Innovation Policy and the Economy

Volume 5

National Bureau of Economic Research

edited by Adam B. Jaffe, Josh Lerner, and Scott Stern

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8. Unless otherwise determined by the Board or exempted by the terms of paragraphs 6 and 7, a copy of this resolution shall be printed in each NBER publication as described in paragraph 2 above.

Introduction

This volume is the fifth publication of the National Bureau of Economic Research (NBER) Innovation Policy and the Economy (IPE) group. The appreciation of the importance of innovation to the economy has increased over the past decade. At the same time, an active debate surrounds the implications of rapid technological change for economic policy, and the appropriate policies and programs regarding research, innovation, and the commercialization of new technology. This debate has only intensified with the economic and security challenges that our nation has recently faced.

The IPE group seeks to provide an accessible forum to bring the work of leading academic researchers to an audience of policy makers and those interested in the interaction between public policy and innovation. Our goals are:

- To provide an ongoing forum for the presentation of research on the impact of public policy on the innovative process.
- To stimulate such research by exposing potentially interested researchers to the issues that policy makers consider important.
- To increase the awareness of policy makers (and the public policy community more generally) concerning contemporary research in economics and the other social sciences that usefully informs the evaluation of current or prospective proposals relating to innovation policy.

This volume contains the papers presented at the group's meeting in Washington, D.C., in April 2004.

The first paper of this year's volume evaluates the implications of the rise of internationally competitive software sectors in a small but growing number of non-G7 countries. During the 1990s, India, Ireland, and Israel (the 3Is), as well as China and Brazil, experienced extraordinarily

rapid growth in their software industries (with growth rates ranging from 20 to 40 percent). Across these countries, more than 500,000 workers are employed in the software sector, and the industry now plays a role in these nations' export composition and aggregate economic growth. Ashish Arora and Alfonso Gambardella address the origins and impact of the globalization of the software industry. They pay particular attention to the implications for future U.S. technology leadership. First, they examine the conditions that allowed the countries within their study to experience sustained growth. On one hand, each country has been able to draw on a large population of highly skilled but underemployed workers and has served as an important source of technically trained immigrants to the United States. However, substantial variation exists in the importance of exports and the role played by multinational firms. For those countries with a substantial export orientation, the overwhelming majority of work is focused on relatively low-level programming rather than high-end design work.

This analysis holds several policy implications. First, and perhaps most important, Arora and Gambardella conclude that continued globalization of the software industry offers significant benefits for the United States. U.S. technological leadership rests in part on the continued position of the United States as the primary destination for highly trained and skilled scientists and engineers, and fears about the potential loss of technological leadership through outsourcing are likely overblown. In the vast majority of cases, software exports from countries such as India are far from the technological frontier. For developing economies, it is important to emphasize that the software industry has depended on the availability of a well-trained technical workforce, a low level of investment in physical capital, and a policy of openness to international trade. Beyond a set of direct benefits such as employment growth, the most important impact of these success stories is to provide a model for technology entrepreneurship in other industrial sectors.

The second paper considers the proper training for would-be entrepreneurs. William J. Baumol begins with the observation that innovations emerge from two sources in our economy: large corporations and entrepreneurs. These two activities are complements, not substitutes. Entrepreneurs tend to provide the more heterodox, breakthrough innovations, while the research and development (R&D) establishments of the larger firms create the enhancements to those breakthroughs that

contribute considerably to their usefulness. While routine innovations are of great and probably of growing importance, the entrepreneurial independent innovator in his or her small-business enterprise continues to play a critical role. Revolutionary breakthroughs continue to be provided to a considerable degree by small enterprises that can avoid the conservative propensities of the giant firm.

The education that is best adapted to the requirements of one of these activities is markedly different from that most suitable for the other. Baumol argues that many of the features of the U.S. educational system can serve to stimulate the formation of innovative new firms and to encourage their more radical innovative contributions. The American educational system seems to be less rigid and demanding than those in the other industrialized countries, thereby enabling it to serve more effectively the needs of entrepreneurs. Baumol suggests the need for more attention to this issue so that educational procedures can better prepare students for entrepreneurial careers.

The third paper presents a framework for evaluating the growth strategies of different cities. Maryann Feldman and Roger Martin proceed from the observation that the growth and competitive advantage of individual firms depends on the strengths and resources of the local economic environment, and that the role of location often cannot be understood by evaluating policy at the level of individual countries. Instead, to evaluate strategies whose aim is to reinforce and enhance the value of location-specific resources, the appropriate unit of analysis is most often a city or a metropolitan area. Feldman and Martin argue that cities may benefit from a strategic orientation that seeks to exploit those resources and attributes that are both unique and not easily replicated. To maximize wage and property values, cities should seek to establish and maintain what they call jurisdictional advantage. Drawing from a well-developed literature in firm strategy, their analysis focuses on how the potential for jurisdictional advantage varies across different environments and on the implications of this variation for city-level policy and planning. Their analysis highlights the different roles to be played by firms and governments in the process of identifying and establishing jurisdictional advantage and the importance of translating strategy into action despite substantial implementation challenges.

The fourth paper considers another lever for governments to use in promoting growth: taxes. William M. Gentry and R. Glenn Hubbard seek to understand the extent to which tax policy encourages or discourages entry. They find that the level of the marginal tax rate has a

negative effect on entrepreneurial entry and so does the progressivity of the tax. These effects are principally traceable to the upside effect: if entrepreneurs are successful, they are likely to find their marginal tax rates also increasing. In supplemental analyses, the authors emphasize the importance of taxes on entrepreneurship. First, the effects are large. The Omnibus Budget Reconciliation Act of 1993, which raised the top marginal individual income tax rate (and thus the progressivity of the tax schedule), is estimated to have reduced the probability of entry into self-employment for upper-middle-income households by as much as 20 percent. Second, the effects are economywide, not just confined to traditional manufacturing or service industries. Gentry and Hubbard show that prospective entrants from innovative industries and occupations are no less affected by the considerations they examine than other prospective entrants.

In the fifth paper, Michael L. Katz and Howard A. Shelanski offer an integrated assessment of the interplay between innovation and merger policy. Merger review, the single most active component of antitrust enforcement in the United States, has traditionally focused on whether a proposed transaction would lead to higher or lower prices, based on a static analysis that compared market power and efficiency effects. However, an increasing number of cases focus on environments where an assessment of the role of innovation is crucial for evaluating the impact of the merger proposal on welfare. Katz and Shelanski highlight two ways in which the potential for innovation may warrant a reconsideration of appropriate antitrust policy. First, when market structure influences innovation incentives, the rate and direction of innovation may itself be a crucial dimension of market performance. Merging parties frequently assert that the transaction will allow them to engage in greater innovation, while antitrust enforcers may object to a transaction on the grounds that it will lead to a loss of competition that would otherwise spur innovation. If mergers can have a substantial (positive or negative) impact on the rate of innovation, an important issue for antitrust enforcement agencies is how to incorporate innovation concerns into their mission and evidentiary methodologies. Second, innovation can dramatically affect the relationship between the pre-merger marketplace and what is likely to happen if the proposed merger is consummated. For example, static market shares are often used as a measure of market power. However, significant innovation may lead to the rapid displacement of a supplier that, by traditional measures, appears to be dominant. When innovation is central to competitive

dynamics, effective merger analysis must account for the potential of innovation in forming predictions about the likely competitive effects of a proposed transaction.

These concerns have led some observers to call for fundamental reforms in antitrust policy, such as a laissez-faire approach to mergers in markets subject to a high rate of technological innovation. Katz and Shelanski focus on a less radical approach, arguing that innovation can be incorporated into traditional merger analysis by expanding the set of tools used in antitrust investigations. Accounting for innovation in merger analysis requires reduced reliance on systematic presumptions about the impact of static market shares on price and welfare. Instead, antitrust enforcement agencies can expand the scope of their expertise and undertake factual inquiries that are specific to the circumstances of a given merger proposal.

While the issues involved are undoubtedly difficult, the papers in this fifth volume highlight the role that economic theory and empirical analysis can play in evaluating key policies affecting innovation. They suggest that contemporary research in economics can inform the evaluation of current and prospective innovation policy alternatives.

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1

The Globalization of the Software Industry: Perspectives and Opportunities for Developed and Developing Countries

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Executive Summary

The spectacular growth of the software industry in some non-G7 economies has aroused both interest and concern. This paper addresses two sets of interrelated issues. First, we explore the determinants of success in software in emerging economies. We then touch on the broader issue of the lessons, if any, that can be applied to economic development more generally.

From the U.S. perspective, we think that the interesting debate is not the current one about the impact of outsourcing on jobs, but instead the one about whether offshoring of software is a long-term threat to American technological leadership. We conclude that policymakers in the United States should not fear the growth of new software-producing regions. Instead, the U.S. economy will broadly benefit from their growth. U.S. technological leadership rests in part on the continued position of the United States as the primary destination for highly trained and skilled scientists and engineers from the world over. Though this leadership position is likely to persist for some time, the increasing attractiveness of foreign emerging-economy destinations is a long-term concern for continued U.S. technological leadership.

I. Introduction

One rather unexpected phenomenon of the 1990s has been the spectacular growth of the software industry in some non-G7 economies. The first element of surprise is that these countries are not where one would expect to see the growth of what is commonly thought of as a high-tech industry. The second element is that the 1990s have shown not just growth of the industry but remarkable growth. In India, for example, software production was almost nonexistent in the early 1980s. Today, the software industry employs more than 250,000 employees, sustaining annual growth rates of 30 to 40 percent in revenues and employment over more than ten years. Although less remarkable than

India, countries like Ireland and Israel have also had double-digit growth.

This paper addresses two sets of interrelated issues. First, we explore the determinants of these successful stories. We then touch on the broader issue of the lessons, if any, that can be learned for economic development more generally. Second, the Indian, Irish, and Israeli software industries export a substantial fraction of their output (and services) to advanced economies—particularly the United States. A heated debate exists in the United States regarding the desirability of outsourcing, and the debate follows the familiar free trade versus jobs line. Rather than join this debate, we prefer to focus on a related one that is arguably of greater long-term significance. We ask specifically whether the growth of the software industry in emerging economies is beneficial for the United States, and what that growth means for the technological leadership of the United States in the long term.

In the next section, we discuss the growth of the software industry in five newcomer regions—India, Ireland, Israel, Brazil, and China. This discussion is based on the results of a two-year international project that led to our forthcoming volume (Arora and Gambardella 2005). The five comparisons provide an interesting basis for our discussion because the growth of India, Ireland, and Israel has been fueled by exports, but China and Brazil have grown largely thanks to their domestic market. From the evidence collected for these countries, we then discuss in Section III some of the reasons why they have been successful in software. In Section IV, we discuss some of the implications of this growing international division of labor for the U.S. economy. Section V takes the Indian point of view. One effect in particular must be assessed more carefully: the large outflow of human capital from India. We discuss the pros and cons of these flows for both India and the United States. Section VI discusses whether the patterns in the growth of software in our five countries can provide lessons for other emerging economies, in software or in the information technology (IT) industries more generally. Section VII summarizes some of the policy implications of our analysis; Section VIII concludes by providing some broad considerations on the topic.

II. The Software Industry in Brazil, China, India, Ireland, and Israel

During the 1990s, India, Ireland, and Israel emerged as significant software exporters. In the same period, Brazil and China also developed

Table 1.1
The software industry in Brazil, China, India, Ireland, and Israel compared to the United States, Japan, and Germany (2002 or latest available figures)

Countries	Sales ($ billion)	Employment (000)	Sales/employment (000)	Software sales/GDP (%)	Software development index[c]
Brazil[a]	7.7	160[b]	45.5[b]	1.5	0.22
China	13.3	190[b]	37.6[b]	1.1	0.23
India	12.5	250	50.0	2.5	0.96
Ireland (MNE)	12.3	15.3	803.9	10.1	0.34
Ireland (Domestic)	1.6	12.6	127.0	1.3	0.04
Israel[a]	4.1	15	273.3	3.7	0.17
United States	200	1,024	195.3	2.0	0.05
Japan[b]	85	534	159.2	2.0	0.08
Germany[a]	39.8	300	132.7	2.2	0.09

Data compiled from various sources.
[a] 2001.
[b] 2000.
[c] The software development index is the ratio between software sales over GDP (in %) and the GDP per capita of the country (in 000 $US) (See also Botelho et al. 2005.)

an extensive software sector relying largely on the domestic market and are now attempting to move to exports.[1] Table 1.1 shows that in 2002, the Indian and Chinese industries were of comparable size ($12.5 and $13.3 billion, respectively), while the 2001 sales of Brazil and Israel were $7.7 and $4.1 billion, respectively. The Irish industry reached $13.9 billion in total sales in 2002, of which $12.3 billion is attributed to multinational companies (MNCs) and $1.6 billion to the indigenous sector.[2]

The employment differences among our five countries are more marked than those in sales. In March 2003, the Indian software industry employed about 250,000 people.[3] The 2000 figures for China and Brazil are about 160,000 and 190,000, respectively. As noted, 2002 employment in the Irish software industry was about 28,000 (15,300 and 12,600, respectively, for MNCs and indigenous firms), while 2001 employment in the Israeli industry was about 15,000. To put these figures in perspective, employment in the U.S. software industry was slightly above 1 million, with sales of around $200 billion; the comparable figures for Japan were 534,000 and $85 billion.[4] Germany, the third largest software producer, employed around 300,000 and had sales around $40 billion.[5] The sales and employment figures produce

notable differences in the sales per employee, with Israel having the highest sales per employee, followed by Ireland, whose figures are only slightly lower than the figures for Germany. The revenue per employee of the Indian industry in 2002 was about $50,000, which is comparable to figures for China and Brazil.

The picture that emerges from these figures is consistent with the stylized facts. The Israeli software industry is largely product- and research-and-development-oriented. The software industry in Brazil, China, and India is of a lower value added; it is heavily service-oriented in India. Ireland is in between, with a handful of product-oriented firms, and several small consultancies and niche firms.

Table 1.1 also shows that in Brazil and China, software sales are between 1 and 1.5 percent of gross domestic product (GDP), only slightly smaller than the corresponding figures for richer countries such as the United States, Japan, and Germany.[6] The software share of GDP is higher in Israel (3.7 percent) and India (2.5 percent). The shares for India and China have also increased substantially in recent years, while they have remained more stable for the other countries. In 2001, the GDP share of software was only 0.6 percent in China and 1.7 percent in India. Thus, in these two economies, software has continued to grow faster than GDP in 2001–2002, despite the general slowdown in the IT sector worldwide. In all five countries, software ranks high when compared to their overall level of development, as measured by the ratio between the software share of GDP and the GDP per capita (Botelho et al. 2005). In all five emerging countries, these ratios are far higher than those in the United States, Germany, and Japan, suggesting a specialization in software. The level of the index is particularly impressive for India (about ten to twenty times higher than the levels in the United States, Japan, and Germany).

But the most impressive figures about the software industry in these emerging economies are their growth rates, which have ranged as high as 40 percent per year in the Indian case (table 1.2, column 2). The number of firms has also grown. In India, the membership of National Association of Software and Service Companies (NASSCOM) increased from around 100 in 1990 to 797 in 2000 (Athreye 2005). Similarly, the number of new Irish software firms increased from less than 300 in 1991 to 760 in 2000 (Sands 2005). Botelho et al. (2005) report that out of a sample of 685 Brazilian software firms in existence in 2001, a little less than one-third (210) were founded between 1996 and 2000, and a slightly larger fraction (221) were founded between 1991 and 1995.[7]