalling tactics, such as reinvestigating the criteria for these visas and holding off action until publication in the Federal Register, to prevent having to process and award these visas. As expected, these actions angered the US business community that favors few or no restrictions on temporary work visas. (The USCIS did eventually issue guidelines on how the 20,000 additional visas should be used.) Industry is unhappy with some other practices of the USCIS, and there are unsupported claims that these practices are driving companies to send work directly overseas rather than use the temporary visas to keep work in the United States even if some of it is done by foreign workers. Such practices include an increase in the H-1B application fee from $185 to $2185 in December 2004, an additional charge of $1000 for expedited processing (which is a necessity when there are more applications than the annual cap as has been the situation recently), and glitches in the new Program Electronic Review Management system that must be used by H-1B workers who want to apply for permanent (green card) status.[1]

A different policy approach has focused not on protecting American jobs but instead on providing support to Americans who lose their jobs through offshoring. Workers not only lose their jobs; in many cases, they lose access to their pension and health care benefits. Moreover, studies indicate that workers who have lost jobs over the past several decades have taken wage cuts on average in their new jobs, and people who lost jobs because of trade have taken a larger than average wage cut (Kletzer 2001).

In 1962, the US Congress passed the Trade Adjustment Assistance Act (TAA) to offer job training and extend the length of time of unemployment benefits to American workers who lost their jobs through trade (Storey 2000; Graney 2005). This legislation was directed principally at manufacturing workers. Perhaps most directly significant here is the politics of whether the Trade Adjustment Assistance Act applies to software workers. When the Bush administration came into office, it took the position that the act, which in Section 222 limits the legislation to workers who produce an article, applies only to manufacturing workers. Laid-off programmers filed a class-action suit against the Department of Labor that it had illegally denying 10,000 programmers benefits under the act (still pending as of publication of this report) (Loftus 2004). The Department of Labor argued that the programmers do not qualify because software and IT services do not qualify as products or articles as specified in the act. When the act was reauthorized in 2002, Democratic lawmakers tried to include software and service workers under the act, but the Republican majority blocked it, arguing that broadening coverage would be too costly (despite big increases in funding of the program in FY 2003 and FY 2004).

To some degree, alliances in favor of or opposed to applying TAA to software workers were regional rather than drawn along party lines. For example, delegations in the manufacturing states, notably those in the Midwest, were generally not supportive of the extension of TAA to software workers because the funding was already stretched thin and there were many manufacturing workers to support with the state's allocation of TAA funds. However, in the state of Washington, with its many software workers, Democrats and Republicans alike (such as Representative Jennifer Dunn (R), a former IBM systems engineer who represented the Seattle suburbs that included Microsoft headquarters) were in favor of extending coverage to software workers. In 2004, Senators Max Baucus (D-MO) and Richard Durbin (D-IL) and Representative Adam Smith (D-WA) all introduced bills that

[1] As this report was going to press, the Senate Judiciary Committee was discussing an increase in the number of H1-B visas by 60,000 per year for five years. The IEEE-USA is mounting a campaign among its members to write to their representatives to block this increase.

would provide coverage for software and service workers, but none has yet been passed and signed into law. There has been a recent set-back for the Bush administration. After being remanded twice for reconsideration by the Department of Labor, the United States Court of International Trade ruled that software development work at Ericsson in Brea, California, did involve creating a product and thus their former employees who had lost jobs when this work was moved to Canada were eligible to apply under the Trade Assistance Act (Federal Register, v. 70, No. 25, February 8, 2005).

A number of groups and scholars have called for new policies to protect workers who lose their jobs through trade. These policies include requiring companies to provide three months of notification to workers whose jobs are to be eliminated because of trade, extension of the term length of unemployment benefits, wage insurance paid for by the companies that offshore work as a means to make up some of the drop in wages typical in the displaced worker's next job, improved retraining and reemployment services, temporary health care and mortgage assistance, and multi-year income averaging on federal taxes, as well as extension of the Trade Adjustment Assistance Act to software and service workers. Some of these groups also call for legislation to help American communities hit hard by offshoring, such as more effective government-sponsored regional development programs and funding to create alternative outsourcing destinations within the United States especially in rural communities where wages are already relatively low and unemployment high.

One of the policy initiatives for which support is growing rapidly is to improve the innovation base for the United States. The basic idea is that, although some jobs will undoubtedly be lost to low-wage countries, America can create a substantial number of new jobs, including many that are high on the value chain, through policies that create a climate of innovation.

There is a widely held belief that American prowess in science and innovation is slipping. The Task Force on the Future of American Innovation is a politically active group with representation from industry, research organizations, and universities. Members include, among others, IBM, Microsoft, Texas Instruments, Hewlett Packard, Intel, the Council on Competitiveness, the National Association of Manufacturers, the Semiconductor Industry Association, and most of the major professional societies (including ACM) from the physical sciences and computing disciplines. In February 2005, the task force published a benchmark report that showed serious problems in the American innovation base (The Task Force on the Future of American Innovation 2005). A sample of their findings include the following.

- The US share of worldwide science and engineering degrees at both the undergraduate and doctoral levels is declining.
- The percentage of US citizens enrolled in US science and engineering graduate programs is dropping.
- Asian students, once a leading part of the graduate population studying science and engineering in the United States, are increasingly less likely to study in the United States.
- The US share of science and engineering publications worldwide is declining.
- US patent applications from Asia are growing seven times as fast as applications from the United States.
- Government investment in research and development is growing much more rapidly in many countries than in the United States.

- There is a 30-year decline in support for basic research in engineering and physical science in the United States as a percentage of GDP.
- There is a 20-year decline in the US share of worldwide high-tech exports.
- The United States has had a high-technology trade deficit every year since 2001.

Richard Florida, a professor of economic development at Carnegie Mellon University, and his colleagues have identified factors associated with regions that have high levels of creative economic growth (Florida 2004). They include large populations of talented individuals, a high level of technological innovation, and a tolerance of diverse lifestyles. Measured by these factors, Sweden rates higher than the United States; Finland, the Netherlands, and Denmark are close behind; and the United Kingdom and Belgium are also doing well. Based on these same measures, Sydney and Melbourne are doing as well as Washington, DC, and New York City. Vancouver and Toronto best New York City, Miami, and Los Angeles in the number of immigrants. Clearly, the unchallenged lead of the United States in the creative wars is no longer assured, according to Florida.

Generating the large numbers of talented individuals called for by Florida has become a problem for the United States. Many of the engineers and entrepreneurs who drove the build-up of Silicon Valley and the dot-com boom were foreign-born. But the number of visas applications for immigrants to work in the United States has dropped significantly since 2001. For example, 163,600 H1-B visas were issued in 2001 but only 79,100 in 2002. Not all H1-B visas are awarded to scientists and engineers, but they receive the largest percentage of these visas. There has been a similar drop in foreign applications to study science and engineering disciplines in US graduate schools with applications from India and China down by about a third to a half. This could be in part because there are increasingly competitive educational opportunities in China and India (Griffiths 2005). But it also could be because of events in the United States, such as

- anger over US government actions in Iraq and other parts of the world,
- tightening of the visa process by USCIS,
- a weakening of the US computer industry with the dot-com bust,
- fewer opportunities for graduate research assistantships with DARPA redirecting some funds from academia to industry,
- stricter classification requirements on research sponsored by the federal government,
- the Real ID Act which makes it harder for foreigners to obtain valid identification,
- newly proposed Commerce Department restrictions on dual-use technologies which may make it harder for foreigners to gain access to the laboratory equipment they need.

There is also a problem attracting US students to prepare for IT and other science and engineering careers. According to the Computing Research Association Taulbee Survey, the number of students declaring computer science majors has dropped 39% since 2000 (Vegso 2005). Women and ethnic minorities remain seriously under-represented. To get some perspective, in 2002, China graduated between 200,000 and 300,000 engineers (sources vary on the exact number), compared to fewer than 70,000 in the United States. There are apparently multiple reasons for this lack of interest in technical subjects among American students. They are ill prepared by their K-12 education for science and engineering majors in college. The dot-com bubble bursting and the flight of some jobs out of the country through offshoring (overblown by the press) appear to have caused students to believe there are not opportunities for good careers in IT. Many complex interacting socio-cultural and economic factors contribute to the under-representation of women and minorities in the IT field.

Much of the high-tech community has been critical of the Bush administration which is perceived by them to be hostile to science. (For a response from the Bush administration, see OSTP 2005.) While the Bush Administration proposed a small increase for NSF in FY 2005, Congress ended up cutting its budget by 1.9 percent. This was the first cut since 1996. This year, much to the displeasure of the high-tech community, the Administration only requested a slight increase to $5.6 billion, which is $100 million below its request from the previous year and only slightly above the 2004 level – and approximately $75 million of that increase is from shifting maintenance responsibilities for two Coast Guard cutters over to the agency. In high-profile cases, the Bush administration has decided that it is not worth the job losses to sign on to international treaties on global warming for which there is scientific evidence, and it has decided there is greater value in policy that protects the life of embryos than in making fetal tissue available for important medical research. With the notable exception of Samuel Bodman, many of the senior Bush advisors are from old-technology industries such as railroads, and none of them is seen as a particular advocate of high technology. The role of the national science advisor has been downgraded in comparison to previous presidencies. The Bush administration was slow to make appointments to the President's Information Technology Advisory Council and has recently subsumed it under the Presidential Council of Advisors on Science and Technology. In these and other ways, the academic science community believes the Bush administration has demonstrated a lack of interest in promoting high-tech as an economic driver.

Thus there has been skepticism in the scientific community as to whether the Bush administration would support an innovation policy. However, at least in Congress, there has been growing bipartisan support for an innovation policy. (For more background, see Wilson 2005a; National Academies 2005.) Even ardent free trade supporters in Congress believe there is value in making the United States more competitive in the world market. For example, Representatives Frank Wolf (R-VA), Vern Ehlers (R-MI), Sherwood Boehlert (R-NY), and Don Manzullo (R-IL) have called for an Innovation Summit to be held in late 2005 to address the loss of US leadership in science and innovation. (R&D funding is only one aspect of innovation strategy. The history of Japan's auto industry, for example, shows that leadership may come from production and scale. In this case, the most important matters are human resources management, inventory management, and quality. Russia provides another example where research does not equal innovation and economic leadership, given that Russia has been a leader in basic research but has had limited production and scale.)

Political responses to these innovation problems generally encompass four elements: making it more attractive for foreign students and scientists to work in the United States, improving the educational system in the United States, attracting US citizens to the science and engineering disciplines, and increasing federal support for research and development. For example, Representative Wolf has called for tripling federal funding for basic research in the physical sciences, including computing; legislation to forgive loan interest for math and science majors; and the national innovation summit. As this report was going to press, in the fall of 2005, two pieces of legislation were working their way through Congress. One is an education bill, the College Access and Opportunity Act (H.R. 609), which passed the

House Education and Workforce Committee in July and is now pending before the House of Representatives. (For more information, see Wilson 2005b.) One of its provisions is for awarding mathematics and science scholarships and allowing a partial waiver of interest on student loans; in both cases, the student is required to work in a related field of science or engineering for five years after graduation. The other legislation is an amendment to the Defense Authorization Bill for FY2006, introduced by Senators Ted Kennedy (D-MA) and Susan Collins (R-ME) and receiving wide bipartisan support. (For more information, see

Harsha 2005.) This amendment would increase funding for basic research coming from defense department agencies and introduce a new scholarship and fellowship program to attract students to science and engineering fields.

Several non-profit organizations have suggested detailed platforms of reform that would encourage innovation as a means to create jobs and prosperity in the United States. The elements include R&D investment, tax credits, infrastructure improvement, and educational reform. Educational reform concerns both the incumbent and future workforces. The platforms for the Computer Systems Policy Project, which is a group of CEOs from leading IT companies such as IBM, Intel, Hewlett Packard, Dell, and Motorola, and from the Progressive Policy Institute are outlined in Table 1.

Table 8.1: Two Policy Platforms for US Economic Development Through Innovation

Computer Systems Policy Project

Promote innovation through:

- A permanent and improved R&D tax credit
- Increased federal funding for university-based research in the physical sciences
- A series of policies to support the chain of innovation in areas such as customer service, price and productivity
- Invest in infrastructure through:
    - A new infrastructure investment act that shortens depreciation schedules for IT assets, provides a tax moratorium on Internet access and eliminates multiple and discriminatory Internet taxation, and reforms international tax rules that include double taxation of foreign-source income
    - Provide a national plan for increasing broadband access
    - Expand the e-government initiative to make government operation more efficient
    - Improve US education and training through:
    - Greater funding for existing federal and state education priorities
    - Enhanced federal funding for math and science education programs
    - Support greater access to and use of IT
    - Improvements in teacher preparation and performance through higher pay, flexible certification requirements, professional development opportunities, and support for graduate and continuing education
    - Incentives for employers to train and hire highly skilled workers
    - Training programs for displaced workers

Progressive Policy Institute

Boosting Innovation through:

- An additional $10 billion per year to fund advanced cyberinfrastructure, industry-university alliances, innovation infrastructure grants to universities, a productivity enhancement research fund, and doubling the NSF budget
- Fund a revenue-neutral incremental tax credit for investment in information-processing equipment, software, and industrial equipment
- Develop a national information technology strategy to accelerate the transformation to a digital economy, e.g tax credits to get individuals to move to high-speed broadband service, sectoral initiatives to transform health and financial services through innovative uses of IT, and improved e-government services
- Expand federal support for early-stage company financing, such as the Small Business Innovative

Research Program

- Boosting skills through:
  - Reorganization of existing federal employment and training programs into a more effective national skills corporation
  - Fund math and science education
  - Make it easier for foreign math, science, and engineering Ph.D. graduates to become US citizens
  - Correct abuses in the L-1 and H-1B visa programs

Sources: Atkinson 2004; Computer Systems Policy Project (2004)

There are some other policies that are not directly about offshoring but have a bearing on it. These include issues of privacy, data security, national security, and intellectual property protection. These topics are covered in Chapter 6, so they will not be discussed here. There are also issues having to do with open markets, in an attempt to provide a level playing field in the global marketplace. Consider the case of China. The Chinese government has adopted a standard for wireless communications devices that is different from the international standards, presumably in order to keep foreign competition out of its domestic market. China waives value-added tax on exports from its domestic semiconductor manufacturers. It is planning procurement rules that require foreign companies to establish joint ventures and share proprietary technologies with Chinese companies if they wish to sell in the Chinese domestic market. China is also planning on allowing its government agencies to buy software exclusively from domestic sources.

Finally, there is the question of currency manipulation. China presents the best example. (For more background information, see Areddy et al. 2005.) Over the past few years, the Chinese yuan has been seriously undervalued against the US dollar, perhaps by as much as 40%. This makes it less expensive for manufacturers to locate production in China. Were the exchange rate at true market value, in some cases it would be more cost-effective for companies to locate production facilities in the United States; it would also price Chinese-made products more fairly in the international marketplace. The US government has placed pressure on China to revalue the currency to a more realistic level. In growing frustration at the lack of Chinese action, Senators Charles Schumer (D-NY) and Lindsay Graham (R-SC) introduced an amendment in 2005 to a State Department spending bill that would place a 27.5% import duty on all Chinese imports into the United States if China did not agree to revalue its currency. China had been considering doing so for several years and agreed to act, but only if its action was not seen as a direct result of US pressure. So the US Senate agreed to table the vote on the Schumer-Graham amendment until August 2005, and China announced in July that it was going to adopt a managed floating exchange rate tied not to the US dollar but instead to a basket of currencies. The yuan began immediately to rise in value against the dollar, but how far the Chinese government will allow it to rise is an open question. So far, the amount has been small.

8.2. Australian Policy

Australia presents an interesting case study in the politics of offshoring in that it is a country that has benefited greatly from free trade, both in terms of its important export markets for wheat, wool, coal, wine, education, and tourism, and for the range of products that are available as imports to its citizens. In the early 1980s, the Australian government lowered tariffs significantly. This caused some job loss, and individual companies and industries had to go through significant adjustments. There was some public outcry as a result, but the Australian government stuck with its liberalized trade laws, and, by 2004, the economy was strong, inflation was consistently low, overall unemployment was a favorable

6%, and approximately 20% of Australian jobs were related to exports. Australia also serves as an interesting case study because it is subject to job loss by sending IT work overseas, and it is a destination for IT work (onshoring) because of its English-speaking population, strong infrastructure, political and economic stability, and large talent pool especially in financial services.

Debates over free trade arose again in 2004 in the context of offshoring. These were stimulated in part by the concerns of the American about American job loss to offshoring, the high profile this issue was given in the US presidential election, the fact that Australia was experiencing its first high levels of unemployment in the computer and telecommunications sector (12.4% in 2002 and 10.6% in 2003), and the high profile the press gave to a $75 million contract the Australian telephone company, Telstra, awarded to the Indiana offshoring company, Infosys, in 2003 which was expected to cost 180 Australian jobs. There was sharp criticism from the opposition Labor Party, for example, from Senator Kate Lundy, the Shadow Minister for Sport, Tourism, and IT, of the lack of policies protecting Australian jobs and workers from the government of John Howard. (See Lundy 2003.)

In May 2004, the Australian Computer Society released the ACS Policy Statement on Offshoring (www.acs.org.au). Interestingly, it took basically a free-trade position and did not call for protectionist measures. Instead, it called for improvements in existing government programs to help displaced workers with retraining and retooling, check lists that would educate Australian companies on the cost-benefit analysis of offshoring so that they would not rush headlong into it, and changes in industrial policy to enhance Australian research and development. Not all the members of the professional society were happy with this position, but the leadership stood firm. (See Montgomery 2004.)

The sitting Howard government was pleased with the ACS report. In a response to the report by Daryl Williams, the Minister for Communications, Information, and the Arts, it was argued that "The Howard Government's approach is that we don't need protection" and at another point "Globalization is not a one-way street." (See Williams 2004.) Williams outlined the initiatives being taken by the Howard Government to address offshoring:

- Make more readily available government services for displaced workers
- An insourcing initiative, known as Invest Australia, which had been started in 1997 and had a strong focus on IT (and which had led to $12 billion in foreign direct investment in Australian IT)
- An education and training program focused on general computer literacy, with a curriculum published by the government in 2003 under the title "Learning in an Online World"
- A proposed national assessment of IT skills of 6- and 10-year olds
- Additional funding for the Australian Quality Teacher Program

Recently, the Australian Computer Society has changed its position somewhat on immigrant workers. Numbers released in 2005 by the Australian Department of Immigration Multicultural and Indigenous Affairs (DIMIA) indicated that almost half of all temporary skilled worker visas for IT workers were held by Indians and that almost one third of all 457 visas were being used for people doing programming work at a time when there was an abundance of programmers in Australia. The 457 visa program, which is similar to the H1-B visas in the United States, is intended to enable Australian companies to bring skilled workers to the country to fill skill shortages and to help companies to set up operations in Australia. These visas are specifically not to be used to bring low-wage workers into the country to displace Australian workers. Critics of the 457 visa program have used the new DIMIA statistics as ammunition in their assertions that the 457 system has been employed to undercut local wages by importing workers from low-skill countries.

In response, the Australian Computer Society has taken positions on both the skilled temporary visa program (457) and on a permanent residence visa program known as the General Skilled Migration Program. While still endorsing the basic immigration policy of the Australian government, ACS has called for adjustments in the 457 system to make it fairer. In particular, ACS has called for (quoted verbatim from ACS's press release)

- DIMIA to collect and publish information on the skill set and specialization of 457 visa applicants to determine any mismatch between those roles/skills in short supply and those in oversupply.
- Mandatory skills assessment for 457 visas to verify the skill sets of 457 Visa applicants….
- DIMIA should publish regular data on actual salaries paid to 457 visa holders in ICT occupations, compared to the DIMIA approved salaries.
- DIMIA should publish data showing which companies employ 457 visa holders on an annual basis compared to their initial sponsoring employer.
- The minimum threshold salary for 457 visas be set at the prevailing market rate for each particular ICT specialty and reviewed annually.
- Employers sponsoring 457 visas be required to include 'no displacement undertaking' as part of their obligations covering the three months before and after Visa hiring. When making the application, the employer should sign a declaration that in hiring the 457 visa applicant they are not displacing an Australian incumbent.
- 457 visa holders who change positions or employers should be required to transfer to a class/specialization and level of job no lower that that for which they were sponsored….

With respect to the permanent residence program, the ACS called for the General Skilled Migration Program to be substantially reduced until (quoting directly from the ACS press release):

- the market can absorb the level of ICT graduates from Australian universities;
- the intake to ICT courses stops declining and begins to increase;
- the unemployment rate for ICT professionals falls to levels in line with that of all other professionals in Australia.

8.3. Swedish Policy

Sweden is a small, highly internationalized and technologically advanced country in the European Union. Swedish policy in relation to globalization and offshoring should therefore be of considerable interest to other countries.

Although part of the European Union, EU policies do not directly affect Sweden and Swedish offshoring. The Lisbon Agenda, a ten-year plan agreed to in March 2000 by the European heads of state to make the European Union the most competitive knowledge-driven economy, is an important EU manifesto; however, it is primarily directed to the EU member states, where the actual economic and political power in Europe still resides. It should be noted that the European Union is not a federal entity yet and comparatively small resources for action are available at the EU level. Any advancements of importance have to be generated by the individual member states. Therefore, it is necessary to focus on nation-level innovation strategies and their possible combined effects if EU policies of relevance for EU competitiveness are to be understood. Swedish policy is an interesting part of that story.

The Swedish economy and welfare have benefited greatly from a long tradition of free trade which, in fact, was one of the fundamental pillars of the long-term Swedish economic growth that started in the late 19th century and continued into the early 1970s. Part of this successful macro-economic policy was the general agreement in the early 1930s between the central employer and worker associations on the basic principles for setting wages. A key principle in this agreement was related to a common commitment to overall Swedish industrial competitiveness in relatively knowledge-intensive and high-wage industries. From a wage perspective, this was reflected in internationally high and continuously increasing low-wage floors. As a consequence, Swedish industrial competitiveness had to be based on increasing productivity levels through industrial rationalizations that were rapid by international standards. At the same time, Sweden had to reduce the amount of simple production retained domestically (Marklund 2004).

Two sets of important consequences have resulted from the general Swedish industrial macro-economic policy related to industrial dynamics. First, Sweden has experienced high long-term economic growth which made it possible for the country to afford for decades one of the largest public sectors in the world. In relation to its size, Sweden has generated one of the biggest high-tech industries in the world; and it has one of the highest rates of investments in research and development and outputs in terms of scientific publications and patenting. Second, Sweden has become one of the most internationalized economies in the world. Sweden is one of the countries with the highest dependence on foreign trade for its Gross Domestic Product. It has probably experienced one of the most rapid industrial rationalizations in the world of which a considerable part has taken place through offshoring to countries with lower production costs. Sweden also has one of the most internationalized domestic industries in the world in terms of foreign ownership (Marklund 2004).

Thus, Swedish policy has generally been highly free-trade oriented, based on the across-the-political-board faith in the long-term benefits free trade has for growth and employment. This policy has been possible because of ambitious labor market insurances for individuals facing unemployment and regional policy measures for regions facing severe industrial restructuring. On several occasions, specific industrial policy measures have been taken by the Government to support industries with low and decreasing international competitiveness. The three most important examples are the steel, clothing, and marine industries. In the 1970s, considerable industrial support was given to these industries when they faced large-scale failures, with the resulting unemployment and regional effects. These measures all turned out to be futile, and today Sweden does not have any clothing or boat industries worth mentioning, and the mining industry now focuses on specific niches of specialty steel. Another important policy initiative aimed at strengthening the general Swedish industrial competitiveness was taken in the late 1970s when the Swedish currency was depreciated. However, the overall impact of this measure was wage-driven inflation which quite rapidly decreased the cost advantage sought for by the currency depreciation. The effect of the policy initiatives in these three industries on large-scale industrial policy projects has been substantial. Today, all political camps regard both the industrial policy initiatives and the currency depreciation as huge failures and based on the wrong political principles.

As a consequence, Swedish policy has, to a large extent, returned to the basic policy principles on which the long and successful industrial and growth history prior to the 1970s was based. Thus it is not particularly surprising that the Swedish policy attitude towards the current globalization trends is almost completely free from protectionist arguments and direct job-protection arguments. In addition, Sweden has, as have most developed countries, joined the international monetary agreements that rule out monetary policies that are radically different from the rest of the world.

Nevertheless, growing political awareness of the recent trends towards offshoring of knowledge-intensive services and service jobs, including research and development, has rapidly moved up on the political agenda. This has been spurred by Swedish jobless growth, that is, stagnating job creation despite one of Europe's most rapid economic growth rates in the recent five-year period (although the direct relationships to the trend towards increasing service offshoring is unclear and probably far from direct). A growing sense of a trend towards decreasing Swedish technological competitiveness has generated increasing uneasiness within the Swedish policy establishment.

As a consequence of the growing policy concern, a number of initiatives have been taken to improve Swedish competitiveness and counteract the negative impact of offshoring. Although they are all related to a new national innovation strategy advanced in the spring of 2004, the overall policy is not based on explicit political targets. The Swedish policy initiatives combine three fundamental points (Swedish Government 2004).

- Technology development and research and development as the key to Swedish competitiveness.
- Specific industrial-focused investments in large-scale public/private partnerships to achieve centers of excellence in research and development.
- Major institutional restructuring and increased funding of early-stage R&D-based start-ups and R&D-based small and medium-sized enterprise growth.

So far, three industries have been addressed in order to develop high-technology centers of excellence.

- Automotive. This has generated a public/private development program based on a total of one billion Euros in public financing over 10 years, including investments in research and development and infrastructures (Swedish Government 2005).
- Biotech. This is currently under discussion and is based on an analysis and a proposal for a national strategy that has been worked out with commitments from important agents in the Swedish biotech industry. (VINNOVA 2005a)
- Security. This is currently under discussion, based on an analysis and a proposal for a national strategy that has been worked out with commitments from important agents in the Swedish security industry (VINNOVA 2005b).

Industry-related discussions with similar purposes are currently taking place in other important Swedish industries such as telecommunications, steel, and pulp and paper. These discussions may lead to new initiatives with a focus on technological competitiveness (Swedish Government 2004).

The software industry is not a specific focus in the current policy discussions and initiatives. The basic reason is that the major part of Swedish software development and production is primarily embedded in different important manufacturing or service-providing value chains. Sweden does not have a significant independent software industry.

Apart from these initiatives oriented to the long-term and with a focus on the technological competitiveness of key Swedish industries, the government has increased its focus on improving Swedish rates of R&D-based start-ups and growth. As a consequence, there has been a large structural reform of Swedish public support for pre-seed, seed, and growth capital, drawn from a total capital fund of about 200 million Euros. This initiative addresses a widely felt weakness in the Swedish innovation system in terms of generating new firm and small- and medium-sized enterprise-based industrial renewal.

The Swedish policy discussion has been quite general and has not had a particularly strong focus on educational reform. There has been an ambitious drive during the last decade to increase university enrollment and expand doctoral programs, and these efforts have greatly increased the share of young people going to university and then on to doctoral studies. Currently, the debate is focused on how the emerging excess supply of highly-educated people should be employed; and some important voices are arguing for decreasing the education ambitions because of the increasing numbers of highly-educated people who are facing meager job opportunities (Marklund 2004).

8.4. Indian Policy

India has the most rapidly growing offshoring industry, and there have been significant policy issues at the national and state levels that have shaped the climate for this industry. This section considers regulatory policy as it affects foreign direct investment, taxation, building an infrastructure, protecting intellectual policy, data protection and privacy, and education and training policy.

The *regulatory history* is the longest and most detailed of all Indian policies affecting offshoring. When India achieved independence in 1947, it set out to establish a democracy with a socialist economic policy. In the 1950s, 1960s, and early 1970s, much of the economic policy focused on identifying ways for domestic companies to replace imports. An industrial policy reform in 1973 targeted the influence of foreign investors and multinational companies in key Indian industries. The Foreign Exchange Reduction Act of 1973 forced foreign companies to reduce their equity in Indian companies to no more than 40%. In protest, both Coca Cola and IBM left India (in 1978). Due to the lack of domestic capital, little competition, and other reasons, local manufacturing industries were able to grow only modestly in this policy environment during the 1970s and 1980s.

The Microcomputer Policy Act of 1978 permitted companies in many different industries to obtain licenses to manufacture systems that embedded computer hardware. Foreign brand names were not permitted in the products that were developed, and foreign know-how was not permitted except in a few special cases, such as peripherals. Because of the government's fear of job loss through automation, there was no effort to push either the computerization of Indian society or the development of a domestic computer hardware industry.

Government policies in 1984 and 1986 promoted the development of a domestic computer hardware industry. The Computer Policy of 1984 made microcomputers more readily available and encouraged software exports which it regarded as a growth industry. The Software Policy of 1986 identified software as one of India's most promising export fields and allowed import of foreign-built software and software tools.

India was forced to liberalize its economy in 1991 in the face of a balance of payments crisis. The new industrial policy reduced licensing requirements in most industries, allowed foreign companies to hold a majority interest in Indian companies in many industries, provided for automatic approval for hiring foreign technicians and foreign testing of technologies developed in India, and reduced restrictions on the ways in which mergers and acquisitions could take place.

In addition to regulation, *tax policy* had a shaping effect on the Indian software industry. In 1981, the Indian tax code was revised to establish tax-free zones on profits and gains for manufacturers. The law was written broadly enough that it applied to software manufacturing. In 1993, changes in the law broadened the tax-free zones to include Science and Technology Parks which had been established by federal law three years earlier and also to include Electronic Hardware Technology Parks. Under the law, profits and gains from the export of software were exempt from taxes for ten years (and the exemption was subsequently extended). Beginning in 2005, this law was further broadened to include all Indian software export, not just that done from the technology parks

Another policy that shaped the software industry was *infrastructure policy*. Most laws and executive orders that were intended to build a favorable infrastructure for the software industry were set by individual state governments, mostly in the southern part of India. The one infrastructure issue subject to federal governance was telecommunications policy. The Indian telecommunications sector was wholly-owned by the government until 1984 and "was characterized by underinvestment, outdated technology and unfocused growth" (Thakker, 8). A Centre for Development of Telematics was established in 1984 by the government to handle switching and transmissions research. In 1986, two public sector firms were established to promote the introduction and use of new telecommunications technologies. Beginning in 1991, the telecommunications sector experienced a series of deregulations: telecommunications equipment manufacturing (1991), cellular phone service (1992), basic telephone service (1994), Internet service (1998), long-distance telephone service (2000), international long distance and Internet telephony (2002), and broadband service (2004). These changes enabled the Indian software industry to have access to a completely modern telecommunications system with a capacity and cost that enabled the offshoring service companies to be internationally competitive.

The state infrastructure initiatives were taken primarily to make them competitive in recruiting and retaining software companies. These initiatives take a number of different forms. Labor laws were modified to permit women to work night shifts, all employees to work on national holidays, and offshoring companies to operate round the clock all year long. Science and technology parks, made possible by federal regulation, were funded by state governments. They gave companies tax breaks, good facilities (such as uninterrupted electrical power), reduced bureaucracy (such as in filing for permits), and other benefits. Access to good land to build their offices and reductions in land taxes were also common.

There were numerous educational and training reforms. These are discussed in Chapter 7. There were also political actions concerning privacy, data security, and intellectual property protection, which are covered in Chapter 6.

8.5. Chinese Policy

China provides an interesting contrast to India. China is a policy-driven society, and one sees much more significant intervention of the state in the economic development of the software industry in China than in India. The national software strategy in India has been focused on the export service market, while the Chinese are interested in capturing their domestic software product and service markets as well as participating in the export market.

China's economic history plays an important role in understanding what is going on in its software industry. Until the 1980s, there were only local, not national companies in China; few companies operated more than five kilometers from their headquarters. Much of the capital available to businesses was tied in one way or another to the state, and many of the capital decisions were made at the local level. Since then, internal trade barriers have been dropped, and companies have been building scale and moving into neighboring markets. In recent years, the national government has promoted economic reform through competition among provinces and growth for individual companies by providing access to capital through the national stock market. In at least a few industries, notably consumer electronics, there has been intense competition and a desire to play in the international market, and this has driven consolidation so that today, for example, three companies control half the domestic market for personal computers. This shakeout has not yet occurred in the Chinese software industry. As of 2002, there were over 6,000 software firms in China, and only 19 of them had sales exceeding $120 million. The average firm is small, employing only about 25 software developers.

Chinese policy towards forming technologyl capabilities has changed over time. From 1978 to 1985, the focus was on central planning and state control. In the period 1985 to 1991, the focus was on enhancing the innovation system through greater state support for both public and private research and development. Since 1992, the focus has been on enabling market-oriented reforms to improve the quality of research and the skills of the workforce and to broaden the focus on development beyond the defense and heavy technology industries.

One area in which the government has taken a strong hand is the development of trained personnel for the software industry. The Chinese government set a national goal to increase the number of software engineers from the actual number of 250,000 in 2002 to 800,000 by the end of 2005. The Ministry of Education directed all higher education institutions to establish software schools, use international textbooks, and invite experts from China and elsewhere to teach in these programs. As of early 2005, 90% of Chinese universities had established programs in computer science or software engineering. The government has also been attempting to concentrate highly-skilled software talent into particular locales and, to that end, has directed government institutions to facilitate the transfers of skilled software personnel to these places, including providing accommodation for their spouses and children. The Chinese government has also provided incentives for overseas Chinese software workers, especially managers, to return home through such incentives as cash payments, cars, houses, and promotions. One third of the Chinese who went abroad to study since 1980, have returned to China.

Another area of government policy in support of the software industry is support for research and development in universities, research institutes and, to some extent, industry. The best known of these was the Ministry of Science and Technology's High Technology R&D Program, known more commonly as the "863 program" which has provided more than a billion dollars of government funding for basic research since 1986, with an equal amount of matching funding from other sources. However, there have been a series of other programs to provide research support, including the Development Fund on Electronic Information Industry, an R&D Fund on Industrial Technology, and a Technological Innovation Fund. Although the government has continued to support important state research institutes such as the institutes of the Chinese Academy of Sciences, there has been an effort to make them less dependent on the state (smaller state subsidies) and to encourage them to reach out to obtain external funding sources. In fact, the CAS Institute of Software decreased its staff from 500 to 125 in the period 1999 to 2001. The government has changed the research and tenure system, forcibly retiring some older researchers and replacing tenure with renewable five-year contracts for most researchers. The government has also been attracting foreign companies to establish R&D centers in China, and, in some cases, foreign firms are pressured to bring R&D activity to China if they want access to cheap labor.

Another government initiative to develop high technology was the Torch Program which provided over $3 billion between 1988 and 1999. Much of the support went to IT areas. Among other activities, the Torch Program supported the establishment of nineteen software parks around the country that were tied closely to regional development of the software industry.

Research is also being promoted through some large government-sponsored projects to improve the use of information technology in government operations. There are 12 so-called *Golden* projects, including Golden Bridge to build a high-capacity Internet, Golden Card to get millions of Chinese citizens to use electronic funds, and Golden Tax to computerize the tax collection system.

In addition, the government has taken steps to improve the competitive environment for its firms. China does not have a long history of regulating anti-competitive behavior in the technologyl sphere, and it has thus had to pass a series of acts that protect a competitive environment, making illegal certain kinds of behavior such as impugning another company's reputation, bribing, threatening, and dumping. The government has awarded targeted tax reductions to companies that meet certain sales and export figures. Exporting firms have been given favorable terms on bank loans, export insurance, and taxes and duties.

China has one of the world's worst software piracy problems. The Chinese government has taken a series of steps to try to curb piracy. In addition to the general copyright law, China has passed several laws targeted at fighting organized crime that manufactures and distributes copies of pirated software. Government organizations are coordinating anti-piracy campaigns and are being encouraged to be model citizens by not using pirated software themselves. A registry system has been established under which owners who register their copyrighted software are given extra protections under the law. However, software piracy remains a big issue. (There are also concerns about data privacy in China. For more about risks to data privacy and intellectual property through offshoring, see Chapter 6.)

8.6. Conclusion

There is a limited amount that one can conclude from five brief case studies, but some patterns do emerge. Politics is one of the ways (together with education and labor action) that nations have responded to the offshoring phenomenon. The general movement has been to avoid protectionist legislation. Sweden has completely espoused free trade even though it risks some level of unemployment for its IT workers. Australia has not objected directly to offshoring, but it has recently begun to seek restrictions on the use of both temporary and permanent skilled immigrants, positions that are often used by Indian offshoring companies as part of a blended strategy of doing some of the work offshore and some of it on the client's premises. In recent years, India has moved far from its protectionist and isolationist politics of the 1960s and 1970s. At both the state and federal level in the United States, protectionist actions have been suggested, but most of these efforts have not been enacted into law, and there are today many people calling for the United States to enhance its competitiveness (through enhanced innovation) rather than to protect its jobs by legal and economic barriers. Perhaps China is the most protectionist of the countries studied here in terms of trying to protect its emerging domestic IT market from foreign competition.

All of the countries understand that they have to make their national laws conform to some degree with global practices if they want to be players in the global marketplace. Thus China, for example, has been willing to revalue its currency despite the short-term gain from keeping it artificially low; India has eased many of its trade barriers; the United States has entered into numerous international trade agreements; and Sweden has conformed to international monetary policies.

All of the countries we studied recognize that there are certain risks of sending software work across national boundaries. These include questions of intellectual property, privacy, and data security. Europe has taken the lead in strong privacy policy, and India has seen the economic value in meeting European and US standards on privacy. China is not so far advanced in managing these risk issues as India is, but there is every reason to believe it will have to do so, especially concerning intellectual property protection if it wishes to continue to attract international business. (See Chapter 6 for a detailed discussion of these risks.)

For the developed countries that send work offshore, a common political approach is to build new jobs and prosperity through policies that increase innovation. Sweden is increasing government support for research and development, and there are many calls for the United States to do so as part of a future innovation policy. However, the US financing has not been there; with the notable exception of heath and defense-related programs, federal funding for fundamental research in the physical sciences has been flat for some time. The two countries differ on other parts of the innovation platform. Sweden currently has an abundance of highly-educated workers so it is not particularly interested in ramping up its educational system. The United States is facing decreasing numbers of foreign scientists studying and working there as well as declining numbers of American students studying these technical disciplines, so an integral part of the innovation platform for the United States is likely to involve improving the education system and making it more welcoming for foreign workers and students to come to the United States (to the degree this is compatible with national security goals). So far, national security goals have won out.

India and China have a number of similar policies for developing their offshoring industries. Both are interested in ramping up their educational systems to supply an adequate number of skilled workers for their IT companies. Both are concerned about having adequate infrastructures (power, transportation systems, telecommunications) to provide good service to their IT companies. Both have adopted a series of policies intended to attract foreign investment. India is more experienced than China in its government planning for an export software industry, but China is advancing rapidly and has a more centralized government planning model in place.

8.7 Bibliography

Anderson, S. 2003. Creeping Protectionism: An Analysis of State and Federal Global Sourcing Legislation. *The National Foundation for American Policy*. (Dec.) Washington , DC.

Areddy J., King Jr., N., Kessel, M., and Dean, J. 2005. Behind Yuan Move. *Wall Street Journal* (July 25) A1.

Atkinson, R. 2004. Meeting the Offshoring Challenge. *Progressive Policy Institute*, (July).

Australian Computer Society 2005. ACS Calls for Migration Programs to Better Align with ICT Industry Needs. Media Release (April 29).

Bajkowski, J. 2005. Australian IT Visa Data Ignites Controversy. *Computerworld* (Aug. 15).

Bernstein, J. 2004. The Changing Nature of the Economy. *Economic Policy Institute 11* (March).

Brink, L. 2004. Job Losses and Trade: A Reality Check. *Center for Trade Policy Studies, Cato Institute* (March).

Broad, W.J. 2005. Top Advisory Panel Warns of an Erosion of the U.S. Competitive Edge in Science. *New York Times* (Oct. 13) A16.

Brody, W. 2005. The West Has Lost the Will to Fund Basic Research. *Finanacial Times* (Aug. 19) London.

Carafano, J.J., Kane, T., Mitchell, D., AND Nguyen, H. 2004. Protectionism Compromises America's Homeland Security. Backgrounder, 1777. *Heritage Foundation* (July) Washington, DC. (www.heritage.org/research/homelanddefense/bg1777.cfm).

Cerf, V. and Miller, H.N. 2005. America Gasps for Breath in the R&D Marathon. *Wall Street Journal* (July 27) A12.

Committee for Economic Development. 2005. Making Trade Work: Straight Talk on Jobs, Trade, and Adjustment. *The Research and Policy Committee (March)* Washington, DC..

Computer Systems Policy Project. 2004. Choose to Compete: How Innovation, Investment, and Productivity Can Grow U.S. Jobs and Ensure American Competitiveness. *Computer Systems Policy Project*. Washington , DC.

Cooney, M. 2005. States Target Offshoring – Again. *ComputerWorld* (Network World) (Feb. 28).

The Education for Innovation Initiative. 2005. Tapping America's Potential. Distributed by the Business Roundtable, Washington, DC: July.

Diana Farrell, Tarun Khanna, Jayant Sinha, and Jonathan R. Woetzel, "China and India: The Race to Growth" The McKinsey Quarterly, 12 July 2005.

FLORIDA, R. 2004. Creative Class War: How the GOP's Anti-Elitism Could Ruin America's economy. *Washington Month* (Jan./Feb.).

Freeman, P. and Aspray, W. 1999. The Supply of Informatic Technology Workers in the United States. *Computing Research Association*, Washington. DC.

Gotsch, T. 2004. Jobs, Privacy Concerns Spark State Trend Against Sending Call Center Jobs Overseas. *Telecommunications Reports 70,* 3 (Feb.) 25-26.

Graney, P. 2005. Trade Adjustment Assistance for Workers: A Fact Sheet. CRS Report for Congress. *Domestic Social Policy Division, Congressional Research Service*. (Jan.).

Griffiths, P. 2005. Policy Implications of International Graduate Students and PostDoctoral Scholars in the United States. *Committee on Science, Engineering, and Public Policy. National Academy of Sciences.*

GRISWOLD, D.T., AND BUSS, D. D. 2004. Outsourcing Benefits Michigan Economy and Taxpayers. Policy Brief. *Mackinac Center for Public Policy*. Midland, MI. (Sept.).

Halbfinger, D. M. 2005. Pentagon's New Goal: Put Science Into Scripts. *The New York Times* (Aug. 4).

Harsha, P. 2005. Help Requested in Support of Defense Authorization Amendment. Computing Research Policy Blog. *Computing Research Association* (July). http://www.cra.org/govaffairs/blog/archives/000383.html

HAVEMAN, J. D. AND SCHATZ, H. J. 2004. Services Offshoring: Background and Implications for California. *Public Policy Institute of California* (Aug.).

HIRA, R. 2003. Utilizing Immigration Regulations as a Competitive Advantage: An Additional Explanation for India's Success in Exporting Information Technology Services. *Center for Science, Policy, and Outcomes, Columbia University* (March).

HIRA, R., 2004. Offshoring of High Skilled Jobs: Emerging Global IT Business Model. *ACM Job Migration Task Force Meeting* (Dec.) Washington, DC.

HIRA, R. Does India's IT Industry Need Labor Mobility in an Age of Offshore Outsourcing? In T. Thatchenkery and R. Stough*, ICT and Economic Development.* Edward Elgar, Northampton, MA. To appear.

HIRA, R. AND HIRA, A., 2005. *Outsourcing America.* AMACOM, New York, NY.

KALITA, S. M. 2005. As Government Cap on Work Visas Rises, So Does Confusion. *Washington Post* (April 8) E1.

KLETZER, L., 2001. Job Loss from Imports: Measuring the Cost. *Institute for International Economics*, Washington, DC.

Kronstadt, K.A. 2004. India, 2004 National Election. *Congressional Research Service, Library of Congress,* Washington, D.C., CSR 2-3.

Loftus, P. 2004. Lawsuit Seeks Govt Benefits for Laid-Off Software Workers. *Dow Jones Business News* (Jan. 28).

Lundy, K. 2003. Australia v's Offshore –How Can Australia Win? Melbourne, Australia (Oct. 10). www.katelundy.com.au/offshoring.htm.

Mark, R. 2005. Senators Promise 'Brain Drain' Bill. www.internetnews.com/bus-news/print.php/3521851 (July 21).

MARKLUND, G. 2005. World Investment Trends: Summary of UNCTAD World Investment Report 2004 (The Shift Towards Services, 2004). *Swedish Institute for Growth Policy Studies*.

Marklund, G. 2004. The Swedish National Innovation System 1970-2003. *VINNOVA Analysis*. VA 2004:2. Stockholm, Sweden.

Maslog-Levis, K. 2005. ACS Wants ICT Immigration Tightened. *ZDNet Australia* (April 29).

MCCARTER, P. M. 2005. US Government Agency's Approval of Unauthorized Visas Cuts US Jobs. Press Release. *IEEE-USA* (March 18).

McEachern, C. 2005. Technology on the Back Burner? *VARBusiness* (Aug. 5).

Montgomery, G. 2004. Techies on Tenterhooks. Dispatch (Aug.) *apcmag.com.* <http://apcmag.com>.

The Nation. 2004. Toward a Progressive View on Outsourcing. *The Nation* (March 22) 22-26.

National Academy of Science, National Academy of Engineering, and Institute of Medicine 2005. Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future. Report of the Committee on Prospering in the Global Economy of the 21st Century. *National Academies Press,* Washington, DC.

Office of Science and Technology Policy, Executive Office of the President, Response to Union of Concerned Scientists Document. http://www.ostp.gov/html/ucs.html <http://www.ostp.gov/html/ucs.html>. (Accessed Aug. 2005).

PRNewswire Ltd. 2003. Back to the Future as North West Faces Severe Service Sector Jobs Haemorrhage. (Sept. 3).

Puzzanghera, J. 2005. Bush's High-Tech Report Card. *SiliconValley.com* (July 25).

Samuelson, R. 2005. It's Not a Science Gap (Yet). *Washington Post* (Aug. 10) A17.

Saxenian, A. 2003. Government and Guanxi: The Chinese Software Industry in Transition. Global Software from Emerging Markets, *London Busniess School* (May).

SCHWARTZ, E. 2005. Green Card Regulations Encourage Offshoring. *Info World* (March 29).

SPERLING, G. Raising the Tide and Lifting All Boats: Toward a Pro-Growth Progressive Consensus on Globalization. *Progressive Politics 32*, 82-88.

Sternstein, A. 2005. Facing an Innovation Deficit. *Federal Computer Week* (Aug. 18).

Storey, J. R. 2000. IB98023: Trade Adjustment Assistance for Workers: Proposals for Renewal and Reform. CRS Issue Brief for Congress. *Social Policy Division, Congressional Research Service* (Oct. 3).

Swedish Government. 2004. Innovative Sweden – A Strategy for Growth Through Renewal. DS 2004:36. Stockholm. Sweden.

Swedish Governmental Statement 2005 (June 2) related to the proposal in VINNOVA, Produktionsteknik & Fordonstelematik, VINNOVA Policy VP 2005:04. Stockholm, Sweden.

The Task Force on the Future of American Innovation. 2005. The Knowledge Economy: Is the United States Losing its Competitive Edge? (Feb.). http://www.futureofinnovation.org/PDF/Benchmarks.pdf.

Thakker, B. 2005. Globalization of Business Process Services – Analytical Study for India. *The Globalization of Services Conference, Asia_Pacific Area Research Center, Stanford University* (June).

Tschang, T. and Xue, L. 2005. The Chinese Software Industry. In A. Arora and A. Gambardella Eds. *From Underdogs to Tigers*. Oxford University Press, Oxford, UK, 131-167.

Vegso, J. 2005. CS Bachelor's Degree Production Grows in 2004; Poised for Decline. *Computing Research News, 17*, 2 (March). http://www.cra.org/info/taulbee/bachelors.

VINNOVA Swedish Agency for Innovation Systems. 2004. The Swedish National Innovation System 1970-2003: A Quantitative International Benchmarking Analysis.

VINNOVA. 2005a. Strategi för tillväxt – Bioteknik. VINNOVA Policy VP 2005:2. Stockholm, Sweden.

VINNOVA. 2005b. Knowledge for Safeguard Security. VINNOVA Policy VP 2005:3. Stockholm, Sweden.

Walton, J. 2004. WTO: China Enters Year Three. *China Business Review* (Jan.). http://www.chinabusinessreview.com/public/0401/01.html.

Williams, D. 2004. Response to the Australian Computer Society Policies. House of Representatives Alcove, Parliament House. Canberra, Australia (May). <http://www.dcita.gov.au/>.

Wilson, C. 2005a. Congress, Media, and Research Societies Bring National Attention to IT R&D Funding, USACM Weighs In. *ACM Washington Update 9*, 5 (May). http://www.acm.org/usacm/weblog/index.php?p=278.

Wilson, C. 2005b. Congress to Bolster Math and Science. Tech Policy Blog. *USACM* (July 29). http://www.acm.org/usacm/weblog/index.php?p=298.

Worthen, B. 2004. Offshore Regulations: What to Worry At. *CIO Magazine* (June).

Worthen, B. 2005. Why George Bush Needs a Technology Czar. *CIO Magazine* (April).

Wulf, W. 2005. The Importance of Foreign-Born Scientists and Security of the United States. Testimony before the *Subcommittee on Immigration, Committee of the Judiciary, US House of Representatives* (Sept. 15).

Yang, D., Ghauri, P., and Sonmez, M. 2005. Competitive Analysis of the Software Industry in China. *International Journal of Technology Management 29*, 1-2.

Appendix A.

Biographies of Job Migration Task Force Members

Alok Aggrawal
Alok Aggarwal is the Founder and Chairman of Evalueserve—a company that provides various high-value added IT enabled services to North America and Europe. Prior to starting Evalueserve, Dr. Aggarwal was the Director of Emerging Business Opportunities for IBM Research Division Worldwide. In this capacity, his responsibilities included converting business innovations into business models and then take them to market to form profitable business. He has served as program chairperson for a number of conferences, including Symposium on Theory of Computing, Foundations of Computer Science, and Symposium on Computational Geometry. He has also served as a Chairperson of the IEEE Computer Society's Technical Committee on Mathematical Foundations of Computing and on the editorial boards of *SIAM Journal of Computing, Algorithmica*, and *Journal of Symbolic Computation.* Dr. Aggarwal received his B. Tech. from IIT Delhi in 1980 in Electrical Engineering and his Ph.D. from Johns Hopkins University in Electrical Engineering and Computer Science in 1984.

Frances E. Allen
Frances Allen is an IBM Fellow Emerita at the T. J. Watson Research Center in Yorktown Heights, NY. Her technical specialty is compilers for high-performance systems. Prior to retiring in 2002, Allen was a Senior Technical Advisor to the Research Vice President for Solutions, Applications and Services. Earlier she was President of the IBM Academy of Technology, a global organization of IBM technical leaders charged with providing technical advice to the company. Allen has worked in research and product development, taken university sabbaticals at New York University and Stanford, and served on numerous professional boards including the CSTB, CISE, CRA, and ACM. She is a member of the National Academy of Engineering, the American Academy of Arts and Sciences, and the American Philosophical Society. Current focus areas are the history of high-performance compilers and the role of women in computing.

Stephen J. Andriole
Dr. Andriole was the Director of the Cybernetics Technology Office of the Defense Advanced Research Projects Agency (DARPA). He was also the Chief Technology Officer and Senior Vice President of Safeguard Scientifics, Inc. and the Chief Technology Officer and Senior Vice President for Technology Strategy at CIGNA Corporation. Dr. Andriole is currently the Thomas G. LaBrecque Professor of Business Technology at Villanova University, where he teaches and directs applied research in business technology management. He is formerly a Professor of Information Systems & Electrical & Computer Engineering at Drexel University and the George Mason Institute Professor, and Chairman of the Department of Information Systems & Systems Engineering at George Mason University. Some of his books include *Interactive Computer-Based Systems Design and Development* (Petrocelli Books, Inc., 1983), *Microcomputer Decision Support Systems* (QED Information Sciences, Inc., 1985), *Applications in Artificial Intelligence* (Petrocelli Books, Inc., 1986), *Information System Design Principles for the 90s* (AFCEA International Press, 1990), the *Sourcebook of Applied Artificial Intelligence* (McGraw-

Hill, 1992), a (co-authored with Len Adelman) book on user interface technology for Lawrence Erlbaum Associates, Inc. entitled *Cognitive Systems Engineering* (1995) and a book for McGraw-Hill entitled *Managing Systems Requirements: Methods, Tools & Cases* (1996). He has recently published articles in *Software Development*, *IEEE Software*, *Communications of the ACM*, and *the Cutter IT Journal*. His most recent book—*The 2nd Digital Revolution*—was published by IGI Press in 2005.

Ashish Arora
Ashish Arora has a Ph.D. in Economics from Stanford University and is Professor of Economics and Public Policy at Carnegie Mellon University, Pittsburgh. Dr. Arora is also co-director of the Software Industry Center at Carnegie Mellon University. His research focuses on the economics of technological change, the management of technology, intellectual property rights, and technology licensing. In addition to publishing pioneering studies about the Indian software industry, he has published extensively on the economics of patents, technology licensing, the growth and development of biotechnology and the chemical industry, and software quality and security.

William Aspray
William Aspray is the Rudy Professor of Informatics and Special Advisor on Information Technology and Professional Partnerships in the Office of the Vice President for Research at Indiana University in Bloomington. His research focuses on policy and history of information technology. One of his interests is in workforce issues, and in this area he has co-authored four reports: on the IT workforce in the United States (with Peter Freeman), the recruitment and retention of minority graduate students in IT (with Andrew Bernat), the recruitment and retention of women graduate students in IT (with Janice Cuny), and the recruitment and retention of computing faculty (with John Stankovic). Aspray was previously executive director of Computing Research Association. He has also taught at Harvard, Minnesota, Penn, Rutgers, Virginia Tech, and Williams, and held administrative positions at the Charles Babbage Institute and the IEEE.

G. Balatchandirane
G. Balatchandirane teaches East Asian Economic History and Japanese language at the Department of East Asian Studies, University of Delhi, and has worked on the development issues of East Asia and South Asia. He has written mostly on aspects of agriculture, education, and information technology and the way they impinge on development as seen from a comparative perspective. He jointly edited the book *India and East Asia: Learning from each other*. Recently he has contributed to the report on *Development of IT Industries and Regional Innovations in BRICs—The Case of India* for The Asian Institute for Regional Innovation, South Korea; and to the book by Tojo Thatchenkery *et al (e*ds.,) *ICT and Economic Development* (Edward Elgar, 2006). He was a visiting Professor at the Kanazawa University and the Yokohama National University. He has been invited by the Institute of Developing Economies, Japan, to work on gender discrimination in education and its impact on economic development.

Burt S. Barnow
Burt S. Barnow is Associate Director for research and Principal Research Scientist at the Institute for Policy Studies at the Johns Hopkins University. Dr. Barnow has over 30 years of experience conducting research and evaluation studies relating to employment and training programs, labor economics, welfare programs, child support, and responsible fatherhood programs. Dr. Barnow joined the Institute for

Policy Studies in 1992 after working for eight years at the Lewin Group and nine years in the US Department of Labor. He has a B.S. degree in economics from the Massachusetts Institute of Technology and M.S. and Ph.D. degrees in economics from the University of Wisconsin at Madison. Dr. Barnow has published widely in the fields of labor economics, program evaluation, and employment and training. He has co-edited two books published in 2000: *Improving the Odds: Publicly Funded Training in a Changing Labor Market*, co-edited with Christopher T. King and published by the Urban Institute Press; and *The Dynamics of Evaluating Comprehensive Welfare Reform*, co-edited with Robert Moffitt and Thomas Kaplan and published by the Rockefeller Institute Press. Dr. Barnow served as Vice Chairman of the National Academy of Sciences Committee on the Information Technology Work Force and Chairman of the Research Committee of the National Association of Schools of Public Affairs and Administration. He currently is a member of the National Academy of Sciences Board on Higher Education and Workforce, the National Academy of Sciences Committee on the NASA workforce, and the Baltimore Workforce Investment Board Workforce System Effectiveness Committee.

Orna Berry
Orna Berry is a Venture Partner in Gemini Israel Funds Ltd. and the Chairperson of Adamind (LSE: ADA) Ltd. and Prime Sense, Inc. Dr. Berry is a member of EURAB (European Union Research Advisory Board) and the IRAB (Israel National Research Advisory Board). She is a former Chief Scientist of the Ministry of Industry and Trade of the Government of Israel. In this capacity she was responsible for implementing government policy toward industrial research and development and entrepreneurship. During her tenure, the office of the Chief Scientist awarded $450M a year in direct research and development grants in Israeli industry and academia as well as in international programs with the United States, European Union, Canada, United Kingdom, Singapore, and Korea. Dr. Berry is also the co-founder of ORNET Data Communication Technologies Ltd., (acquired by Siemens), and is the former Chief Scientist of Fibronics, Inc. She received B.A. and M.A. degrees in Statistics and Mathematics from Haifa and Tel Aviv Universities and a Ph.D. in Computer Science from the University of Southern California. Dr. Berry has been involved in setting a number of national and international research and development frameworks and is an international expert in the field of science and technology policies.

Michael Blasgen
Michael Blasgen is a consultant in information technology. Most recently he was vice president and head, Computing Technologies Laboratory, at Sony's US Research Laboratory. Prior to Sony, he was director of IBM's Austin Research Laboratory that completed the world's first 1GHz microprocessor. Prior positions include director of RISC Systems at IBM's T. J. Watson Laboratory responsible for the 801 project that led to the introduction of the RISC System/6000, and manager of database systems at IBM's Almaden Laboratory responsible for System R, the first relational database system that led to DB2. Dr. Blasgen holds a Ph.D. in electrical engineering and computer science from the University of California, Berkeley. a B.S. from Harvey Mudd College, and an M.S.E.E from California Institute of Technology. Dr. Blasgen is a Fellow of the ACM and a Fellow of the Institute of Electrical and Electronic Engineering.

Arndt Bode
Arndt Bode is Professor of Informatics of Technische Universität München, Germany. Since 1999 he is Vice President and CIO of Technische Universität München. Dr. Bode's research interests include computer architecture for single processor and

distributed and parallel architectures, tools for parallel systems and parallel applications. Current projects are centered around applications of distributed and parallel computers in the fields of bioinformatics, computational fluid mechanics, medicine, and other application areas. Dr. Bode is head of the Bavarian Competence Network for High Performance Supercomputing KONWIHR at the German Supercomputer installations of Leibniz-Rechenzentrum, Bavarian Academy of Sciences in Munich.

Jean Camp
Jean Camp is an Associate Professor in the School of Informatics, Adjunct Professor of Telecommunications, and Adjunct Professor of Computer Science at Indiana University. She is the author of two books, 16 book chapters, and more than 50 peer-reviewed publications. She is a Senior Member of the IEEE. Her service to the academic community includes two terms as a Director of Computer Professionals for Social Responsibility and two terms as President of the International Financial Cryptography Association. She is a pioneer in the interdisciplinary study of privacy, security, and digital trust.

Seymour E. Goodman
Seymour (Sy) E. Goodman is Professor of International Affairs and Computing at the Sam Nunn School of International Affairs and the College of Computing, Georgia Institute of Technology. He also serves as Co-Director of the Center for International Strategy, Technology, and Policy and Co-Director of the Georgia Tech Information Security Center. Dr. Goodman studies international developments in the information technologies and related public policy issues. In this capacity, he has published over 150 articles and served on many government and industry advisory and study committees. He has been the "International Perspectives" contributing editor for the *Communications of the ACM* for the last 15 years. Immediately before coming to Georgia Tech, Dr. Goodman was the director of the Consortium for Research in Information Security and Policy (CRISP), jointly with the Center for International Security and Cooperation and the School of Engineering, at Stanford University. He has held appointments at the University of Virginia (Applied Mathematics, Computer Science, Soviet and East European Studies), The University of Chicago (Economics), Princeton University (The Woodrow Wilson School of Public and International Affairs, Mathematics), and the University of Arizona (MIS, Middle Eastern Studies). Dr. Goodman was an undergraduate at Columbia University, and obtained his Ph.D. from the California Institute of Technology.

Vijay Gurbaxani
Dr. Vijay Gurbaxani is Associate Dean, Professor of Information Systems, and Director of the Center for Research on IT and Organizations Industry-University Consortium at the Graduate School of Management, University of California at Irvine. His research and teaching and interests focus on the application of economic principles to strategic issues in the information systems context. He is an expert on sourcing strategies for IT services and on the valuation of IT investment. Dr. Gurbaxani received Master's and Ph.D. degrees in Business Administration from the William E. Simon Graduate School of Business Administration, University of Rochester, New York. His doctoral thesis won the prize for the best dissertation in a worldwide competition sponsored by the International Center for Information Technologies. Dr. Gurbaxani received an integrated five-year Master's degree in Mathematics and Computer Science from the Indian Institute of Technology, Bombay. He was awarded the 2002 Outsourcing World Achievement Award in the academic category by PricewaterhouseCoopers and Michael Corbett and Associates.

Juris Hartmanis
Juris Hartmanis is the Walter R. Read Professor of Computer Science and Engineering, Emeritus at Cornell University. He received his Ph.D. from California Institute of Technology in mathematics and after teaching at Cornell and Ohio State University and working at GE Research Lab he returned to Cornell as the founding chair of Cornell's Computer Science Department in 1965. His research interests are focused on computational complexity. Dr. Hartmanis was co-recipient with R.E. Stearns of the 1993 ACM A.M. Turing Award for laying the foundations for computational complexity. He is a member of the National Academy of Engineering, the American Academy for Arts Sciences, and foreign member of the Latvian Academy of Science, as well as Fellow of the ACM and AAAS. In 1992 he was awarded the B. Bolzono Gold medal of the Academy of Science of the Czech Republic and in 1995 the Grand medal of the Latvian Academy of Science. He holds honorary degrees from University of Dortmund and University of Missouri, Kansas City.

Charles House
Charles House is Director of Societal Impact of Technology for Intel Corporation. After 29 years at Hewlett-Packard, he was an officer of Informix, Veritas, and Dialogic corporations, and President of Spectron Microsystems. He is Chairman of Attensity Corporation and TII Networks Corporation (NASDAQ:TIII). He is a past ACM President, IEEE Publications Vice-President, and chair of the Information Section of the Council of Scientific Society Presidents in Washington DC, and General Chair of ACM 1—a major Futures conference about the direction and meaning of computing in society. House has participated since 1975 in setting up and managing R&D facilities in multiple countries, for Hewlett-Packard, Informix, Veritas, and Dialogic corporations—in India, China, and Japan as well as a host of European countries. In 2002, he authored the keynote essay, "Careers in a WWW World", for the annual compendium of the International Association for Human Resources (www.ihrim.org).

William Jack
Mr. William Jack is a Corporate Vice President with SAIC, with almost 50 years experience in the telecommunications industry. He is currently acting as the senior telecommunications advisor to the Chief of IT IS at the National Security Agency. Prior to joining SAIC, Jack retired from AT&T; his last assignment being Director of Special Accounts. In this capacity, he was responsible for AT&T's customer facing organization with the nation's intelligence agencies, as well as the State Department, FEMA, and the White House Communications Agency. He has extensive experience in program management, including numerous classified programs involving state-of-the-art signal processing and encryption. Jack was the AT&T program manager for the design, manufacture, and deployment of the STU III, as well as the transportable communications package used to support the President of the United States while traveling. He has served on numerous high-level classified review committees in the intelligence community and on boards of telecommunications companies. He is the recipient of the National Foreign Intelligence Community Seal Medallion award.

Martin Kenney
Martin Kenney is a Professor in the Department of Human and Community Development at the University of California, Davis and a Senior Project Director at the Berkeley Roundtable on the International Economy. His interests are in the history and development of Silicon Valley and venture capital. Recently, he has studied the globalization of high-technology industries and venture capital and the movement of services to India (with Rafiq Dossani). He edited the book *Locating Global Advantage* (Stanford 2004) *and Understanding Silicon Valley* (Stanford 2000).

He is the author or editor of five books and has published over 100 scholarly articles. He has been an invited visiting professor at Hitotsubashi University, Osaka City University, Kobe University, University of Tokyo, and Copenhagen Business School, and was an Arthur Anderson Distinguished Visitor at Cambridge University.

Stefanie Ann Lenway
Stefanie Lenway is the Dean of the College of Business Administration at the University of Illinois at Chicago, as well as Professor of Management. Previously, Dr. Lenway was the Associate Dean for MBA Programs and General Mills Professor of Strategic Management at the Carlson School of Management of the University of Minnesota. She received her MBA and Ph.D. in Business and Public Policy from the University of California at Berkeley. Her research and consulting interests focus on global technology management and the impact of global thinking on corporate performance. Her most recent book, *Managing New Industry Creation*, co-authored with Tom Murtha and Jeffrey Hart, was published by Stanford University Press in December 2001. The results of this research have been published in major strategic management, international relations, and political economy journals, and discussed in numerous industry, trade, and corporate workshops. Dr. Lenway also co-developed and co-directs the Effective Global Leadership survey program and has consulted with a number of US and European multinational companies that have used the survey to identify organizational and human resource obstacles to global strategy implementation. She held the McKnight Land Grant Professorship at the University of Minnesota from 1988-1992. She is also past Chair of the Social Issues in Management Division of the Academy of Management and past Vice President and 1999 Program Chair of the Academy of International Business. In 2001, she was elected to a three-year term on the Board of Governors of the Academy of Management. In 2002, she became Fellow of the Academy of International Business.

Vivek Mansingh
As a Country Manager for India Development Center of Dell Products Group, Bangalore, Dr. Mansingh spearheads a highly talented team of software professionals in developing Dell's award-winning portfolio of products. Prior to Dell, he was Managing Director of Portal Software's India Development Center. Dr. Mansingh led his team in developing Portal's award-winning portfolio of revenue management software, developing consulting practice, and global technical support. Previously, he was Managing Director of Ishoni Networks in India, where he led the organization in developing extremely innovative broadband technology and products. In the US, Dr. Mansingh was founder and executive vice president of ATTI, a subsidiary of Aavid. Aavid was listed in *Fortune* magazine as one of the 100 fastest-growing companies in the US for 1999. Prior to that, he worked in the Silicon Valley for more than 15 years at Fujitsu and Hewlett Packard, as Director of Marketing & Sales, Senior Scientist, and Member of Technical Staff. He holds six US patents and has published more than 85 technical papers in various scientific and trade publications. He has also authored a chapter in a <u>Handbook of Microelectronics</u>, published by McGraw Hill. Dr. Mansingh is a member of the Board of Governors at the National Institute of Technology, Allahabad, India. He is a Charter Member of TiE, The Indus Entrepreneur, a worldwide entrepreneurial organization headquartered in Silicon Valley. He graduated with a Ph.D. and a M.S. in mechanical engineering from Queen's University, Kingston, Canada, in 1986. He also underwent the Executive Business Management Program for Growing Companies, Stanford University in 1996. Vivek was awarded the Gold Medal for graduating at the top of his class of Mechanical Engineering from Regional Engineering College, Allahabad.

Göran Marklund

Göran Marklund is Science and Technology Attaché at the Swedish Offices of Science and Technology within the Swedish Embassy in Washington DC. He is also guest researcher at the Center for International Science and Technology Policy (CISTP) at George Washington University. He has a Ph.D. in Economic History, with a focus on Swedish innovation policy. In Sweden, Dr. Marklund is head of the Department for Strategy Development and member of the board of directors at VINNOVA, The Government Agency for Innovation Systems. VINNOVA funds industrially relevant R&D with the aim to contribute to economic growth and sustainable development in Sweden. VINNOVA's Department for Strategy Development focuses on foresight, analysis and evaluation of innovation policy programs in order to promote innovation policy priorities and policy learning. His own research has primarily focused on the international competitiveness of the Swedish national innovation system and of different industrial innovation systems in Sweden. A key competence of his is indicators on human resources, R&D, innovation, and economic growth.

Frank Mayadas

Prior to coming to the Sloan Foundation, Frank Mayadas spent 27 years at the IBM Corporation. He was Vice President, Research Division, Technical Plans and Controls from 1991 to 1992; Vice President, Technology and Solutions Development, Application Solutions Line of Business, from 1989 to 1991; General Manager, University of College Systems, IBM Personal Systems Line of Business, from 1988 to 1989; Secretary of IBM's Corporate Management Board and the IBM Management Committee, from 1987 to 1988; and the IBM Management Committee, from 1987 to 1988; and IBM Research Division Vice President and Director, Almaden Research Center, San Jose, California from 1983 to 1987; and an IBM Research Division Director, Technical Planning and Controls, from 1981 to 1983. At Sloan, Dr. Mayadas is involved in a number of areas: online education, globalization of industries, industry studies, and career choice in technical fields. He started the Sloan online learning program in 1993. He shares responsibility for the Sloan industry studies program with Gail Pesyna of Sloan, and is directly responsible for seven Sloan industry centers: the Automobile Industry Center at MIT, the Computer Software Center at CMU, the Internet Marketing Center at Vanderbilt, the Wood Products Industry Center at Virginia Tech, the Apparel Center at Harvard, the Printing industry Center at RIT, and the Metal Forming Center at WPI. Dr. Mayadas received a Ph.D. in Applied Physics from Cornell in 1965, and a B.S. from the Colorado School of Mines in 1961. He has over 40 published papers in Systems, Devices, Solid State Physics, and online learning and holds several patents, and awards from IBM. He is a fellow of the IEEE, a member of the American Physical Society, and a past Director of the Society of Engineering Science.

Peter Mertens

Dr. Peter Mertens, born 1937, is professor for information systems at the University of Erlangen-Nuremberg, Germany, where he is a member of both the business and the engineering schools. He taught at various universities in Germany as well as abroad. Before rejoining the university, he was one of the presidents of a large software and consulting firm. Dr. ens is engaged in IT projects with German firms in several different industries. One of his research areas is offshoring/nearshoring. He wrote and co-authored several books on information systems as well as on SAP's initiatives, some of which have also been published in the US. His books have been translated into Chinese and Italian. He received honorary degrees from four universities in Germany, Austria, and Switzerland, and he is Fellow of the German

Computer Science Society and Honorary Member of the Association of University Professors of Management.

Rob Ramer

Rob Ramer is a senior information security consultant with 25 years in the information technology industry. His experience includes founding an international security company dedicated to risk mitigation for global sourcing. He has worked for Fortune 500 companies and small non-profits and written extensively about outsourcing, international business, and security technology. Born and raised in India he now lives and works in St. Paul, MN.

Bobby Schnabel

Bobby Schnabel is Vice Provost for Academic and Campus Technology at the University of Colorado at Boulder. In this position he serves as chief information officer for CU-Boulder, and as director of the ATLAS (Alliance for Technology, Learning and Society) Institute, a campuswide institute that provides multidisciplinary curricular, research and outreach programs involving the content and tools of information technology. Dr. Schnabel has been a faculty member in the Department of Computer Science since 1977, and has served as department chair, and as associate dean for academic affairs in the College of Engineering. His teaching and research interests are in scientific and high-performance computation. He currently serves as editor-in-chief of *SIAM Review*, on the board of directors of the Computing Research Association, and as chair of the national Information Technology Deans group. He is a co-founder of the National Center for Women and Information Technology.

Bankim Shah

Bankim Shah is the founder and president of BRS Associates, Inc. He brought to BRS his extensive international experience as a senior executive with IBM. During the past 10 years, he has consulted with premier companies in US, Japan, and India in areas ranging from Business and Competitive Strategies and Business Process Reengineering to Outsourcing. His continuing interest in emerging trends and directions has led him to focus more of his work on understanding the impact of these changes on corporations as well as individuals.

Marie Stella

Marie Stella, CISSP, is the lead security engineer for the FAA's National Airspace Communications Effort. On assignment to the Center for Technology and National Security Policy (CTNSP) at the National Defense University from 2003-2004, she led the CTNSP efforts in Information Assurance policy and technical issues as they relate to military transformation and homeland defense. She led a joint effort of developing workshops on Complexity and the Critical Infrastructure between the CTNSP and the Cyber Conflict Studies Association and was the technical editor for a book on Information Assurance Vulnerability. Stella is a member of the NTIA’s Economic Security Working Group and the Department of State's International Outreach program. She also chaired the security workshop efforts for NASA's Integrated Communication, Navigation and Surveillance Conferences from 2002-2004. Prior to coming to the FAA in 1991, Stella served in senior management and technical positions at a variety of companies, including Network Management Inc., Network Strategies, the MITRE Corporation, IBM, and the Port of Authority of New York. She holds an undergraduate degree from CCNY and a Masters in telecommunication engineering from the University of Colorado School of Electrical Engineering.

Valerie E. Taylor
Valerie E. Taylor earned her B.S. in Electrical and Computer Engineering and M.S. in Computer Engineering from Purdue University in 1985 and 1986, respectively, and a Ph.D. in Electrical Engineering and Computer Science from the University of California, Berkeley, in 1991. From 1991-2002, Dr. Taylor was a member of the faculty of in the Electrical and Computer Engineering Department at Northwestern University. Dr. Taylor joined the faculty of Texas A&M University as Head of the Dwight Look College of Engineering's Department of Computer Science and holder of the Royce E. Wisenbaker Professorship II. Her research interests are in the areas of computer architecture and high performance computing, with particular emphasis on mesh partitioning for distributed systems and the performance of parallel and distributed applications. She has authored or co-authored over 80 papers in these areas. Dr. Taylor has received numerous awards for distinguished research and leadership, including the 2002 IEEE Harriet B. Rigas Award for woman with significant contributions in engineering education, the 2002 Outstanding Young Engineering Alumni from the University of California at Berkeley, the 2002 Nico Habermann Award for increasing the diversity in computing, and the 2005 Tapia Achievement Award for Scientific Scholarship, Civic Science, and Diversifying Computing. Dr. Taylor is a member of ACM and Senior Member of IEEE-CS.

Takashi Umezawa
Takashi Umezawa is Professor of Human Resource Management in Kokushikan University, Tokyo, Japan. His research focuses on HRM in the IT industry, especially the software industry. His current interests include the international division of labor in the software industry. He has researched the software industries of India and China, Israel, Ireland, Russia. He has written a report for the Japanese ministry of health and labor about foreign software engineers in Japan (2003). His books are *HRM in Information Service Industry* (2000) and *The Builders of the Japanese Software Industry* (with Ken Uchida, 2001).

Moshe Y. Vardi
Moshe Y. Vardi is the George Professor in Computational Engineering and Director of the Computer and Information Technology Institute at Rice University. He chaired the Computer Science Department at Rice University from January 1994 till June 2002. Prior to joining Rice in 1993, he was at the IBM Almaden Research Center, where he managed the Mathematics and Related Computer Science Department. His research interests include database systems, computational-complexity theory, multi-agent systems, and design specification and verification. Dr. Vardi received his Ph.D. from the Hebrew University of Jerusalem in 1981. He is the author and co-author of over 250 technical papers, as well as a book titled *Reasoning about Knowledge*. Dr. Vardi is the recipient of three IBM Outstanding Innovation Awards and a co-winner of the 2000 Goedel Prize. He is a Fellow of the ACM, the American Association for the Advancement of Science, and the American Association for Artificial Intelligence. He is a member of the US National Academy of Engineering and the European Academy of Sciences.

Roli Varma
Roli Varma is Regents Lecturer and an associate professor in the School of Public Administration at the University of New Mexico. She received her Ph.D. in Science and Technology Studies from Rensselaer Polytechnic Institute in 1993. Dr. Varma's research focuses on the under-representation of women and minorities in science and engineering, new immigrants in science and engineering workforce in the United States, and management of industrial and academic science. Her research is

supported by the grants from the National Science Foundation and the Sloan Foundation.

Richard C. Waters:
Dr. Richard Waters is President and CEO of Mitsubishi Electric Research Laboratories (MERL), leading the 80-person North American research and development operations of Mitsubishi Electric Company. The research at MERL focuses on five areas: computer vision, off-the-desktop interaction and display, digital communications, digital video, and sensor and data systems. Prior to Joining MERL in 1991, Dr. Waters worked for 13 years at the MIT artificial intelligence laboratory as a Research Scientist and co-principal investigator of the Programmer's Apprentice project, which developed semi-automated software engineering tools. Dr. Waters is currently a member of the board of directors of the Computing Research Association.

John White
John R. White is Executive Director and Chief Executive Officer of the Association for Computing Machinery (ACM). Prior to joining ACM, Dr. White was Manager of the Computer Science Laboratory at the Xerox Palo Alto Research Center (PARC) where he managed numerous research projects in electronic document systems and services. Prior to his 17 years at Xerox PARC, Dr. White was a professor of computer science at the University of Connecticut. Dr. White served as ACM President from 1990-92. A Fellow of the ACM, he received the ACM Outstanding Contribution award in 1994, honoring his key volunteer roles. He is also a recipient of a Xerox PARC Excellence in Science and Technology Award and holds a US patent.

Stuart Zweben
Stu Zweben is Associate Dean of Academic Affairs and Administration in the College of Engineering at The Ohio State University. He is a Fellow and former president of ACM, a former member of the Board of Directors of the Computing Research Association (CRA), a Fellow and former president of CSAB, a Fellow of ABET, and a member of the executive committee of the Computing Accreditation Commission of ABET. For the past several years, he has been chair or co-chair of CRA's Surveys Committee, responsible for the annual Taulbee Survey, one of the most widely used instruments in assessing workforce issues within academic computer science programs. Dr. Zweben has served on task forces studying the U.S. IT workforce and the recruitment and retention of computing faculty, and he helped develop an information technology career academy program serving urban high schools in Columbus, OH.

Appendix B.

Selected Abbreviations and Acronyms Used in this Report

ACCR American Chamber of Commerce in Russia

ACM Association for Computing Machinery

ACS Australian Computer Society

BCA Bachelor of Computer Applications (India)

BEA Bureau of Economic Analysis

BIT Bachelor of Information Technology (India)

BITKOM German IT Association

BLS Bureau of Labor Statistics

CAS Chinese Academy of Science

CMMI Capability Maturity Model Integration

CompTIA Computing Technology Industry Association

COTS Commercial Off-the-Shelf Software

CRA Computing Research Association

CSIR Council of Scientific and Industrial Research (India)

DIMIA Department of Immigration, Multicultural and Indigenous Affairs (Australia)

DMCA Digital Millennium Copyright Act

ECTS European Credit Transfer System

EDP Electronic Data Processing

ERM European Restructuring Monitor

EU European Union

EURAB European Union Research Advisory Board

FFIEC Federal Financial Institutions Examiners Council

FSA Financial Services Authority (UK)

GAO Government Accountability Office

GATT General Agreement on Tariffs and Trade

GDP Gross Domestic Product

GNP Gross National Product

H1-B Visa for Foreign Workers with Special Skills to Supplement US Workforce

HIPPA Health Insurance Portability and Accountability Act

IEEE Institute of Electrical and Electronic Engineers

IES Institute for Employment Studies

IIIT Indian Institute of Information Technology

IIM Indian Institute of Management

IISc Indian Institute of Science

IIT Indian Institute of Technology

ISRO Indian Space Research Organization

IT Information Technology

ITAA Information Technology Association of America

ITES Information Technology Enabled Services

ITI Indian Telecom Industries

ITSS Information Technology and Software and Service Industry

IRAB Israel National Research Advisory Board

JISA Japanese Information Service Association

L-1 Visa for Intra-company Transfer of Workers

MCA Masters in Computer Application (India)

MLS Mass Layoff Statistics

NASSCOM National Association of Software and Services Companies (India)

NBER National Bureau of Economic Research

NCW Network-centric Warfare

NSB National Science Board

NSF National Science Foundation

ODC Offshore Development Center

OECD Organization for Economic Cooperation and Development

PPP Purchasing Power Parity

PPP GDP Purchasing Power Parity Gross Domestic Product

SCADA Supervisory Control and Data Acquisitions Systems

SEI Software Engineering Institute

STPI Software Technology Parks of India

TAA US Trade Adjustment Assistance Act

UGC University Grants Commission (India)

URI Universities and Research Institutions

USCIS United States Citizenship and Immigration Service

VoIP Voice over Internet Telephony

VPN Virtual Private Network

WTO World Trade Organization