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Innovation, R&D and Offshoring

Ashok Deo Bardhan & Dwight Jaffee

I. Offshoring, Jobs and Innovation:

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 weak nature of the economic recovery since the last recession and the accompanying sluggish job creation has prompted speculation that perhaps offshoring is to blame for the slow jobless growth. 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 in the short-run, the long-run and under different scenarios.

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 globalization, free markets, communications technology, wage differentials and the supply of college graduates in developing countries, the so-called five factors contributing to the surge in the phenomenon, show no signs of abating. They also claim there are no signs of any emerging sectors or occupations that will take up the slack, as the US software sector did during the 1990s. The case for minor impact is based on the clear fact that the magnitude of job loss attributable to offshoring has been minor so far. Supporters claim that the US economy is robust and dynamic enough to replace the jobs lost and indeed create many more, 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 the 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. One of the key lessons from the economic history of the United States going back to the era of rapid industrialization in the late 19th century suggests that the innovative dynamism of the US economy, the creation of new goods, new services, new value, and the temporary global monopoly that

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.

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. This has been the case from 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, similar to what happened during the wave of manufacturing offshoring during the early 1990s in the aftermath of the recession, continued innovation and creation of entire new sectors of the economy will more than compensate for the ongoing white collar job losses. The industrialized countries, as well as developing countries would benefit from this win-win scenario.

At the same time, concern has 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 possible movement of offshoring activity further up the value chain, encompassing research, design and development operations in manufacturing and services, and the general offshoring of innovative activity. The broad consensus among economists is that there are long-term welfare gains to economies that offshore jobs since this allows firms to raise their productivity, the gains from which, at least in part, are then channeled into R&D, which leads to the development of new products and services and to the creation of high paying jobs. The suggestion or evidence that R&D itself is being offshored is therefore met with particular concern. But is a significant amount of R&D activity being offshored? And even if the volumes are sizeable, does that imply that future innovations would originate in other countries (after all, many innovations in the recent past as well have originated outside the US), but also that the economic benefits would disproportionately accrue to other nations? And, more critically perhaps for residents of the developed countries, does this imply that their own living standards must fall?

Our focus in this research report is on the offshoring of research, design and development in the context of a new, emerging, international division of highly skilled labor. This report 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. Section III describes the results of our firm survey that deals with questions such as which firms resort to offshoring of R&D? What are the reasons behind offshoring of this kind of high value-added R&D? Section IV deals with the macro-economic state of R&D in the US, including R&D expenditures, R&D employment, patent generation, and their impact on the economy.² Section V contains

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 and of observable facts without specific applications toward processes or products;

the concluding remarks and analyzes the implications for US innovation, the economy and job creation.

II. R&D Activity and Offshoring

From The Domestic Proprietary Model to Offshoring

In industrialized economies, as pointed out by Mowery (1990), the characteristics of the innovation process led to the 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 19th, early 20th century in the United States. The R&D unit was an organizational innovation that institutionalized invention related activity, separated the latter from production related processes and connected inventions to the marketplace through the auspices of a single firm. Through specialization, economies of scale and scope, and safeguarding of the invention process by internalizing it, firms were able to make inventive activity more efficient and to ensure high returns from it. 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 sensibly 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 “produce to market”. The rapid incursion into new markets with different product cultures has now put a severe strain on the R&D resources and capabilities of individual firms. Moreover, the increasingly interdisciplinary nature and the complex organization of most research projects calls for the services of researchers from many diverse disciplines, such as statistics, computer science, genetics, nanotechnology and so forth, and it is problematic 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 offshoring of manufacturing and service activity has served to open the door to exploring offshoring of R&D activity. Other imperatives for R&D globalization include

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- 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.

On the other hand, the narrower definition of National Science Foundation (NSF) says R&D involves activities carried on by persons trained, either formally or by experience, in the physical sciences such as chemistry and physics, the biological sciences such as medicine, and engineering and computer science, while excluding experts in economics, artificial intelligence and expert systems, consumer, market and opinion research, engineering psychology, management and organization structure. Our paper is guided largely by the broader definition.

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, in addition to the need to access R&D talent in different scientific-cultural climes leading to different technical solutions.³

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 pre-conditions necessary for offshoring in general and R&D offshoring in particular. The liberalization of state controls and opening up of Russia, China and India to trade and investment flows has occurred serendipitously at a time when the technological wherewithal for offshoring 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, usually geographically concentrated, thus forming major scientific agglomerations in certain urban centers, 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, and 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 areas of software, bio-tech and pharmaceuticals, engineering design and development, 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 an 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 56 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

³ 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 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 a technology bust, problematic returns to R&D and increasing competition has created fertile grounds for the "push factors" needed for divesting R&D operations by firms in the US.

owned or joint ventures and constitute a veritable who's who of the US high tech industry. The official web site claims that nearly 90% of the firms are involved in research, development, production and marketing in cutting edge fields, such as new materials, electronics and energy. Around 38% are state-affiliated in some form or the 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.

Globalization of R&D

Business media now report the offshoring of R&D activity in sectors ranging from pharmaceuticals and bio-technology to computer hardware and software. An increasing number refer to wholly owned R&D centers in countries such as Russia, China and India, or sometimes even arms length sub-contracting of R&D in these countries. 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 1500. Intel also has a hi-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 \$1.2 billion in 2004, 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.⁴

III. Firm Survey

The authors carried out the first stage of a survey of high tech firms during 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 survey involved answering a web based questionnaire. Initial requests were sent to a sample of 488 California headquartered firms involved in the following broad areas of 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 1 shows that a majority of the firms in our sample were small and medium sized firms with less 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

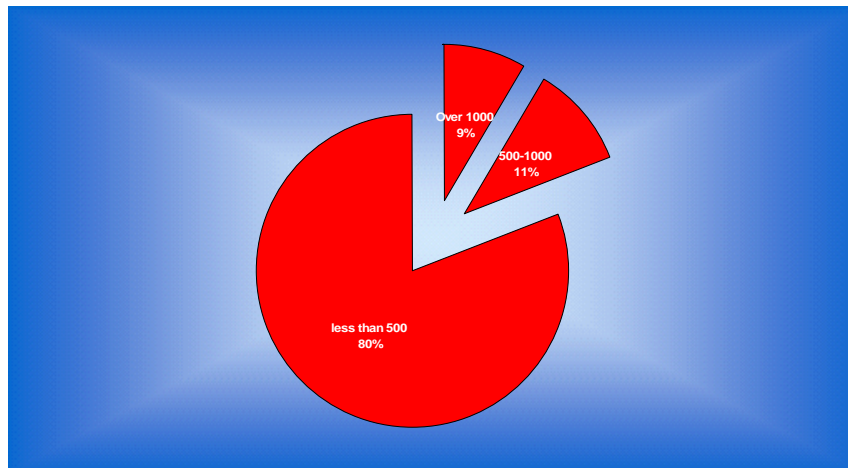
⁴ The OECD report "OECD Science, Technology and Industry Outlook 2004" data show that, on average, "R&D performed abroad by foreign affiliates represents 12% of total expenditure on industrial R&D in the OECD area. Outflows of R&D to developing countries are on the rise, especially to China and India. US foreign affiliates in China performed USD 506 million worth of R&D compared to only USD 7 million in 1994 (OECD, Activities of Foreign Affiliates database)".

out-of-sample firms, during winter 2005. A second stage of the survey is planned for Fall 2005.⁵

Outsourcing

Twenty six of the forty eight firms in our sample resorted to domestic outsourcing of all kinds of activity⁶. Most of this was manufacturing, and fourteen of those 26 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 report 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 and then as the cost pressures mounted adopted foreign outsourcing, more recently firms have, in many cases, directly resorted to a foreign presence, leapfrogging and bypassing the domestic option.

Figure 1
Size Distribution of Firms



⁵ While we make no special claim for the representativeness of our sample, we believe that our findings are indicative of broad trends in the business world, make sound intuitive sense and are further confirmed by our interviews with leading figures in the industry, except in those cases and instances specifically referred to by us in the pages that follow.

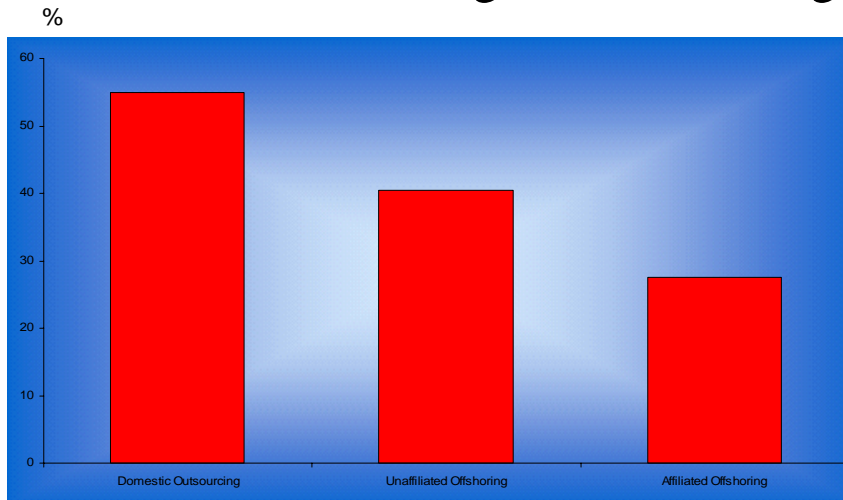
⁶ Defined as an activity earlier carried out by the firm, or one which is normally done in-house by firms in that sector.

Offshoring

Nineteen firms resorted to foreign outsourcing, that is importing intermediate goods or services from independent suppliers, while 13 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, 7 firms resorted to the three forms, domestic outsourcing, affiliated offshoring, and unaffiliated offshoring simultaneously.

Figure 2

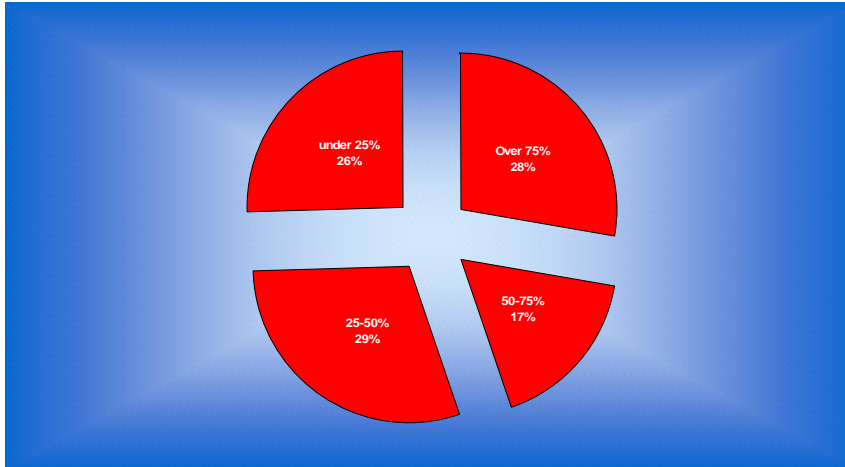
Forms of Outsourcing and Offshoring



Innovative Capacity

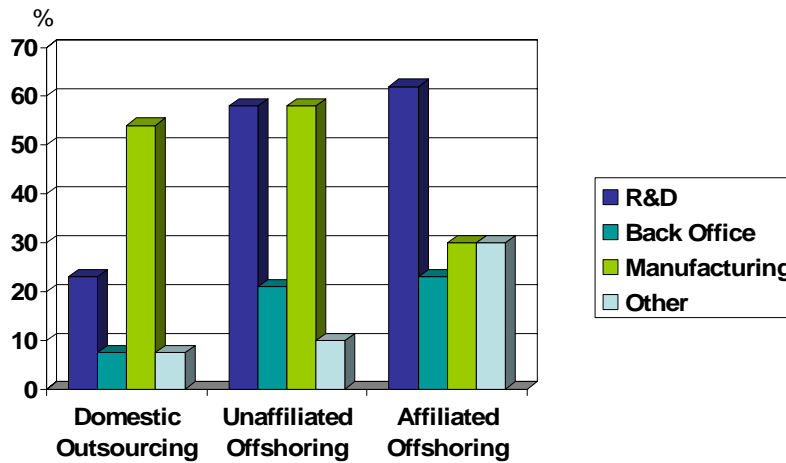
The sample of firms underscores the innovative and dynamic nature of the high tech sector. As figure 3 shows, close to half (45%) of the firms surveyed had more than half of their current sales from products and services that were less than three years old. Again, while the novelty of a product or a service might be marginal and the definition fuzzy, we believe a self-assessment of the importance placed by firms on their innovativeness is key. Interviews revealed that executives at high tech firms consider their capacity to innovate to be one of the core attributes of competitiveness 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.

Figure 3
Innovative Dynamism



Note: Firms with Percent of Current Sales from Products and Services less than three years old

Figure 4
Nature of Activity Outsourced



Nature of Activities Outsourced and Offshored, Including R&D

Figure 4 gives the distribution of the nature and specific kinds of activities outsourced/offshored to various locations. The general progression of outsourcing 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.⁷ It is important to note that our question did not qualify the phrase Research and Development in any manner. While manufacturing is the most common form of activity 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 countries 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, 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 as yet, 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.⁸

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 match their organizational strategy and structure to the needs of innovation being pursued. As pointed out by Teece and Chesbrough (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 research on “drastic” innovations, embodying a qualitative break from attributes of previous products or processes, within the firm, while outsourcing the search for common, marginal improvements and individual innovative elements of a product package. On the other hand, narrowing the sample to innovative firms (see below) shows that the more innovative firms do not offshore their R&D.

Reasons for Offshoring

The primary reasons given by firms that do not resort to offshoring are concerns and sensitivity about intellectual property rights and security (32%), lack of knowledge and exposure to the potential targeted host countries (26%), and interestingly enough, high

⁷ 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.

⁸ Incidentally, one should also take account of the fact, that in the case of software firms, subsequent interviews uncovered that firms had assigned outsourcing of routine, repetitive activity to the category “other” and any kind of developmental activity to “R&D”.

costs (26%), particularly for smaller firms. The latter seems to suggest that the issue of lumpy, upfront, fixed costs mentioned earlier deters at 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, on the other hand, vary both by the nature of activity offshored as well as the organizational form of the supplier. The motivation for affiliated offshoring of R&D is a combination of access to skilled labor, costs and focus on core competence, but with a greater stress on access and costs than for offshoring of other activity. For foreign outsourcing or unaffiliated offshoring of R&D, reduction in costs was critical, while for domestic R&D outsourcing all reasons given above are now of more or less equal importance. Generally speaking, costs are of greatest significance for foreign outsourcing and least for domestic outsourcing. When it comes to R&D, the importance of costs increases somewhat for domestic outsourcing and relatively decreases somewhat for both kinds of offshoring.

Size, Innovative Dynamism and Offshoring

Is there a relationship between size and propensity to offshore? As Table 1 shows, the larger firms resort more readily to offshoring, 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

Table 1
(Differences in Mean Size of Firm, in Number of Employees, Along Various Dimensions)

Size	<i>Innovative</i> 588	<i>Not Innovative</i> 2486	<i>Significance</i> *
Size	<i>Offshoring</i> 2931	<i>No Offshoring</i> 487	<i>Significance</i> **
Size	<i>Offshoring (R&D)</i> 4243	<i>No Offshoring (R&D)</i> 477	<i>Significance</i> *
Size	<i>Affiliated Offshoring (R&D)</i> 7837	<i>No Affiliated Offshoring (R&D)</i> 512	<i>Significance</i> **

Note: ** denotes significance at 10%, and * at 5%.

innovative products and helped in quicker implementation of new technology in production and dissemination.

Miscellaneous

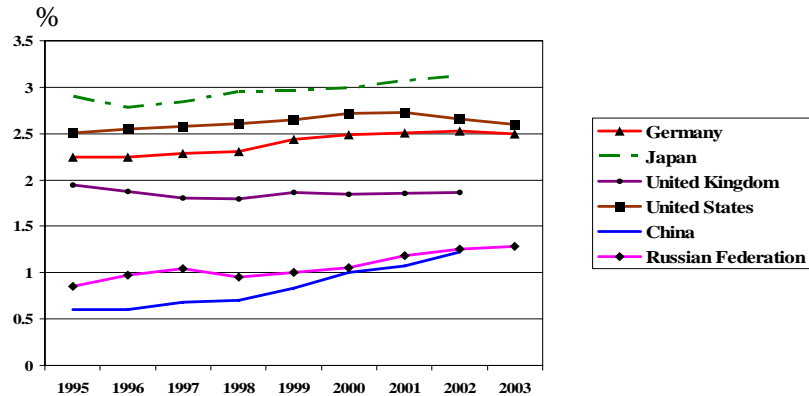
Most unaffiliated offshoring was carried out on a long-term contractual basis. Seventy five percent of these firms adopted long term agreements with trusted independent suppliers, who had experience and a proven track record in the industry. Of the remainder, most had one-time contractual deals with 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 is still very much the senior management at US firms. The role of intermediary, specialized, consulting firms facilitating the offshoring process is of a minor nature, as is the role of firms from other countries actively promoting offshoring and attracting customers.⁹ 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.

IV. The State of R&D in the US

What are the implications of this offshoring and globalization of R&D for the US economy as a whole? We now look at some macroeconomic indicators, including R&D expenditures, patent generation and productivity growth. In terms of gross spending on R&D, US expenditures have been quite robust and have indeed shown a significant increase in the last decade or so. Figure 5 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. In current PPP (purchasing power parity adjusted) dollar amounts the US expenditures have increased by around 60% over the 8 year period. The figure points to China's rapid rise, with the country having doubled its R&D expenditures as a proportion of its GDP. Indeed, OECD data on full time equivalent researchers employed shows China outstripping every country except the US.

⁹ 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.

Figure 5
 Gross Expenditures on R&D as a
 percentage of GDP

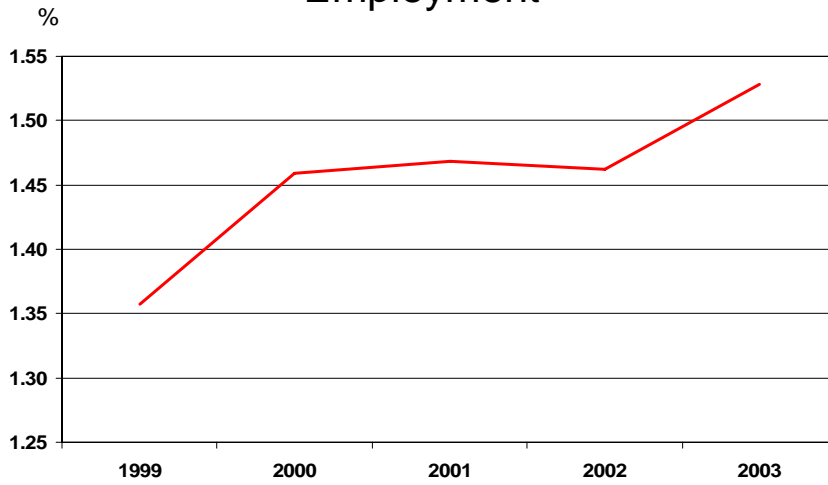


Data Source: OECD

A correspondingly large number of scientists and researchers are employed in R&D activity in the United States. Between 1999 and 2003, the number of scientists has increased from about 268,000 to about 355,000.¹⁰ A broader definition of R&D workers, guided by the OMB definition and based on the occupational descriptions of Bureau of Labor Statistics and comprising 37 occupations, ranging from industrial designers, to computers and information scientists, as well as engineering and technical occupations, yields a total number of R&D employment at 1.73 million in 1999 and 1.95 million in 2003, an increase of over 220,000; this, at a time when the number employed in all occupations went from 127.274 mill. to 127.420 mill., i.e. an increase of about 146,000 over the same period. Figure 6 shows our estimates of the R&D employment as a share of total employment in the US. After a temporary slowdown in growth during the recession, the ratio is increasing again. During the same period, the average weighted nominal wage for these 37 R&D occupations has increased by a healthy 20% (see Figure 7), again, a figure that is higher than the nominal 15% increase for all occupations as a whole.

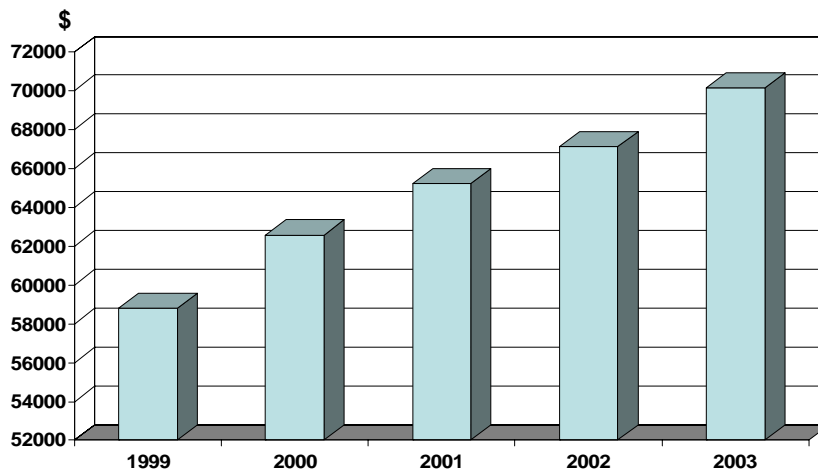
¹⁰ Estimated by the authors from Bureau of Labor Statistics occupational data, based on the narrower NSF definition. The data primarily includes occupations from the life science and physical science occupations.

Figure 6
**R&D Employment Share in Total
 Employment**



Source: Estimates by authors from BLS occupational data

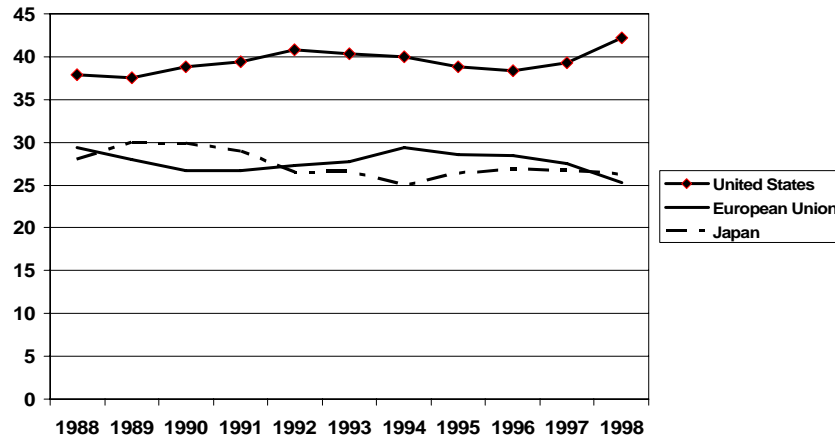
Figure 7
Annual Average Wages of R&D Personnel



Source: Calculations by authors based on 37 occupations; BLS data

Figure 8

Triadic Patents: Share of Total(%)



Source: OECD

Patents serve as an indicator of innovative performance. In comparing patents issued in individual regions and countries we must note that there will be a bias toward patents issued to domestic firms and entities. To control for this, Figure 8 shows the triadic patent family registrations received by entities and individuals based in the US, Japan and the European Union.¹¹ As the chart shows the US share has been steady and has even shown a slight increase to an all-time high of around 43% by 1998.¹²

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 jobs (which tend to be 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 therefore 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% per year during the last decade. The US global market share in key technologies, such as computers, telecommunications equipment and pharmaceuticals has remained steady in the 30% range for nearly the past quarter century.

¹¹ 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).

¹² By comparison, US residents received 54% of the patents granted by the US Patent Office in 2000. Note: 1998 is the latest year for which reliable triadic data were available.

A summary reading of productivity growth, global hi tech shares, balance of payments of technology goods and services¹³ etc. may suggest that all is well with the state of R&D, but other factors point to a more complex picture. It is not entirely clear that the economy is reaping benefits commensurate with the huge amount of spending associated with R&D. There is a body of literature in economics on the connection between innovation and productivity, which raises critical issues regarding the impact of information technology on productivity growth, often referred to as the Solow paradox, as well as on other related matters (See Baily and Gordon (1988), Gordon (1999), David (1990), Nordhaus (2005). For example, 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, the increased convenience and comfort are not reflected in standard economic measures. 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, and 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. This is particularly true in an environment of intense global competition, where R&D expenditures and patenting also have a strategic role to play.¹⁴ 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.

V. CONCLUDING REMARKS

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 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 the possibility of rising productivity and technological innovations among US trading partners, which could seriously challenge US leadership in high-tech industries with the attendant impact on wages and job creation.

¹³ Technology balance of payments data include money paid or received for the acquisition and use of patents, licenses, trademarks, designs, know-how and closely related technical services and for industrial R&D carried out abroad. Criteria such as indicators of technological competitiveness that look at a range of educational and performance related criteria also show the US leading other countries by a significant margin.

¹⁴ See Hall (2000, 2004) on patent strategy.

Results of a survey of 48 technology firms reveal that it is mostly the large firms that resort to offshoring. If R&D activity is carried out abroad it is primarily under the aegis of affiliated offshoring. While it is the small firms (less than 500 employees) that are the more innovative ones (after all, in Silicon Valley the medium through which new innovation has been brought to market has been through the creation of new firms), the 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” innovative ideas need incubation and development close to the “cutting” edge market with the greatest potential for appropriation of the economic returns to innovation.

While US R&D expenditures, patent generation and productivity growth have been consistently robust and the technology balance of payments has been favorable, both data at the national level and firm interviews raise concern for the cost-effectiveness of R&D spending, leading to firms looking for greater returns, sometimes through offshoring. The increasingly global sales of firms are forcing them to “design to market,” and the complex, interdisciplinary nature of modern research and its skill requirements 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 chunk of the scientific pie. More importantly however, 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 markets, as well as 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 a series of challenges to white collar workers, engineers, designers and scientists, 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” good, 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 changing spatial location of technical innovation in the future, can the US, and Silicon Valley in particular, continue to dominate in the field of the economic appropriation of R&D, and hence continue to attract innovative firms from around the world? Can they sustain their strength 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? 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 of 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 firm headquarters and the benefits of firm establishment, the initial job creation and so-forth may still occur in Silicon Valley.¹⁵ In evaluating the positive aspects, Jaffee (2004) also points out some of the additional institutional and policy advantages that the US enjoys at present in way 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 socio-cultural predisposition toward invention and risk-taking among a part of the populace, and technology supportive immigration policy.

The first critical issue therefore is the promotion of R&D and innovation itself. Experts are in wide agreement about the critical issues relating to school and higher education, as well as the problematic occupational choices being made by newer entrants to the labor market (see Freeman op.cit.). There is scope for government policy not just in the educational sphere but 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 is biotechnology or nanotechnology, and expend funds on it to the exclusion of others, there is perhaps room for further research and policy study of issues of promotion of technology agglomerations and R&D incentives. It needs to be recognized that all technologies are not born equal. Those that have the intrinsic capacity to be used as an input into every sector of the economy, also known as general purpose technologies, 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 might be taken into account when policies are formulated, and which would enable technologies to evolve, disseminate and diffuse quickly and have an economy wide impact on the industrial and economic structure.

¹⁵ 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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