# 2 *Globalization of R&D*

## Offshoring innovative activity to emerging economies

ASHOK BARDHAN AND DWIGHT JAFFEE
University of California at Berkeley

## Introduction

Recent years have seen a major debate in academia, the media, and policy circles on the impact of the phenomenon of offshoring on the US economy.[1] The relatively sluggish job creation numbers have been blamed on offshoring, among other factors. Varying estimates of job migration and potential future job losses have been developed, and supporters have lined up on both sides of the issue, debating the pros and cons of offshoring for the US economy (for an early account of the impact of offshoring on jobs, see Bardhan and Kroll [2003]).

Broadly speaking, there are two schools of thought regarding the magnitude and potential impact of offshoring. The votaries of a major and continuing job loss note that the confluence of the five factors that gave rise to the phenomenon – (1) globalization, (2) free markets, (3) information and communications technology, (4) wage differentials, and (5) the large numbers of college students graduating annually in developing countries – show no signs of abating. They also claim there are no signs of any new, emerging sectors or occupations that will take up the slack, as the US software sector did during the 1990s when manufacturing jobs continued to decline. The case for minor impact is based on the fact that the magnitude of job loss attributable to offshoring has been minor so far. Supporters of this view claim that the US economy is robust and dynamic enough to replace the jobs lost, and that China, India, and other countries have severe constraints in terms of how many more offshoring related jobs those economies could create, absorb, and sustain. Moreover, they claim, a significant share of the jobs being lost to offshoring currently are low-paying, service sector jobs, such as in call centers, and the key long-run challenge facing the US economy is the creation of high value-added, high-paying jobs.

Both camps are largely in agreement on the importance of continued innovation as the primary way to create high-paying new jobs in the country. The innovative dynamism of the US economy, the creation of new goods, new services, new value, and the temporary global monopoly that comes with them as well as the spillover effects that these innovations have on productivity in other sectors of the economy, have played a large part in the creation of high-paying jobs. It is one of the key lessons from the economic history of the United States going back to the era of rapid industrialization in the late nineteenth century. This has been true from the time of the automobile revolution to the world of the Internet. This realization has prompted entrepreneurs, economists, venture capital firms and policy makers to look for the coming of the NBT (next big thing) – the next major technological breakthrough that will create new high-paying jobs in the US. While the pessimists fret that there is no "Next Big Thing" on the immediate horizon, the optimists are firm in their belief that continued innovation and creation of entire new sectors of the economy will more than compensate for the ongoing white collar job losses, as was the case during the wave of manufacturing offshoring during the early 1990s in the aftermath of the recession. The industrialized countries, as well as developing countries, would benefit from this win-win scenario.

The evidence that R&D itself is being offshored is therefore met with particular concern, and in this context worries have been expressed in western economies about (a) the growth of innovation clusters and evolving critical masses of engineers and scientists in parts of India, China, Russia, and other countries, and (b) the movement of offshoring activity further up the value chain, encompassing research, design and development operations in manufacturing and services.

What are the economic and business management implications of R&D offshoring? Is a significant amount of R&D activity being offshored? And if the volumes are sizeable, does that imply that future innovations would originate in other countries and also that the economic benefits would disproportionately accrue to other nations? These are some of the questions discussed here. The chapter is organized in the following manner: the next section describes the evolution of R&D carried out by firms in the US, starting with in-house R&D operations, and the reasons that have led to the offshoring of R&D activity, as well as the global conditions that have facilitated this phenomenon. This is followed by an examination of the macroeconomic state of R&D in the US, including R&D expenditures, R&D employment, patent generation, and their impact on the economy.[2] Next, we describe the results of our ongoing firm survey that deals with questions dealing with characteristics of firms which resort to offshoring of R&D. We then look at the analysis of the management challenges faced by R&D affiliates in emerging economies and the organizational evolution of global corporate R&D. Finally, we give our concluding remarks and analyze the implications for US innovation, the economy, and job creation.

## Global corporate R&D

### *From the domestic proprietary model to offshoring*

Mowery (1990) points out that the nature of the innovation process led to the early development of industrial research as an in-house or intra-firm activity. Corporate research and development departments and organizations first started appearing in the late nineteenth, early twentieth century in the United States. The in-house R&D unit was an organizational innovation that institutionalized invention-related activity, separating it from production-related processes, and connecting inventions to the marketplace under the auspices of a single firm. Through specialization, economies of scale and scope, and by internalizing the invention process, firms were able to make inventive activity more efficient and to ensure high returns. Increasingly savvy consumers, burgeoning competition, as well as rapid globalization, initially in the period up to WWI and then later, after WWII, placed heavy demands on firms to continuously introduce new products and services. The dynamic requirements of R&D and its commercialization therefore were such that the large teams of scientists and engineers needed were more effectively housed within the organizational structure of the firm.

The model of the proprietary, internal, domestically based industrial laboratory is, however, changing for a number of reasons, foremost among them being the increasingly global nature of sales of large firms. As firms expanded into hitherto untapped markets around the world, they experienced the need to design their products in consonance with local tastes, leading to the strategy to "design and research to market," in addition to the earlier policy of "produce to market." The rapid expansion into new markets with different product cultures is now putting a severe strain on the R&D resources and capabilities of individual firms. Moreover, the complex organization and increasingly interdisciplinary nature of most research projects calls for the simultaneous services of researchers from many diverse disciplines, such as statistics, computer science, genetics, nanotechnology, and so forth. It is not always feasible to hire all these specialists on a permanent basis, when the need for their services is sporadic, and depends on specific projects. The experience accumulated in the offshoring of manufacturing and service activity has served to open the door to exploring the offshoring of R&D. Other factors behind R&D globalization include the need for a shorter R&D cycle from conception to implementation, the need to ramp up efficiency and effectiveness levels of R&D activity, and the need to access R&D talent in different scientific-cultural climes leading to different technical solutions. The widely heard theme in business literature today about returning to the core competence of firms has been interpreted by some firms in the context of R&D activity as well. Since the offshoring/outsourcing option as a lumpy cost-cutting procedure is exercised particularly during times of distress and downturns (see Bardhan and Howe, 2001), the combination of an economic downturn, problematic returns to R&D and increasing competition can create fertile grounds for the "push factors" needed for divesting R&D operations by firms in the US.

### *Changing global environment, availability of skilled labor and R&D offshoring*

The political, technological, and economic changes that have taken place in the last two decades have given rise to the preconditions necessary for offshoring in general and R&D offshoring in particular. Serendipitously, the liberalization of state controls and opening up of Russia, China, and India to trade and investment flows has occurred at a time when the technological wherewithal for offshoring, in the form of the Internet, was being put in place. The arms race during the Cold War, and the belief in science and technology as a primary tool of economic development led the former Soviet state to invest heavily in the creation of specialized research institutes and centers. These research establishments were usually geographically concentrated, thus forming major scientific agglomerations in certain urban areas employing large numbers of scientists and engineers. The end of the Cold War and the disintegration of the USSR displaced many highly trained scientists, engineers, and technicians from their work in the scientific-research and military-industrial establishment, who now constitute a significant pool of global R&D labor (see Bardhan and Kroll, 2006).

The skilled labor potential of China and India is also becoming well known. Playing to Indian strengths in engineering and a wide range of basic science research, there is an ongoing transfer of R&D activity to India, particularly in the areas of software, biotech and pharmaceuticals, engineering design and development, and animation and simulation, as well as basic research activity in the physical sciences. High-tech clusters are appearing rapidly, in and around the major and even secondary metropolitan areas of India. While the premier institutions of higher education in engineering and sciences in India are justly famous, there is a growing second tier of institutes that actually produce a larger number of graduates, and in the long run may have a greater impact. The large network of public sector scientific institutes and laboratories, some of them affiliated to the defense establishment, has been instrumental in creating a solid base of science and technology in the country.

In the case of China, the institutional umbrella of a science and technology park is one innovation model being tested. A network of laboratories, research institutes, universities, and firms, the Zhongguancun-Haidian Science Park, based in Beijing, is touted as China's answer to Silicon Valley. The establishments here include fifty-six universities, including two of China's leading institutions of higher learning, Beijing University and Tsinghua University, as well as 232 research institutes of various kinds led by the Chinese Academy of Sciences. A fifth of the firms located at Haidian are wholly foreign-owned or joint ventures, and constitute a veritable "who's who" of the US high-tech industry. The official website claims that nearly 90 percent of the firms are involved in research, development, production, and marketing in cutting-edge fields, such as new materials, electronics, and energy. Around 38 percent are state-affiliated in some form or other. Walsh (2003) points out that while the absolute number of R&D centers or facilities in the PRC is not known; recent Chinese news articles put the number at anywhere between 120 and nearly 400 foreign-owned or jointly owned R&D centers spread throughout the PRC.

## *Pace of offshoring of R&D*

Offshoring of R&D activity in sectors ranging from pharmaceuticals and biotechnology to computer hardware and software is on the rise, particularly from the US. Intel, for example, has labs carrying out advanced microprocessor design work in Novosibirsk and St. Petersburg in Russia, after having bought Elbrus, a leading Russian computer technology research center and boosting its Russian research staff to over 1,500. Intel also has a high-tech development center in Bangalore, India, working on digital signal processing, device drivers, and process and chipset design, and a major facility in Beijing, the Intel China Research Center for the development of next-generation networking and wireless platform solutions. According to the Indian National Association of Software and Service Companies (Nasscom), the total market size of this so-called knowledge process outsourcing (KPO) business in India was around $1.5 billion in 2006, and is expected to increase substantially. Original equipment manufacturers to whom value-added resellers would offshore *component* manufacturing, are giving way to original *design* manufacturers in the Asia-Pacific region. The latter design, engineer, and manufacture products from the ground up with little input from their clients, whose major role often is to contribute the brand name.

## A macro-look at the present state of R&D in the US

We now look at some macroeconomic indicators, including R&D expenditures, patent generation, and productivity growth, which portray the economy-wide context of R&D offshoring. In terms of gross spending on R&D, US expenditures have been quite robust. Figure 2.1 shows the gross expenditures on R&D for selected countries as a share of the economy. Japan is at the top of the list of most R&D intensive economies, with the US a close second. The figure also points to China's rapid rise, with the country having doubled its R&D expenditures as a proportion of its GDP over the last decade. There has been corresponding robust growth in both employment and in wages of R&D occupations. Figure 2.2 shows our estimates of the R&D employment as a share of total employment in the US. During the post-2000 period, the average weighted nominal wage for these thirty-seven R&D occupations has increased by around 17 percent, marginally

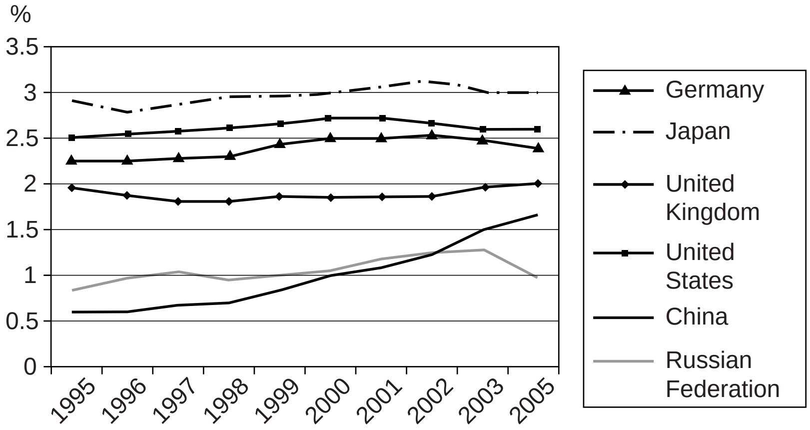


**Figure 2.1.** Gross expenditures on R&D as a percentage of GDP.
*Source:* OECD.

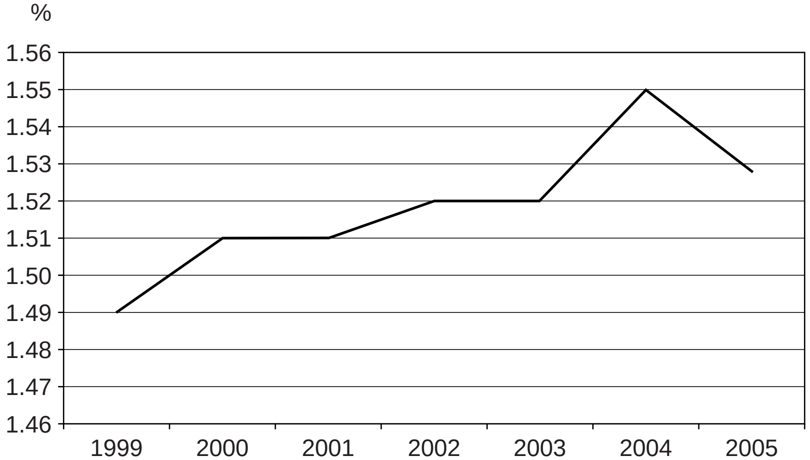


**Figure 2.2.** R&D employment share in total employment in the US.
*Source:* Estimates by authors from BLS occupational data.

higher than the nominal 15 percent increase for all occupations as a whole.

The "nominal output" of the R&D sector, as measured by its patent production, has also been healthy. OECD developed triadic patent family registrations (received by entities and individuals based in the

US, Japan, and the European Union)[3] show the US share has been relatively steady, amounting to about a third of all patent registrations.

The economic impact of a nation's R&D establishment and its inventive capacity are ultimately measured not by patents, which are after all an intermediate step on the way to economic appropriation, but by productivity growth, which determines the standard of living, as well as by measures of global market share of new goods and technologies, and creation of new, high-paying jobs. In brief, technology helps us do something better or it helps us do something new. In order to get a sense of the economic impact of R&D and innovative activity we need to look both at (a) variables that directly reflect technological prowess inherent in doing something better, such as productivity growth, as well as those (b) where "newness," a greater variety of goods, higher quality, etc., can be proxied by some "revealed" variables, such as exports and global market share of high-tech goods. While lagging behind European countries in the post-war decades, US productivity growth has picked up significantly in the post-1995 period and averages over 2.5 percent per year during the last decade. Over the quarter century 1980–2005, the US global market share in key technologies such as pharmaceuticals has remained steady in the 30 percent range; in aerospace it has declined somewhat but is still about 50 percent; in communications equipment it declined in the 1990s but has again increased to around 35 percent; and in computing and office machinery it has declined from 40 percent in the mid-1980s to 24 percent due to offshoring and the "China effect."

A summary reading of productivity growth and global high-tech shares may therefore suggest that all is well with the state of R&D, but other factors point to a more complex picture. How effective is all this R&D spending? How much bang is the economy getting for the R&D buck? It is not entirely clear that the economy is reaping benefits commensurate with the huge amount of spending associated with R&D. The number of patents granted by the US Patent and Trademark Office over the period 1985 onward has been growing at approximately twice the rate of the economy. As pointed out by Randall Stross in *The New York Times* (July 31, 2005), the changed intellectual property environment has led software firms, for example, to file more patents than they did in the earlier copyright era. Firms these days apparently target the number of patents that they wish to file relative to their R&D spending. One can also gain a sense of the

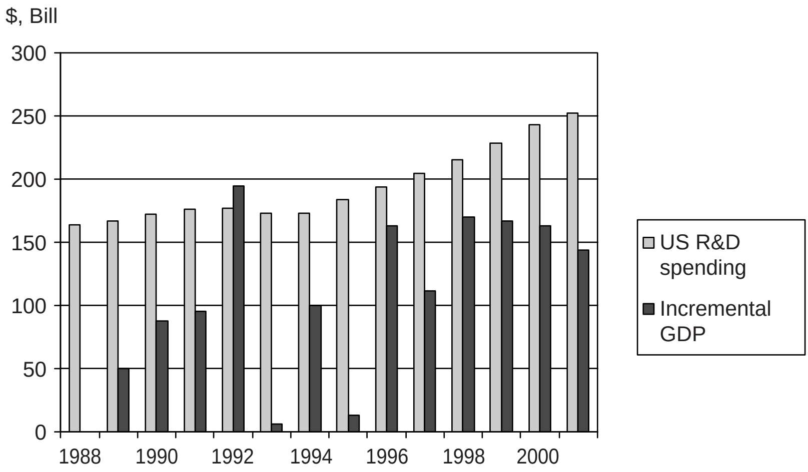


**Figure 2.3.** US R&D spending and incremental GDP due to productivity growth.
*Source:* Calculations by authors from NSF, DOC.

problematic returns from R&D by looking at Figure 2.3, which plots the incremental GDP due to productivity growth (deducting that part of additional GDP which is due to increase in employed labor force) against annual R&D spending. A superficial reading of the graph might suggest that the overall annual addition to the GDP is less than the amount spent on R&D. Of course, a number of cautionary factors need to be considered, such as the need to take into account a significantly longer time series, and to include lagged and multiplier effects.

There is a vast body of literature in economics on the connection between innovation and productivity, which addresses questions regarding the impact of information technology, R&D, and technological progress on productivity growth (see Baily and Gordon, 1988; David, 1990; Lipsey, 2002; Nordhaus, 2004). Comin (2004) suggests that the contribution of R&D to productivity growth in the US is in the range of three- to five-tenths of one percentage point. Apart from the fact that it is difficult for firms to appropriate much of the returns to innovative activity (see Nordhaus, 2004, on Schumpeterian profits from innovation), it is also true that many of the benefits of innovation are not reflected in macroeconomic data. The emergence of new goods and particularly the non-economic benefits of the Internet, such as increased convenience and comfort, are often not reflected in standard economic measures. Ultimately, the subject matter of innovation, technology, and their economic impact flounders in the confusion surrounding definitions, measurement issues, data issues, and indeed even issues of a conceptual nature when it comes to categorization of new goods and so forth. There does seem to be an agreement among many observers that for the US, as indeed for many advanced countries, this particular time in economic history is fraught with somewhat decreasing effectiveness of R&D spending, at least in terms of the latter's impact on standard measurements of economic well-being. The diminishing effectiveness of R&D spending at the national level seems to be getting reflected in decisions by individual firms to outsource, as well as offshore part of their R&D activity in order to make it more cost-effective.

There are some other issues specifically related to the kinds of technologies at the forefront today. The difficulty of appropriating innovation profits on a consistent basis due to increased competition and the nature of some of the innovations has led to greater cost-cutting pressures. Add to this the increasing share of services, both in GDP and in R&D expenditures, and the operation of Baumol's disease, which condemns service sectors to slower productivity growth, and one can see the compulsions to offshore and cost-cut. Most of the increase in R&D spending in services has taken place in the information technology related services, and the professional, scientific, and technical services sector, both of which are at the forefront of the R&D offshoring wave. R&D offshoring is also given a boost in an environment of intense global competition, where R&D expenditures and patenting also have a strategic role to play (see Hall, 2004). The compulsions of spending on competing me-too products, with marginal, indeed even insignificant new attributes in a kind of arms race of creeping innovation have forced firms to look for ways and means to restructure their R&D operations.

## Ongoing Silicon Valley firm survey

The authors carried out the first stage of a survey of high-tech firms, initially during the summer and fall of 2004, in order to get some tentative answers to the questions posed earlier and to understand better the characteristics of R&D offshoring. The continuing survey has involved

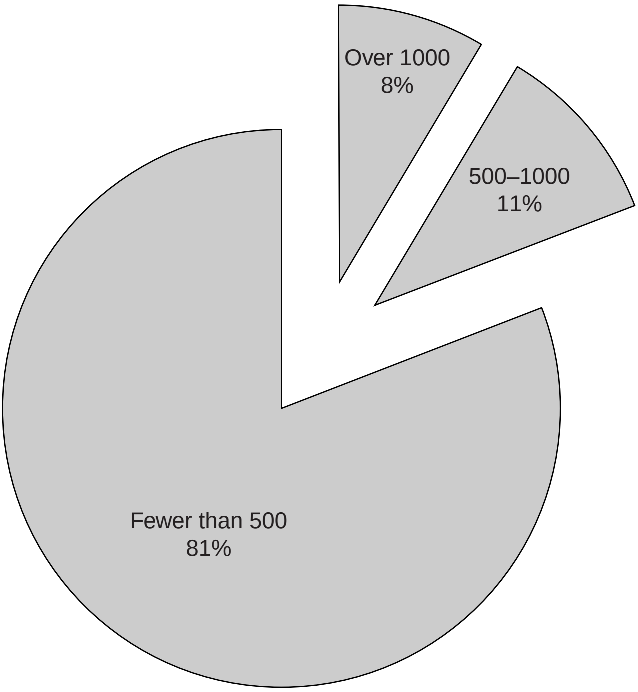


**Figure 2.4.** Size distribution of firms (by number of employees).
*Source:* Survey by authors.

answering a web-based questionnaire. Initial requests were sent to a sample of 488 California-headquartered firms involved in the following broad business and industrial sectors: computer hardware and software, including semiconductors, telecommunications, instrumentation and electronics, and research and testing services. Forty-eight firms responded to our survey and filled out the online questionnaires. Figure 2.4 shows that a majority of the firms in our sample were small and medium-sized firms with fewer than 500 employees. A number of follow-up interviews were also carried out with business executives at some of the firms in our sample, as well as with executives at out-of-sample firms during winter 2005 and with in-sample firms in 2007.

## *Domestic outsourcing*

Twenty-six of the forty-eight firms in our sample resorted to domestic outsourcing of different kinds of activity. Most of this was manufacturing, and fourteen of those twenty-six firms indicate that they outsource to other locations within California itself or in the nearby states of Arizona, Oregon, and Nevada, whereas the rest had outsourcing arrangements in other states within the US. While domestic outsourcing is not the focus of our chapter, it needs to be stated that it is the largest and most common form of outsourcing resorted to by the firms in our sample, and interviews indicate that perhaps the possibilities for domestic outsourcing have not been exhausted yet. However, while earlier there was an element of sequencing involved, i.e., firms often first resorted to domestic outsourcing, and then adopted offshoring as cost pressures mounted, more recently, in many cases firms have directly resorted to a foreign presence, leapfrogging and bypassing the domestic option.

## *Offshoring*

Nineteen firms resorted to foreign outsourcing, i.e., importing intermediate goods or services from independent suppliers, while thirteen firms imported from their own offshore units, affiliates, and subsidiaries (we refer to the latter phenomenon as affiliated or intra-firm offshoring and the former as unaffiliated offshoring). Ten firms had participated in both affiliated and unaffiliated offshoring. For the sample as a whole, seven firms resorted to all three: domestic outsourcing, affiliated offshoring, and unaffiliated offshoring simultaneously (summarized in Figure 2.5).

## *Innovative capacity*

Our sample of firms underscores the innovative and dynamic nature of the high-tech sector. An innovative firm was defined by us as one having more than half of its sales from products and services that were less than three years old. As Figure 2.6 shows, close to half (45 percent) of the firms surveyed were “innovative” firms by this measure. While the novelty of a product or a service might be marginal and the definition fuzzy, we believe that self-assessment of the importance placed by firms on their innovative dynamism is a valuable judgment criterion. Interviews revealed that executives at high-tech firms consider their capacity to innovate to be one of the core attributes of competitiveness

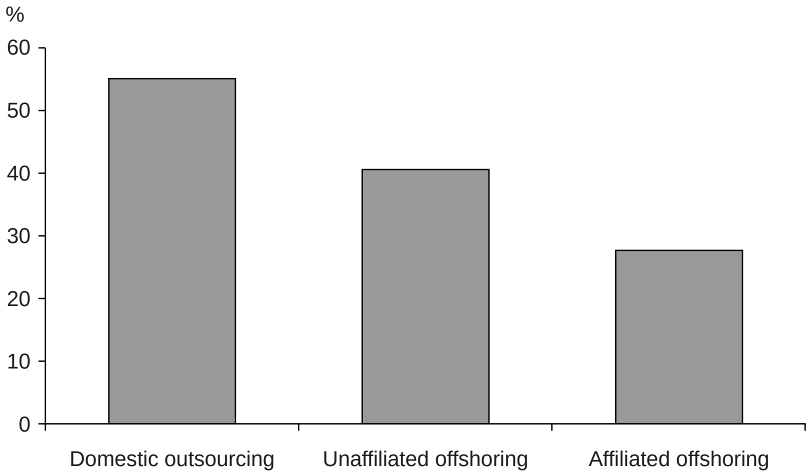


**Figure 2.5.** Forms of outsourcing and offshoring.
*Source:* Survey by authors.

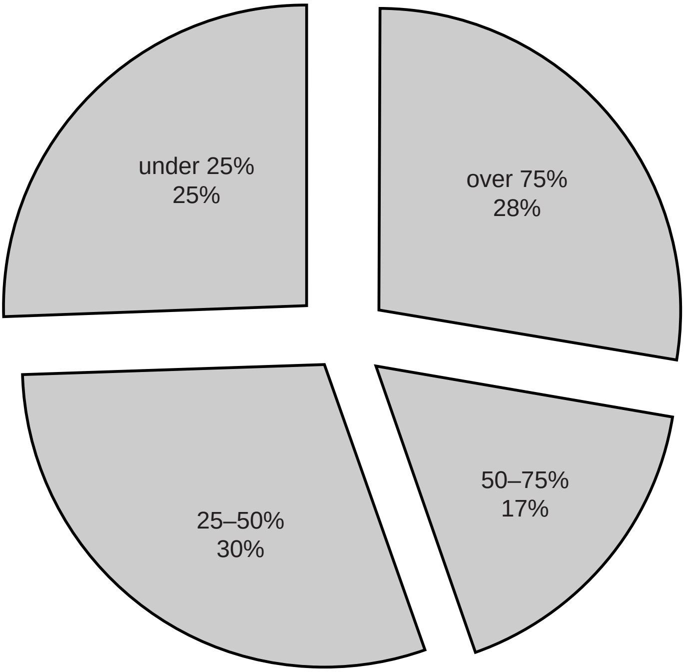


**Figure 2.6.** Innovative dynamism.
*Note:* Firms with percent of current sale from products and services less than three years old.
*Source:* Survey by authors.

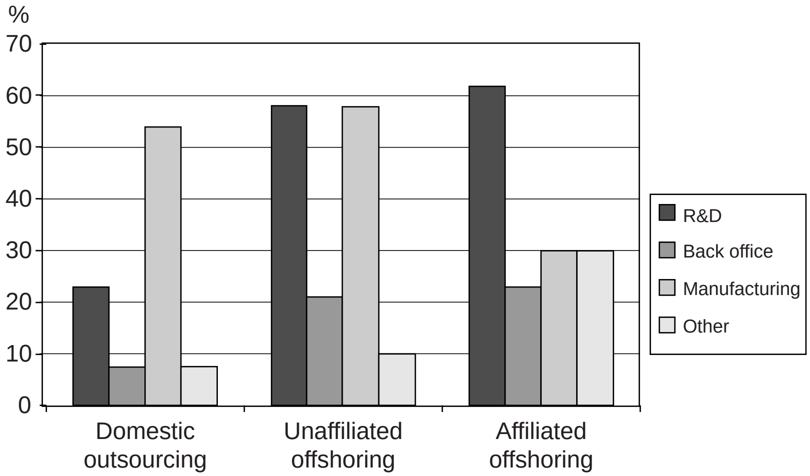


**Figure 2.7.** Nature of activity outsourced/offshored.
*Source:* Survey by authors.

and an integral part of overall business strategy. Some indicated that the impulse to innovate at the product and process level was even more important than the imperative to cut costs.

## *Nature of activities outsourced and offshored, including R&D*

Figure 2.7 gives the distribution of the nature of activities outsourced/offshored to various locations, within each category of outsourcing/offshoring. The general progression of offshoring from manufacturing and back-office services now also includes R&D activity, albeit broadly defined as any developmental, research, and design activity involving the products and services of the company; it is important to note that our question did not qualify the phrase "Research and Development" in any manner.[4] While manufacturing is the most common form of activity outsourced/offshored overall, there is a significant amount of R&D offshoring as well. Two-thirds of the offshoring resorted to by firms in our sample is to developing countries, primarily China and India, followed by OECD countries and then the transition economies of Eastern Europe. This pattern does not change even when we look at offshoring of R&D activity alone, whether to arms-length contractors or to subsidiaries. The relatively low incidence of offshoring of back-office activity is perhaps due to the nature of our sample. Back-office activity of the kind that has generated publicity in the recent past, such as call centers, payroll, and data and record management offices are a lumpy cost segment, to be offshored in one fell swoop. It is possible that for many firms, at least at the present stage, the cost advantages of offshoring back-office activity might not be as significant or worth the bother as for offshoring software and other technical work, which create larger immediate gains. Back-office offshoring has been more common for large service-oriented firms, while large set-up costs continue to deter the smaller firms.

It is interesting to note that R&D is the most significant segment in the intra-firm offshoring category, i.e., to foreign affiliates. Apparently, when it comes to carrying out R&D abroad it is important to safeguard proprietary business procedures and intellectual property rights under the aegis of your own firm. Firms attempt to match their organizational strategy and structure to the kind of innovative activity being pursued. As pointed out by Chesbrough and Teece (2002), "to organize a business for innovation, managers must first determine whether the innovation in question is autonomous (it can be pursued independently) or systemic (it requires complementary innovations)," and also determine whether the capabilities needed for innovation can be easily outsourced or created in-house. Interviews suggest that within the universe of offshoring, the more routine developmental activity was subcontracted to arms-length parties while more sensitive aspects were dealt with by the firm's subsidiary. Also, firms preferred to carry out in-house research on "drastic" innovations, embodying a qualitative break from attributes of previous products or processes, while offshoring the search for routine, marginal improvements and individual innovative elements of a product. Reflecting this, we find that (see below) the more innovative firms do not offshore their R&D.

## *Reasons for offshoring*

The primary reasons given by firms for not offshoring are concerns and sensitivity about intellectual property rights and security (32 percent), lack of knowledge and exposure to the potential targeted host countries (26 percent), and, interestingly enough, high costs (26 percent), particularly for smaller firms. The latter seems to suggest that the issue of lumpy, upfront, fixed costs mentioned earlier deters at

**Table 2.1** ***Mean size of firm, by attribute***

| | Innovative firm | Not innovative firm | Significance |
|---|---|---|---|
| Number of employees | 588 | 2,486 | * |
| | Offshoring firm | Not offshoring firm | |
| Number of employees | 2,931 | 487 | ** |
| | Firm offshores R&D | Firm does not offshore R&D | |
| Number of employees | 4,243 | 477 | * |
| | Firm does affiliated offshoring of R&D | Other firms | |
| Number of employees | 7,837 | 512 | ** |

*Note:* ** Denotes significance in mean difference at 10%, and * at 5%.
*Source:* Survey by authors.

least some firms from offshoring, particularly given the relative inexperience and paucity of specialized intermediary and consulting firms, and the extent of due diligence required for setting up an appropriate contractual structure with the suppliers.

The reasons for offshoring vary by the nature of activity offshored and the organizational set-up of the supplier. The motivations for affiliated offshoring of R&D include a mix of access to skilled labor, costs, and a focus on core competence, but with a greater weight placed on access to skilled labor than for offshoring of other activity. For unaffiliated offshoring of R&D cost savings were critical, while for domestic outsourcing of R&D all reasons given above are now of more or less equal importance. Generally speaking, costs are of greatest significance for unaffiliated offshoring and least for domestic outsourcing.

## *Size, innovative dynamism, and offshoring*

Is there a relationship between firm size and propensity to offshore? As Table 2.1 shows, the larger firms resort to offshoring more readily, whether of R&D or any other kind of activity. This is particularly true for those firms that set up their own R&D affiliates abroad, where the size factor is of particular significance (see row 4). At the same time, it is clear from our sample (row 1) that it is the smaller firms that are more innovative. We find that the more innovative firms tend not to use offshoring for their R&D activities, although they are above average in their overall use of offshoring. Follow-up interviews on the topic also suggested that the more innovative firms claimed that having development take place in-house helped in cutting down the lead time between innovative products and helped in quicker implementation of new technology in production and dissemination.

### *Miscellaneous*

Most unaffiliated offshoring was carried out on a long-term contractual basis; 75 percent of these firms adopted long-term agreements with trusted independent suppliers, who had experience and a proven track record in the industry. Of the remainder, most had one-time contractual deals with suppliers, and a few had concluded joint ventures and spun off separate entities. The primary decision-makers and the driving force behind the phenomenon of offshoring remain US-based senior management. The role of specialized, intermediary consulting firms in facilitating the offshoring process is minor, as is the role of firms from offshoring-receiving countries actively promoting offshoring and attracting customers. This is consistent with the notion that it is the "push" factors, embodied primarily in high costs, which were responsible for offshoring; US firms faced with the imperative of cost-cutting had taken the initiative in scouting for potential locations, while the "pull" factors, reflected in the available supply of technically educated, relatively low-wage labor had acted as a facilitating condition.

While concessions, subsidies, and other recipient country policies to attract investment were important, they were not the decisive factor in either the decision to go abroad or the choice of country. They were assessed in an overall cost estimation exercise that included the additional transactions costs that firms would face in an uncertain environment of regulatory flux and infrastructural inadequacy. Since R&D is a sensitive and critical activity, the stance of the recipient country's policies toward investment of this nature is of particular importance. While a strong intellectual property rights regime was preferred, it was not seen to be a major stumbling block, perhaps because of the industries in our sample. Studies have shown that intellectual property rights are of greater importance in some industries, such as pharmaceuticals, than in others.

## *Follow-up in-sample interviews*

Follow-up interviews with senior executives from some of the companies in the initial sample were carried out over the summer and fall of 2007, in order to fine-tune the earlier results and check their robustness over the intervening period. Perhaps due to the combative nature of the initial debate on offshoring, we found the firms somewhat more willing to look for opportunities for domestic outsourcing than before, particularly where cost was not the primary factor.

The search for establishing and expanding subsidiary R&D outfits in China and India continues unabated, with R&D projects of ever increasing complexity being offshored, subject to constraints and compulsions mentioned in the next section. If the routine back-office offshoring surge (call centers, payroll, etc.) seems somewhat tempered, it may owe more to the fact that it has become more customized and tailored to the needs of the parent establishments in the US, in addition to being already a somewhat mature market. There is a marked tendency to greater unbundling and disaggregation of tasks; the offshoring business environment has evolved from being driven by the earlier cost-push considerations of the high-cost side, to an attempt to figure out the disengageable elements in the supply chain and the task-universe, both by parent firms, as well as specialized intermediary-consulting companies.

Among those firms from our earlier sample that still do not offshore, the reasons seem to have migrated from "lack of knowledge of target country" to issues relating to management challenges of offshoring, particularly relating to R&D offshoring, and the issue of compatible organizational set-up to deal with them. By 2007, there had been ample dissemination of knowledge about the potential of India, China, and East European countries as bases for offshoring. There is considerable accumulated experience of successes and failures, with a greater appreciation of some of the organizational and logistical pitfalls. The reasons for continuing offshoring have therefore become more subtle and nuanced, with a greater clustering around different factors, unlike the significantly greater stress on "lower costs" before. Indeed, there is an increasing appreciation of the market potential of these target countries and the linkages to domestic industry there, instead of the sole reliance on abundant, low-cost labor markets.

## The view from the other side: management and organization of R&D in emerging economies

Extensive interviews were carried out in the summer and fall of 2007 with personnel at affiliated R&D centers, research institutions, academics at universities and at think tanks, executives of R&D centers of local firms, as well as policy makers in India (Bangalore, Hyderabad) and China (Beijing, Shanghai), to get a sense of the evolution and trajectory of the globalization of R&D, in general, and of offshoring of R&D from the US to India and China, in particular. Insights were also gleaned from three international conferences on globalization of R&D, organized by one of the authors.

(i) *Issue of isolation and lack of feedback*: A common theme involving stand-alone subsidiary R&D centers was the relative absence of linkages to the local economy, local suppliers, and customers, except in cases where the project involved local market penetration. Consumer and other kinds of feedback are therefore a key issue, in spite of excellent communications and organizational ties to the main consumers of the R&D at the headquarters.

(ii) *Blackboard strategy vs. equipment strategy*: For a multinational with subsidiary R&D centers in many different countries, the global distribution and allocation of research projects is subject to many considerations. A key one is the relative strength and drawbacks of the R&D culture of a country vis-à-vis another – i.e., comparative advantage and specialization in research niches. A better understanding of this issue has resulted in India and Russia getting the more "theoretical" projects, and China the more equipment-heavy, laboratory-intensive ones; in a sense this R&D specialization is compatible with strengths in the sectoral economy, where India and Russia have competitive strengths in the software sector and China in manufacturing.

(iii) *Management challenges*: The risky enterprise of globalization wedded to the uncertain activity of R&D compounds the problem

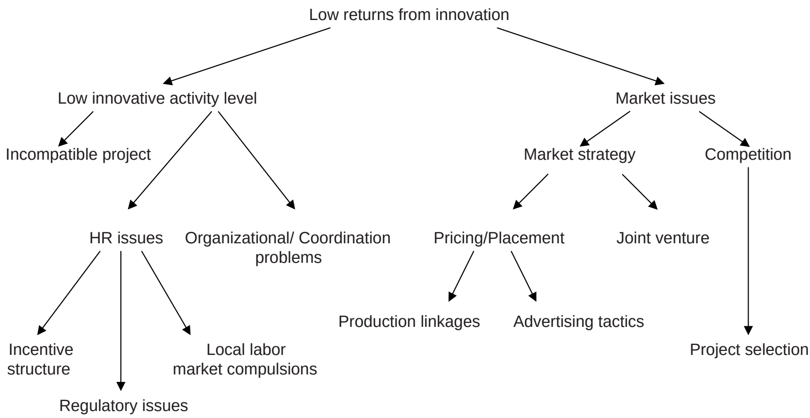


**Figure 2.8.** Firm innovation diagnostics: example of constraints.

of effective monitoring and management of far-flung R&D centers (Bardhan, 2006). The type of innovative activity to be undertaken, its subsequent marketing strategy, the positioning vis-à-vis input and output markets, the commensurate human resource approach, and firm organizational structure are all affected by this interplay of globalized, offshored, affiliated innovative activity. An innovation diagnostics approach can help clarify the binding constraints on the ability of a firm to appropriate higher returns on its innovative activity. Figure 2.8 gives an example.

(iv) *Compatible organization design*: A careful study of the binding constraints on the level of returns to innovative activity would then be translated into a responsive and compatible organizational structure. The choice variables in the decision-making process would include – R&D dedicated to business/product lines vs. country demarcation; joint, cross-country projects vs. sole proprietorship; selective task-based outsourcing vs. project-based, and so on.

## Conclusion

While the impact of offshoring on labor markets in the US is a matter of some debate, it is widely understood that in an environment of global labor arbitrage, innovation leading to creation of new high-paying jobs is the only sustainable path for continued growth in US living standards. Innovation would impact living standards not only through continued increases in productivity but through the creation of new goods and hence a temporary global monopoly, favorable terms of trade and significant Schumpeterian profits for local firms, as well as other benefits accruing to consumers. At the same time, offshoring has been steadily creeping up the value chain and has reached the R&D segment within individual firms. Consequently, concerns have been raised about the sustainability of new job creation and of rising productivity and technological innovations in other countries, which could seriously challenge US leadership in high-tech industries and negatively impact wages.

Results of a survey of forty-eight technology firms reveal that it is mostly large firms that resort to offshoring of R&D. R&D activity is carried out abroad primarily under the aegis of affiliated offshoring. While it is small firms (fewer than 500 employees) that are more innovative (after all, in Silicon Valley the medium through which new innovation has been brought to market has been through the creation of new firms), larger firms are older, and as a result may have a larger share of older products in their product mix. There is some preliminary evidence that the more innovative firms carry out their R&D, certainly the most advanced aspects of it, in the US. The cutting edge, "drastic" innovations need incubation and development close to the "cutting" edge or first-adopter market with the greatest potential for appropriation of economic returns on innovation.

While US R&D expenditures, patent generation, and productivity growth have been consistently robust, both data at the national level and firm interviews raise concern regarding the cost-effectiveness of R&D spending. The increasingly global sales of firms are forcing them to "design to market," and the complex, interdisciplinary requirements of modern research are compelling some of them to outsource and offshore their innovative activity and access global R&D talent.

What issues does this phenomenon raise? To begin with, it should be noted that the offshoring of R&D and innovation is fueled largely by the same considerations as offshoring in general, i.e., costs, spread of education and skills, opening up of markets, technological developments, and so forth, and is equally irreversible. In a nutshell, comparative advantage, or the forces of specialization and trade have reached the market for innovation goods and services. Consequently, it stands to reason that India, China, and other developing and transitioning countries are bound to take a larger slice of the scientific pie. More importantly, however, with the inclusion of the large scientific establishments of developing economies there is the distinct possibility of the pie itself growing faster than before. There could be benefits to geographical diversity in science and technology. Different conditions and different scientific cultures may spur innovation along unusual lines and in more appropriate ways than was possible earlier, leading to a synergy through the development of mutual attraction and compatibility between globally dispersed innovative regions.

The emerging situation with offshoring of R&D related activity is going to pose serious challenges to white-collar workers, engineers, designers, and scientists, and to US firms, as well as to policy makers. It is possible that the future of R&D offshoring will include continued innovation and R&D in the US and the creation of high value-added jobs in Silicon Valley, leading to a win-win situation where the US develops/markets the "new" goods, and the now "routinized" goods and services are offshored. On the other hand, there exists the distinct possibility of major innovations originating abroad. Given this possible change in the spatial location of innovation, can the US, and Silicon Valley in particular, continue to dominate the field of economic appropriation of R&D? Can they maintain their competitive edge in the infrastructure of innovation, i.e. the institutional and financial environment, the armies of venture capitalists, lawyers, accountants, investment bankers, and others, who assist in nurturing new firms, help them develop and market their products, and guide them to financial success through initial public offerings and other landmark financial stages? Can they continue to attract innovative firms from around the world? From the point of view of a foreign entrepreneur, establishment of a company in the US confers some other advantages as well, such as proximity to market, imparting credibility to the start-up firm and the learning effect from other innovative firms. Therefore, even though innovations/inventions may take place abroad, it is conceivable that the location of start-up headquarters and the benefits of initial job creation and so forth may still occur in Silicon Valley.[5] In evaluating the positive aspects, Jaffee (2008) also points out some of the additional institutional and policy advantages that the US enjoys at present in terms of a supportive infrastructure of innovation: these include an economic culture of promoting and rewarding innovation, with failure looked upon as an occasion for a fresh start, a predisposition toward invention and risk-taking among a part of the populace, and a technology-supportive immigration policy.

The first important issue therefore is the promotion of R&D and innovation. Experts are in wide agreement about the critical nature of school and higher education, as well as the problematic occupational choices being made by newer entrants to the labor market (see Freeman, 2005). There is scope for government policy in the educational sphere, in terms of getting re-involved in the retraining of workers, and perhaps in a judicious way in the innovation process itself. While few economists would venture to suggest that the government start picking favorites from the set of technologies comprising the next big thing, whether it be biotechnology or nanotechnology, and channel funds to it to the exclusion of others, there is perhaps room for further research and policy analysis of issues relating to promotion of technology agglomerations and R&D incentives. It needs to be recognized that all technologies are not born equal. General purpose technologies, those that have the intrinsic capacity to be used as an input into every sector of the economy, tend to have a revolutionary impact on the structure of the economic system, on jobs, wages, and living standards through the extraordinary potential for spillover effects. The externalities, coordination failures, standardization issues, and potential social returns must be taken into account when policies are formulated, in order to enable technologies to evolve, disseminate, and diffuse quickly and have an economy-wide beneficial impact.

## *Notes*

1 Offshoring refers to the transfer of at least a part of a firm's production and jobs abroad, with a view to importing the products and services back into the US.

2 The US Office of Management and Budget gives the following definitions for different categories of research:

*Basic Research* as relating to a systematic study directed toward greater knowledge or understanding of the fundamental aspects of phenomena;

*Applied Research* as study to determine the means by which a recognized and specific need may be met, and

*Development* as application of knowledge toward the production of useful materials, devices, and systems or methods, including design, development, and improvement of prototypes and new processes.

Our chapter is guided largely by a broad definition, encompassing all three above.

3 A triadic patent family is a set of patents registered at all of the three largest patents offices, namely the European Patent Office (EPO), the Japanese Patent Office (JPO), and the US Patent and Trademark Office (USPTO).

4 This raises the broader question of what should be considered R&D, how to separate research from development in the context of the many intertwined innovational activities that a firm carries out, and indeed how to separate innovational activity from customized, non-routinized, yet not necessarily completely original work.

5 There is yet another way to look at the issue of innovations abroad. As Walsh (2003) notes, "On balance, although foreign R&D centers are contributing to China's impressive recent high-tech growth and increasing competitiveness in ICT industries, they are contributing as much or more – under newly consolidated, wholly foreign-owned R&D enterprises – to foreign companies' high-tech development and production capabilities and, thus, to the US economy."

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