Why Are Companies Offshoring Innovation?

The Emerging Global Race for Talent

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Abstract

This paper empirically studies determinants of decision by companies to offshore innovation activities. It uses survey data from the international Offshoring Research Network project to estimate impact of managerial intentionality, past experience, and environmental factors on the probability of offshoring innovation projects. The results show that emerging shortage of high skilled science and engineering talent in the US and more generally need to access qualified personnel are important explanatory factors for offshoring innovation decisions. Moreover, contrary to drivers of many other functions, labor arbitrage is less important than other forms of cost savings. The paper concludes with a discussion of the changing dynamics underlying offshoring of innovation activities, suggesting that companies are entering a global race for talent.

Keywords: offshoring, innovation, product development, global talent.

1. Introduction

Outsourcing of manufacturing activities to low-cost countries is widely practiced and well understood (*e.g.*, Dunning, 1993; Lee, 1986; Vernon, 1966). By comparison, the offshoring of high-value-adding white collar activities – pioneered by a few companies in the 1980s – is still a relatively undiffused practice (Amiti and Wei, 2005). However, Dossani and Kenney (2007, p.779) conclude that “in less than six years, offshoring of services has evolved from an exotic and risky strategy to a routine business decision.” The actions of US companies that are increasingly offshoring higher-value-added knowledge intensive processes and are restructuring and reorganizing their innovation processes worldwide are of particular interest to this paper (Henley, 2006; Levy, 2005). According to Apte, *et al.,* (2006) new product development is becoming the fastest growing offshoring segment in India. Ernst (2006) suggests the growing globalization of markets for technology and knowledge workers drive this growth in innovation offshoring. However, the reasons underlying the decisions by firms to offshore value-adding innovative activities remain to be understood conceptually as well as empirically. Conventional wisdom and existing literature (*e.g.*, Barney, 1991; Grant, 1996; Nonaka and Takeuchi, 1995; Patel and Pavitt, 1991; Porter, 1985) suggests that innovation activities are at the core of the firm competitive advantage and should be kept under tight control. This paper aims is to advance a model of why firms find it necessary to offshore innovation activities and to empirically test the model.

Offshoring refers to the process of sourcing and coordinating tasks and business functions across national borders. Offshoring may include both in-house (captive, or international in-sourcing) and increasingly outsourced activities which are performed by an external provider – that is, from outside the boundaries of the firm. The outsourcing activity in turn can be located both domestically (onshore) and/or abroad (offshore). Further, offshoring refers to sourcing rather than sales activities, and it supports global or domestic rather than local operations. Access to new markets is therefore not a primary strategic driver for offshoring (Lewin and Peeters, 2006a and b). Also, offshoring does not include the business activities and processes performed at a subsidiary in another country, such as the HR (human resources) department in a foreign subsidiary that supports local operations (i.e., local sales and distribution). Only if HR services (*e.g.*, payroll services) are provided from offshore in support of global or home-based HR functions is the term ‘offshoring’ applicable. Although it is often assumed that IT infrastructure and business processes were among the early activities that were offshored, offshoring innovation activities began coincidentally with ITO and BPO (Lewin and Couto, 2006; Manning, et al., 2008). The trend is for companies to increasingly offshore more complex and higher-value-adding activities that require access to subject matter expertise and a growing number of highly skilled and qualified workers (Lewin and Peeters, 2006a). This trend is influenced and affected by various factors including trade liberalization policies, advances in information technologies (Doh, 2005; Levy, 2005; Dossani and Kenney, 2006), and the ability of companies to dis-intermediate and modularize almost any process, including knowledge-creating processes (Sako, 2002; Takeishi, 2002). At the same time, however, according to Farrell, *et al*., (2006) and Mehta, *et al*., (2006), the organizational structures and processes necessary for coordinating globally dispersed business units and activities, managing knowledge, selecting locations and managing talent offshore represent major new managerial challenges that could limit the growth in offshoring.

In this paper, we focus on the offshoring of innovation (both captive and outsourced) and seek to study the factors underlying the evolution of offshoring practices towards global sourcing of talent and rapidly rising trend of offshoring product development work (i.e., R&D, product design and engineering services). In the early 1980s, several leading companies such as Texas Instruments, Motorola, and General Electric established technology centers in India and China to secure strategic advantages, such as favorable political treatment (Delios and Henisz, 2003) and access to skilled individuals (Ernst, 2006; Thursby and Thursby, 2006). Twenty years later, small entrepreneurial firms are increasingly offshoring new product development because of their need to grow, to increase speed to market, or simply because their survival depends on it (Dixit 2005; Shah 2005; Buchanan, 2006; Rangan and Schumacher, 2006; Dossani and Kenney, 2007). Asia in particular is playing a central role in the growing global innovation networks, as indicated, for example, by the growth in US patents granted to companies in Asia between 1986 and 2003 (Ernst, 2002 and 2006). Major Asian countries in that respect include South Korea, Singapore, China, Taiwan and India. However, Hirshfeld and Schmid's (2005) argue that, although firms in the US and Europe are increasingly attracted to and are exploring new science and engineering clusters in emerging countries, advanced economies are likely to remain at the forefront of innovation activities, at least in the foreseeable future (Manning, *et al*., 2008).

In order to study the determinants of firms' decision to offshore product development activities, we use original survey data from the Offshoring Research Network (ORN) on 880 offshore implementations initiated by US firms between 1990 and 2006. The ORN is an ongoing multi-year international project tracking the offshoring of administrative and technical work by companies in the US and Europe. In contrast to other datasets, it allows studying offshoring decisions at the level of individual offshore projects, and not at more aggregate firm or industry levels.

In line with a co-evolutionary framework (Lewin and Volberda, 1999; Lewin, *et al.*, 1999; Murmann, 2000 and Volberda and Lewin, 2003), and responding to Hutzschenreuter, *et al*., (2007) call for the need to integrate managerial intentionality into international business strategy and internationalization research as multi level analysis (Buckley and Lessard, 2005), our empirical approach models managerial intentionality, path dependence and environment as factors affecting the decisions to offshore product development (PD) functions and processes. We investigate whether the emerging shortage of highly skilled technical talent in the US – which drives the need to access talent globally – explains the offshoring of product development[1]. We argue that the diminishing attractiveness of science and engineering (S&E) careers (as indicated by the decline in US nationals earning advanced degrees in S&E) combined with the 2003 cutback in H1B visa[2] quota are key factors underlying this trend. The analysis also

[1] Our interpretation of the word "talent" throughout this paper is that of highly qualified individuals with advanced university degrees. Particularly relevant to this study is the concept of technical talent, referring to Master and PhD graduates in Science and Engineering, and experienced workers.

[2] The H1B is a non-immigrant visa category for temporary (3+3 years) workers in specialty occupations requiring the theoretical and practical application of a body of specialized knowledge if a U.S. citizen or

seeks to clarify the role of offshore labor cost savings opportunities in improving the efficiency of the innovation process. We argue that the opportunity to access equally qualified (or more qualified) workers at lower cost does influence companies' decisions to offshore innovation activities, but compared to other non-technical and less advanced functions (administrative and other back office activities), labor arbitrage objectives are less important in the decision to offshore product development. The model also tests the effect of other strategic drivers that are usually assumed to influence product development offshoring decisions, including the importance of increasing speed to market and competitive pressures. Finally, we also investigate the role of firm past experience with offshoring as a determinant to the decision to offshore innovation activities.

In the section that follows, we review the relevant literature and evidence and discuss the research questions pertaining to the role of environmental factors, managerial strategic objectives and firm past experience as determinants of firm decisions to offshore product development (PD) functions and processes. Following a brief introduction on the Offshoring Research Network project, section 3 describes the data used in this study and provides the methodological details. Following that, we present the regressions results. The discussion section interprets the empirical findings in the broader context of the growing globalization of human capital.

2. Literature review and theoretical framework

Three types of arguments have traditionally been advanced to explain firm-level internationalization decisions. First, the market approach argues that firms' internationalization is driven by the advantages of exploiting on a larger market a firm-specific advantage in one activity (Hymer, 1976). Second, the internalization approach applies transaction cost theory (*e.g.*, Williamson, 1975) to suggest that multinationals

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resident is not available. H1B applicants must hold a bachelor's degree or the equivalent in the specific specialty (*e.g.*, engineering, mathematics, physical sciences, computer sciences, medicine and health care, education, biotechnology, business specialties, etc.). Each fiscal year, the US Congress sets a cap on H1B admissions. The H1B visa is the main channel for US companies to employ foreign S&E workers in the US.

internalize the markets for their knowledge-based assets in multiple locations (Buckley and Casson, 1976). Finally, Dunning's (1980) eclectic OLI approach suggests the combination of firm-specific, location-specific and internalization advantages explain FDI decisions. Within that literature, offshoring can be seen as a new form of internationalization by which firms disaggregate their value chains across multiple locations, to include the option of potentially externalizing specific processes and capabilities to third-party service providers.

Earlier studies in the rich literature on internationalization of R&D have shown that large MNEs locating R&D outside the home country is not a recent phenomenon (*e.g.* Granstrand, *et al*., 1992; Kenney and Florida, 1994; Lall, 1979; Pearce, 1999). Cantwell (1995), for instance, showed that back in the 1930s the largest European and US firms carried out about 7% of their total R&D at locations abroad. However, since the 1960s this figure has been steadily rising, particularly in technologically intensive industries. Kuemmerle (1999a) shows in 1965 the 32 multinational firms studied in his paper carried out 6.2% of their R&D efforts outside of the home country boundaries, while in 1995 the corresponding figure was 25.8%. But with the exception of large MNEs in small countries, which have historically expanded their R&D activities offshore since World War II (Cantwell, 1995), the home country remained the most important single location for R&D (Patel and Pavitt, 1991) and the dominant organizational form was one of own and control. Furthermore, in the 1990s FDI involving R&D occurred primarily between a small number of highly industrialized countries (Florida, 1997; Kuemmerle, 1999b).

Researchers have examined the sequence of FDI in multiple host countries. Horst (1972) argues that multinational enterprises commonly expand through a series of host countries, starting with those that are geographically closest (see also Rugman and Verbeke, 2004). Kuemmerle (1999b) showed there are distinct waves of FDI in R&D by country of origin. US companies were pioneer investors in R&D facilities abroad and invested first in Europe, then in Japan, then in the rest of the world (primarily Canada, Australia and a small number of Asian countries). European companies invested first in other European countries, then in the US and then in Japan, but only to a very limited degree in the rest of the world. The surge of Japanese investments in the US, Europe and the rest of the world started in the early 1980s. Those investments significantly increased in the late 1980s and 1990s, doing so simultaneously in the US, Europe and in the rest of the world. The study also found that the US was the most attractive location for FDI in R&D, attracting 30% of all R&D sites established abroad.

A considerable part of the existing literature on FDI argues that FDI occurs when firms seek to exploit firm-specific capabilities in foreign environments (Dunning, 1993; Hakanson, 1990; Hymer, 1976; Vernon, 1966) and suggests that a high level of local R&D is carried out primarily to adapt products to local markets (Hakanson and Nobel, 1993; Howells, 1990). Traditionally, most FDI in manufacturing and marketing is consistent with this category. In the case of R&D, these are often called *asset exploiting* R&D (Dunning and Narula, 1995) or *home-base-exploiting* R&D (HBE R&D) (Kuemmerle, 1999a). Home-base exploiting R&D is mainly concerned with adapting home base R&D to local requirements and is likely to be closely connected to and located in proximity to foreign manufacturing and marketing (Several researchers have described the importance of FDI in R&D for exploiting firm-specific capabilities in foreign environments (Bartlett and Ghoshal, 1990; Hakanson, 1990; Vernon, 1966). They argue that as local demand grows increasingly sophisticated, local R&D capabilities are utilized to adapt existing products to local needs. As firms establish manufacturing facilities abroad and assign increasingly complex products to them, locating R&D sites in close proximity to factories becomes a requisite feature. These sites support the transfer of knowledge and prototypes from the firm's home location to actual manufacturing, especially in those regions where knowledge in particular technology sectors is accumulating rapidly. In addition, companies also may mandate the local business unit to invest in specific new R&D capabilities (Murtha *et al*., 2001). The importance of co-locating firm R&D capabilities with manufacturing operations offshore to serve local demand is also discussed in industrial geography (Howells, 1990) and technology management literature (Clark and Fujimoto, 1991; Hayes *et al*., 1988; Nonaka and Takeuchi, 1995; von Hippel, 1988).

In contrast to the capability-exploiting motive for FDI in R&D, a number of researchers have pointed out that the main driver for FDI in R&D might be a firm's need to augment its knowledge base (Cantwell, 1991; Dunning 1998; Florida, 1997; Howells, 1990). These are often called *asset augmenting* R&D (Dunning and Narula, 1995) or *home-base augmenting* R&D (HBA R&D) (Kuemmerle, 1999a). Home-base augmenting R&D requires developing links with host-country R&D resources to enhance the knowledge base at home and to more closely connect to the foreign R&D environment and gain access to local knowledge (Florida, 1997). Wesson (1993) has made a similar argument for FDI in general. These researchers argue that specific nations, and specific regions within them, might be particularly advantageous locations for locating R&D facilities because of the potential for knowledge spillovers from existing R&D and manufacturing networks. Such networks encompass research universities, publicly funded research institutes and innovative competitors. Feinberg and Gupta (2004) advanced the argument that potential knowledge spillover opportunities are highly relevant for the choice of offshore location. Accordingly, the gains obtained from knowledge activities (R&D and product development and design) are becoming increasingly important (Dunning, 2000). Other externalities that make a country attractive for FDI in R&D involve the availability of supporting industries offering inputs, such as firms that provide laboratory equipment, maintenance or specialized laboratory testing services. A direct extension of these dynamics is the emergence and evolution of global R&D networks which are separate and distinct from R&D FDI or green field R&D investments (see Murtha, 2004)

The rapid advances in IT and ICT have greatly enabled the ability of firms to dis-intermediate and externalize innovation processes through outsourcing and relocation of R&D groups and laboratories overseas (Howells, 1990 and 1995). Moreover, companies seem to increasingly choose offshore locations independent of geographical distance and have located their ITO, BPO and other functions and processes in less developed, lower-cost countries. The particular case of the more recent wave of offshoring innovation should therefore be understood as part of the broader phenomenon of internationalization of R&D (Murtha, 2004). Recalling our earlier definition of offshoring, it appears that R&D offshoring strategies may be evolving from *home-base augmenting* (HBA) to what we can define as *home-base replacing* (HBR) of innovation activities and capabilities. This seems to be the case for large MNEs, whose strategies have been discussed more extensively in the IB literature. Smaller and medium-sized companies (SMEs) in particular may be adopting innovation offshoring strategies that are intended to augment their limited innovation capabilities (HBA). Moreover, in the cases of the emergence of a new industry, offshore R&D may not be so much about *replacing* home based capabilities as it may provide an MNE with geography-based knowledge access in a born-global industry where it might otherwise fail to achieve any position at all (Murtha, et. al., 2001).

In order to explain why firms choose this new form of organizing the innovation process, we rely on the literature on innovation and change, which suggests that environmental forces and managerial practices co-evolve in influencing the adoption of innovation, new organizational forms and new practices by firms (Lewin and Volberda, 1999, Lewin, *et al.*, 1999, Murmann, 2000, and Volberda and Lewin, 2003). Along the same lines, it has been argued that internationalization paths and processes should be viewed as the joint outcome of management intentionality, experience-based learning, and institutional forces (Flier, *et al.*, 2003; Hutzschenreuter, *et al.*, 2007). Following this stream of research, we adopt a co-evolutionary framework and argue that the adoption of innovation offshoring by firms is the result of three types of factors which affect offshoring dynamics and evolution at different levels: (macro) environmental factors; (micro, project level) managerial intentionality; and (meso, firm level) organizational path dependence and learning.

The environment

Reflecting on and testing all the environmental variables that potentially affect decisions by firms to offshore innovation are beyond the scope of this paper. Manning, *et al.,* (2008) provide a comprehensive perspective on the co-evolutionary dynamics that are shaping the evolution of offshoring and the related globalization of innovation, identifying macro-economic forces, domestic and offshore national policies, industry dynamics and firm-level offshoring capabilities driving offshoring decisions. Kshetri (2007) also shows how institutional factors such as regulations, rules and habits influence offshoring decisions, while Murtha and Lenway (1994) discuss how host governments affect MNEs' strategies, particularly by promoting offshore outsourcing through subsidies to locally-based subcontractors (Murtha, 1991; 1993).

In this paper, we consider the growing shortage of technical and scientific talent in the US as a constraint on the ability of companies to staff innovation activities with domestically available talent. Policy debates over the growing shortage of workers with scientific degrees have been increasing in frequency and intensity in the US, and in other countries (Cohen and Zaidi, 2002), reflecting the fact that the shift to a knowledge-based economy results in an increased importance, as well as scarcity, of knowledge workers. Freeman (2005) provides data suggesting job market and economic opportunities for science and engineering (S&E) graduates in the US have worsened compared to those of other high-level occupation fields such as Law or Medicine. As a consequence, fewer Americans are attracted to these fields of study. However, Freeman (2005) also highlights that S&E job market conditions remain sufficiently good to attract highly qualified immigrants. Moreover, an increasing percentage of S&E PhDs are earned by foreign-born students (39% in 2000 compared to 6% in 1966). This fact by itself would not be a cause for alarm if these foreign students trained in the US were staying in the US. But it seems that increasingly they take advantage of the growing work opportunities in their home countries (Chanda and Sreenivasan, 2005; Lieberthal and Lieberthal, 2003; Zweig, 2005).

As illustrated in Figure 1, the number of US nationals earning Master and PhD degrees from US Science and Engineering Schools has been declining steadily starting in 1995. Conversely, the number of foreign workers on H1B visa, normally 65,000, the majority of whom work in science and engineering fields, increased steadily between 1998 (135,000) and 2003 (195,000). But in 2003 the US Congress did not renew the H1B visa quota at the 2002 level and the quota lapsed to the pre-1998 level. Since then, the quota has remained constant at 65,000. The combined result of these two forces is that in 2006, the number of S&E workers available to work in the US is below the 1995 level. At the same time, US GDP has increased between 1995 and 2006 by 43%, suggesting a growing demand for, and a possible shortage of S&E workers. Economic theory would suggest that wages will adjust so that market conditions will improve and the shortage will be avoided. However, because the S&E job market has become global, the adjustment, if any, is likely to require much more time than in the period when labor markets were still very much nationally bound. The fact that companies are able to offshore even technically-advanced activities allows them to access S&E workers globally to support their domestic operations, which counteracts the pressure on wages in the US and may therefore delay the possible market adjustment. This might be a reason why traditional economic indicators such as wages and unemployment rates do not seem to confirm the perceived shortage of S&E (Butz *et al*., 2003). This is also consistent with Farrell, *et al*., (2006) findings that the growth of offshoring innovation work will not trigger sudden upward discontinuities in wages and employment in developed nations. However, the prospect of stagnant or declining real wages in science and technology industries in Western countries may negatively affect the balance of inducements and contributions (March and Simon, 1958) for entering science and engineering careers in the US.

Insert Figure 1 about here

Consistent with Oliver (1991) we assume that companies strategically react to consequences of misalignments between their strategic needs and the configuration of the institutional structure and the macro environment in which they are embedded. In the present case, the decline in number of US nationals (and permanent residents) with advanced degrees in science and engineering combined with H1B visa quota cutback have caused the misalignment. Firms can react by, for example, escaping the institutional constraints of the country (Witt and Lewin, 2007) and responding to the emerging talent shortage by accessing talent offshore and by learning to globalize their innovation activities. But consistent with Oliver (1991), we do not expect that all firms perceive the shortage of talent at the same time or adjust to it in the same way (Nelson, 1991). Some companies may resign themselves to the situation, hire less qualified workers or voice (Hirschman, 1970) their concerns and demand political resolution through their industry associations or lobbying networks, which indeed did enact the annual H1B quota for highly skilled talent to work in the US. However, agreeing to and implementing radical structural changes in the configuration of national institutional structures that would increase the attractiveness of careers in science and engineering (*e.g.*, reforming the teaching of mathematics and science in the K-12 educational system) or attract scientists and engineers to work in the US are politically very complex issues to resolve and very bureaucratic to implement, and therefore require much time[3].

At the same time the attractiveness of S&E careers diminishes in the United-States, the talent pool of several offshore countries has been increasing. Ernst (2006) finds the success of Asia in attracting innovation offshoring largely results from major investments in improving and expanding the talent pool available. For instance, first year doctoral students in S&E in China increased six-fold between 1995 and 2003 (Freeman, 2005). In parallel, the Chinese government has launched programs targeted at retaining university graduates in China as well as attracting talent from abroad, Chinese and other nationalities (National Science Board, 2004). In fact, instead of an absolute shortage of S&E, which would probably appear in wage and employment statistics more than it currently does, the US may be facing a *relative* shortage of technical skills compared to worldwide supply. In other words, even though companies may be able to find the S&E talent in the US required for their current needs, unless other constraints such as IP issues deter them from doing so, they might prefer investing in countries where the relative pool of talent is larger and/or because of the opportunity to grow their S&E workforce as their business expands in the future. Another consideration for some companies is the realization that the countries with a

[3] For a report on policy proposals intended to increase the supply of engineers and scientists in the U.S. and a discussion of the consequences of a continued shortage of engineering and science talent in the U.S. see "Rising Above the gathering Storm: Energizing and employing America for a Brighter Economic Future" Committee on Prospering in the Global Economy of the 21st Century: An Agenda for American Science and Technology, National Academy of Sciences, National Academy of Engineering, Institute of Medicine, ISBN: 0-309-65463-7, 504 pages (2005).

large potential supply of S&E professionals also represent fast growing middle class markets that many US firms seek to enter. Learning to source and manage S&E activities in these countries might constitute a longer term advantage as companies utilize their new local product development capabilities to start developing products adapted to the needs of both these local markets and their home markets.

Managerial intentionality

Hutzschenreuter, *et al*., (2007) present managerial intentionality (MI) as a key factor underlying the observed heterogeneity in industry performance, internationalization paths, or innovation activities. According to the authors, MI encompasses different bundling of firm specific strategies such as growth strategies to become global, orientation towards innovative (early mover) or mimetic (follower) internationalization strategies, managing adaptive tension (internal rate of change), use of slack resources, attitude towards employee creativity and initiative-taking, and so on.

The idea behind the concept of managerial intentionality is that managers have certain strategic objectives in mind that they translate into certain decisions, which influence firm-level outcome. In the area of offshoring, many different strategic objectives have been recognized as playing a role. Dominant conventional wisdom has been that the primary driver for offshoring IT centers, IT applications and business processes is to realize cost savings from labor arbitrage (see, *e.g.*, Dossani and Kenney, 2004; Khan and Islam, 2006; Quélin and Duhamel, 2003). However, Lewin and Peeters (2006a and 2006b) report a notable evolution in the strategic drivers with the emergence of company growth, access to qualified personnel and service improvement as increasingly important objectives leading firms to initiate offshoring projects. Several studies also show that the importance of cost savings as a driver of offshoring tends to decline as companies gain experience with offshoring and experiment with offshoring of increasingly complex and advanced activities. For instance, Pedersen and Jensen (2007) show that cost factors determine the initial decision to offshore but do not affect subsequent evolution towards offshoring of more advanced activities, confirming earlier findings by Maskell, *et al*., (2007) that companies evolve from seeking cost reductions to knowledge-seeking objectives. Similarly, Dossani and Kenney (2003) illustrate the change in companies' mindset, from cost to quality.

Recent work by Bunyaratavej, *et al.,* (2007) has also demonstrated that cost is not as important as the mass media might suggest, but that access to skilled and qualified personnel is a substantial driver of services offshoring among firms. Namely, they argue and find support for the notion that firms seek to obtain parity in terms of the quality of the onshore workforce, but at some level of discounted wages. However, since Bunyaratavej, *et al.,* (2007) studied actual offshoring activities rather than managerial intentions, the model developed in the present paper, which involves managerial perceptions regarding access to qualified personnel by discrete offshoring projects, provides new insight regarding possible divergences between managerial intentions and firm-level actions.

In this paper we investigate four main types of firm-specific objectives as expressions of managers' intentionality that may determine decisions to offshore innovation and product development projects (beyond cost savings): access to qualified personnel, accelerating growth, increasing speed to market and becoming global players. Ernst (2006) argues that competing in the emerging global market for knowledge workers has become a strategic priority especially for high tech firms; as such competition creates new sources of talent which of necessity must be tapped in order to optimize human capital. Combined with the evidence on the tight labor market for S&E graduates in the US, this suggests that the need to find and recruit qualified personnel is likely to be an important determinant of the decision to offshore product development work. Similarly, as a means to increasing the pool of resources (talent) available to a firm, offshoring can alleviate some constraints that are potentially impeding the achievement of the firm's growth objectives. The growth strategy of a firm may involve expansion of existing businesses and entering new markets. For science- and technology-based companies in particular, exploiting new market opportunities often requires access to engineers and scientists capable of developing new products and technologies or adapting existing ones. Companies with significant growth objectives may therefore decide to offshore some of their product development activities to countries where such talent are in relative abundant supply. The pressure to increase speed to market with new or improved products faster than competition may also affect companies' offshoring strategies. Speed to market can be improved by having access to a flexible pool of qualified engineers necessary for responding to changes in demand and for exploiting market and technological opportunities, as well as by new organizational arrangements that enable development around the clock (most product development teams typically work the day shift in the US). Deploying teams of qualified engineers offshore has been shown to provide flexibility for scaling product development efforts up or down as needed, and to allow companies to manage product development processes using a "follow the sun" schedule. Finally, internationalizing innovation through offshoring leads firms to further globalize their activities as they tap new geographic knowledge clusters (diverse labor pools, specific expertise anywhere in the world).

Path dependence

It is unlikely that offshoring decisions will exactly reflect a manager's vision of what should or should not be offshored at any moment in time. Offshoring decisions are also constrained by the offshoring journey a firm has followed in the past, and is influenced by past learning on how to manage offshoring projects. In other words, whether a firm does have some past experience with offshoring or not, and the kind of functions or processes previously offshored, serve to further enable or constrain future offshoring decisions.

The path dependence of offshoring practices has already been recognized by several authors. For instance, Lewin and Peeters (2006a), Maskell, *et al*., (2007) and Pedersen and Jensen (2007) describe the adoption of offshoring by firms as a progressive learning-by-doing process through which firms offshore increasingly advanced activities, including innovation activities. This experience-building process that leads firms to eventually offshore innovation confirms earlier research by Pisano (1990) who argued that R&D procurement decisions are driven in part by historical factors. Three main reasons can explain the role of companies' past experience in determining their offshoring decisions. First, the behavioral and evolutionary perspectives of firms' practices suggest that, because of the search rules (Cyert and March, 1963) and routines (Nelson and Winter, 1982, Nelson, 1991) normally used by firms, a history of internal R&D sourcing is likely to lead to the continuation of internal R&D sourcing even if the environment changes incrementally. Second, several authors have used transaction costs theory to explain firms' sourcing decisions (*e.g.*, Calantone and Stanko, 2007; Murray and Kotabe, 1999; Murtha, 1993, 1991; Pisano, 1990). The argument is that firms with no experience of R&D outsourcing are likely to continue sourcing R&D internally because experience with internal sourcing reduces the cost of performing the R&D activities internally (Coase, 1937). Similarly, it may be risky for these firms to start experimenting with a new form of R&D sourcing. The same reasoning applies to offshoring decisions. Finally, firms' past experience may also influence the range of possibilities managers consider when making offshoring decisions (Hutzschenreuter, *et al.*, 2007).

3. Methodology

The Offshoring Research Network

This research uses data collected in the context of the Offshoring Research Network (ORN) project on offshoring of technical and administrative work. ORN was launched in 2004 at Duke University Center for International Business Education and Research (CIBER), The Fuqua School of Business[4]. In 2004 and 2005 ORN focused on surveying the offshoring practices of US-based companies. In 2006, the online survey was extended to involve research partners from EU universities[5] that recruit companies in their country to participate in the survey as well as conduct case studies. At the core of the ORN project is the contextual commonality of the survey, the centralized online

[4] As of 2006, the ORN lead corporate sponsor is Booz Allen Hamilton, the global management consulting firm. The 2004 and 2005 surveys were supported by the Duke CIBER and Archstone Consulting LLC. In 2007, The Conference Board and PriceWaterhouseCooper became lead collaborators of the ORN Project.

[5] Partner Universities include Copenhagen Business School (covering Scandinavian countries), Wissenschaftliche Hochschule fur Unternehmensfuhrung (Germany), RSM Erasmus University (Netherlands), IESE (Spain), Manchester Business School (UK), ULB - Solvay Business School (Belgium), and Bocconi University (Italy).

administration of the survey (in native business language of a country where necessary) each year. The core survey enables tracking the evolution of offshoring practices involving seven main areas: the functions offshored, choice of offshore location and rationale for this choice, type of service delivery model used (captive, third party, hybrid), strategic drivers of offshoring, perceived risks, performance metrics, and future offshoring plans (18-36 months out).

A unique feature of the ORN survey is its focus on surveying the specific offshore project implementations rather than companies' general experience with offshoring. In practice, this means every specific function that a company (sometimes involving multiple respondents from same company) has offshored in a particular location is identified by the year it was launched and is treated as a separate observation. This survey design results in a very fine-grained database that enables an analysis of offshoring dynamics across various administrative and technical functions located in a wide range of countries or regions of the world, across industries and across types of delivery model (captive, third party or hybrid). Finally, the ORN database includes both companies that already offshore as well as companies that have considered offshoring but have not yet initiated the offshoring of any application.

Data

The present paper uses data from the 2005 and 2006 ORN annual surveys of US companies. The database comprises 253 companies and 880 different offshore implementations, most already operating and some in preparation at the time of the survey. Launch dates of offshore implementations range from 1990 to 2006 and are available for 476 implementations. The sample comprises both large and small companies operating in various industries (see Table 1). Median company employment is 1,750 employees and the average company employment is 22,691 employees.

Insert Table 1 about here

The analysis of the ORN survey classifies offshore implementations into six main functional categories (see Table 2): Administrative (finance and accounting, human resources, legal services, and other back office activities), Contact Centers (call centers, help desks, and technical support), IT (Information Technology-related activities), Procurement, Product Development (R&D, engineering services and product development and design, including software design), and Marketing and Sales. IT applications were among the earliest to be offshored and account for the highest share of implementations in the sample (26%). This may also be a direct consequence of the positive service and quality reputation of India, which continues to be the most preferred offshore location (specifically as regards IT, see Henley, 2006). More surprising is the finding that 26% of offshore implementations involve product development activities. This suggests that companies are offshoring innovative activities that constitute the core of a firm differentiation and value creation strategy. Administrative activities also represent a large share of surveyed implementations (22%). Despite the large coverage in the press and popular media, contact centers represent only 17% of offshore implementations.

Insert Table 2 and Figure 2 about here

ORN data show that "access to qualified personnel" has emerged as the second most important strategic driver of offshoring. On a five point Likert scale it is rated important or very important (4 and 5) for 77% of offshore implementations surveyed. Similarly, the survey reveals that availability of sufficient talent pools and adequate expertise have also emerged as very important reasons for why US firms select particular offshore locations. The particular strategic objectives underlying offshoring decisions vary depending on the type of function offshored (see Table 3). The access to qualified personnel objective is the second most important for both product development and non product development offshore implementations. But the percentage of implementations for which this objective is rated important or very important is higher for innovation-related offshoring. In fact, this pattern of similar ranking but higher relative importance for product development implementations applies to the other major strategic drivers of offshoring as well: non-labor cost savings, growth, global strategy, competitive pressures and speed to market.

Insert Table 3 about here

Finally, industries differ in their proportion of product development offshoring, as well as offshore countries differ in their ability to attract this type of offshoring (Table 4). In the Software and Programming industry, almost 50% offshore implementations concern product development. In Business and IT services, Health/Biotech/Pharma, Manufacturing, and Technology industries about one third of offshore implementations are in product development. The very high percentage for the Professional Services industry should not be extrapolated too much given the very low number of observations. Finally, Financial Services and Other Services, although actively involved in offshoring, have undertaken only a few implementations related to product development.

Insert Tables 4 about here

Regarding offshore locations, the proportion of product development implementations out of total offshore implementations is the highest for China (44%). Other Asian countries also attract proportionately more innovation offshoring than other locations. Weakest regions in terms of product development offshoring are the Philippines, Mexico, Canada and Latin America. Contrarily to China, Mexico does not seem to have been able yet to upgrade its capabilities to move from manufacturing production offshoring to higher value activities in product development.

Empirical validation

To empirically test possible determinants of firms' decision to offshore product development work, we specify a model that estimates the probability of offshoring product development projects as a function of a series of variables related to the firms' environment, past experience, and managers' strategic objectives, and a set of control variables that account for differences in firms' size and industry, and in location and service delivery model of offshore implementations. The equation is estimated as a binary logit model where the dependent variable reflects the type of function offshored, whether product development (R&D, engineering services, or product design) or not. Table 5 provides a detailed explanation of the construction of the variables.

Insert Table 5 about here

The environment in which firms operate influences their offshoring decisions in many ways. In this paper we study the effect of the supply of technical talent in the US, consisting of US Science and Engineering graduates and foreign workers on H1B visas, on the decision to offshore innovative work and services. In order to take into account the declining supply of highly skilled scientists and engineers possibly leading to increasing product development offshoring, we use the number of S&E Master and PhD degrees and the level of the H1B visa quota on the year the offshore implementation was initiated, in logarithm (lnSEH1B)[6]. Data on graduates and visa quota come from the US National Science Foundation and the US Citizenship and Immigration Services respectively. We expect the variable of the supply of technical talent to have a negative impact on product development offshoring decisions, i.e., the larger the pool of technical talent available in the US, the lower the probability of offshoring product development.

To test for the effect of managerial intentionality as a determinant of the probability to offshore product development, we use the ORN survey responses related to the strategic drivers that led companies to initiate their various offshore projects[7]. We selected seven managerial intentionality strategic drivers on the basis of their importance for offshoring PD and non-PD implementations (see Table 3, which also

[6] Alternative measures were tested in the model, including rates of growth and discounting for GDP/pro capita GDP. We chose the operationalization which showed the best performance.

[7] The survey question was: "For each function, please evaluate the importance of the following strategic drivers in your decision to offshore", to be evaluated on a 1 to 5 Likert scale ranging from not important at all to very important.

reports the Chi-2 test and probability that the proportion of 4 and 5 answers for PD and non-PD are significantly different) and on the basis of previous research reported in extant literature. The seven strategic drivers are: access to qualified personnel offshore (QUAL_PERS), realization of labor cost savings (COST_LABOR), realization of other types of cost savings (COST_OTHER), contribution to firm business growth plans (GROWTH), contribution to firm global strategy (GLOBAL), accelerating speed to market (SPEED), and response to competitive pressures (COMPETITION). We expect all strategic drivers to have a positive impact on the probability to offshore product development work, except for labor cost savings and competitive pressures, which involve short term strategies as compared with longer term innovation strategies offshore.

We also expect the probability of offshoring product development to depend on the number of product development projects the company has already offshored in the past (PAST_EXP_PD). The learning process of offshoring involves overcoming crucial coordination and knowledge flow challenges central to effective innovative activities. Firms that have already offshored product development activities are assumed to have developed managerial and coordination competences which increase the probability of deciding to offshore more innovation related projects.

Another important aspect of offshoring strategies is the choice of delivery model for undertaking activities outside the domestic boundaries. The mode of entry in an international market has been extensively discussed in the literature (*e.g.,* Dunning, 1993). A firm basically has four choices when establishing new R&D facilities abroad: establish a greenfield site; build up new capabilities in a subsidiary not previously involved in R&D; make an acquisition, or enter into a joint venture." Caves (1996) argue that multinational enterprises will refrain from FDI through joint ventures when the protection of intangible assets is important to the firm. Mansfield (1984) found that firms are more hesitant to transfer process technology abroad than product technology because it is more difficult to protect process technology from appropriation by local entities and because process technology often manifests unique firm capabilities while product technology represents only the outcome of these capabilities. On the other hand, acquisitions or captive facilities bring high risk of attrition of assets, such as human assets which are highly mobile.

The ORN survey includes questions about the delivery model used for each project that was offshored: captive, outsourced to various service providers (local, same nationality, international) or joint venture. Quinn (2000) argues that tapping the knowledge and capabilities of external organizations has become crucial for firms to stay ahead of the innovation race, leading them to outsource more and more elements of their innovation value chain. The externalization of product development is increasingly being extended to offshore destinations. However, the ORN survey reveals that, due to concerns about a possible loss of control over strategically important activities, most companies offshoring product development activities favor offshoring through a fully owned subsidiary – what is also referred to as the captive model of offshoring – over the offshore outsourcing model. But not all firms have the resources and scale to launch a captive organization offshore, which can influence the decision to offshore product development or not. To control for this possible effect we introduce in the model a dummy variable that takes the value of 1 if the offshore implementation is a captive organization, and 0 otherwise (Captive).

In the model, we also control for firm size and industry, and for the region where the offshore implementation is located. The size of the firm and the industry in which it operates is assumed to influence the relevance of pursuing a product development offshoring strategy, as well as the feasibility of such a strategy given the organizational challenges associated with operating geographically dispersed innovation teams. Size is expressed as the logarithm of the number of employees (lnEmpl). Seven industry dummies ($Industry_p$) are used as control variables in the regressions. Moreover, some countries are more likely than others to attract innovation offshoring projects. As discussed above the offshoring decision is influenced by location advantage, such as national investments by offshore countries in the development of pools of qualified workers. But offshore countries are not equally interested in making such investments or equally effective in developing such talent pools. ORN survey data reveal important differences in the proportion of product development projects across countries (see Table 5), which will be controlled for in the regressions using nine country dummies ($Country_q$). The last control variable accounts for a possible change in the decisions to offshore innovation activities starting in 2003 and which is not accounted for by the other variables of the model. Starting in 2003, some companies are making changes in their sourcing strategy compared to earlier years for two reasons. First, the new H1B visa regulation (quota decreased from 195,000 to 65,000) and second, the American economy resumed its economic growth after two years of economic recession that followed 9/11.

The estimated equation is shown below, where *a* is the constant intercept and ε is the error term:

$$Prob(\text{PD}) = a + b\ \text{lnSEH1B} + c\ \text{PAST\_EXP\_PD} + d\ \text{QUAL\_PERS} + e\ \text{COST\_LABOR} + f\ \text{COST\_OTHER} + g\ \text{SPEED} + h\ \text{GROWTH} + i\ \text{GLOBAL} + j\ \text{COMPETITION} + k\ \text{lnEmpl} + l\ \text{Captive} + m\ \text{D2003} + \sum_{p=1\to 7} n_p\ Industry_p + \sum_{q=1\to 9} o_q\ Country_q + \varepsilon \qquad \text{(Equation 1)}$$

Descriptive statistics and correlations between the explanatory variables are reported in Table 6.[8]

Insert Table 6 about here

4. Results

Table 7 reports the estimation results for Equation 1. The first column shows estimated coefficients for the control variables (Col. 1), followed by odd-ratios (Col. 2). The

[8] Three correlation coefficients, between Speed and Global, overall supply of S&E and D2003, and between Cost of labor and Other costs present medium values (respectively 0.43, -0.43 and 0.38) and statistically significant at 1%. However, when we entered the two variables involved separately the regression results differed only marginally indicating these correlations do not affect the regression model.

coefficients of the full model with control variables and explanatory variables are in Column 3, followed by odd-ratios (Col. 4).

Insert Table 7 about here

Of the three types of factors included in the model, supply of S&E graduates, past experience with offshoring PD and the set of variables representing managerial intentionality, only the latter are statistically significant. In particular, among the strategic drivers of offshoring, access to qualified personnel, increase speed to market and reducing other costs (non labor costs) have a positive impact on the probability of offshoring PD, whereas concerns about labor cost savings and offshoring for growth objectives decrease the probability of offshoring PD. Offshoring as part of a global strategy and responding to competitive pressure have the expected sign but not very high probability of impacting the probability of offshoring PD (Col. 3).

The negative and significant coefficient of labor cost savings and the positive and significant coefficient of other cost savings clarifies the role of labor arbitrage opportunities in explaining offshoring of technical and administrative work. The analysis indicates offshoring is a strategy for increasing cost efficiency also for PD activities, but not through labor arbitrage. Combined with the result of a positive and significant coefficient for the access to qualified personnel variable, our analysis suggests that labor costs savings and the need to offshore in order to access qualified personnel are two distinct strategies that companies do not confuse. Cost savings opportunities are an important driver for many offshore implementations, but when firms need to support their product development strategies in the face of talent scarcity, labor cost considerations are less important relative to accessing talent anywhere.

The significant negative coefficient of the growth strategy variable indicates that although some companies (smaller ones in particular) offshore product development work to support their expansion plans, offshoring of innovation activities is a separate strategy from firm growth strategies. One possible explanation is that growth strategies require a shorter time investment than innovation projects, especially basic research which requires more time. Innovative processes and activities normally have longer term time horizons whereas growth is more likely to have shorter time horizons. Therefore, if companies are focusing on shorter term growth objectives it is less likely that they will attend to offshoring PD activities.

The positive and significant coefficient of speed to market validates the hypothesis that companies offshore PD activities as a way of speeding up their innovation process and introducing products on the market quicker, by means of higher flexibility to scale product development efforts up and down and of around the clock PD processes.

In order to interpret the results better and discuss the magnitude of the estimated effects, we included the odd-ratio calculations (Col. 4). The significant ratios can be interpreted as the increase/reduction in likelihood of offshoring PD over other Non PD projects when the importance of a particular strategic driver increases by 1 point on the 5 points scale. We therefore expect a 1-point increase in importance attributed to labor cost savings objectives to result in a 38% reduction in the probability of offshoring PD over other types of functions. However, efficiency improvements (other cost savings) are significant in explaining offshoring of PD since higher non-labor cost savings objectives are associated with a massive increase in the probability of offshoring PD (odd-ratio of almost 300%). Similarly, a 1-point increase in access to qualified personnel or in increasing speed to market objectives increases the probability of offshoring PD over other types of functions by 67% and 73% respectively. Finally, a 1-point increase in the importance of growth objectives diminishes the likelihood of offshoring PD over other functions by 36%.

The negative effect of firm size indicates that smaller firms have higher probability of offshoring PD projects, suggesting that offshoring enables smaller, more agile companies to augment their innovation capabilities (HBA) more than larger and less flexible companies. The dummy for captive model of offshoring is positive and highly significant. The odds ratio clearly shows that captive operations are much more likely to be involved in PD projects than outsourced operations. This result supports the argument that innovative activities require a higher degree of coordination and stronger governance structure that facilitates knowledge flow and integration and reduces the risk of IP leakage, all of which is made easier in fully owned subsidiaries compared to outsourcing. The sector dummies indicate that, compared to Financial Services, all other sectors have a higher probability of offshoring PD, with the exception of Other Services. In terms of destinations, there is some evidence that compared to Latin America PD projects are more likely to be offshored to China and other Asian regions, but less to the Philippines.

The diagnostics at the bottom of table 7 indicate that overall the model is meaningful (LR Chi2). Consistent with a co-evolutionary framework, a possible reason for lack of significance of the other independent variables may be that each variable explains a different level of influence in the decision to offshore PD. Managerial intentionality is measured at the level of the specific project that is offshored (our unit of analysis). Past experience is a company-level variable and the supply of S&E graduates is an exogenous environmental level factor. However, all three elements are relevant to the model that we specified and are consistent with understanding offshoring as a multi-level phenomenon. In order to explore further the role of the two other variables (supply of S&E graduates and company experience with offshoring PD) we re-ran the regressions and omitted the managerial intentionality variables (Table 8). From a methodological point of view, regressing the probability of offshoring PD on company experience and the exogenous supply of S&E also overcomes the common method problem of using only same-survey items (managerial intentionality items).

Insert Table 8 about here

Table 8 shows that the domestic supply of scientists and engineers (US citizens with post-graduate degrees in science and engineering and foreign workers with H1B visas) has a significant negative effect on the probability of offshoring PD (Col. 1), supporting our conjecture that the lower the supply of skilled and experienced workers in the US, the higher the probability of offshoring R&D, engineering services and product design. Furthermore, consistent with the importance of cumulative learning and acquisition of idiosyncratic knowledge as a consequence of implementing and managing product development activities offshore, past experience with offshoring product development increases the probability that companies further offshore PD (Col. 2). When supply of S&E and past experience variables are simultaneously introduced in the model (Col. 3), the results for the main variables and controls are maintained. However, the structural dummy for 2003 becomes significant with a negative sign, indicating that projects implemented in 2003 and the following years have a 41% lower probability (the odds ratio is 0.593) to be focused on product development relative to other functions.

Considering the trends observed in Figure 1 and this last result, the sample was divided into two subsamples and the equation for implementations launched between 1990 and 2002 – and for implementations launched between 2003 and 2006 – were estimated separately[9]. Recall that the US congress changed the H1B quota in 2003 (decrease from 195,000 to 65,000) and the US economy began to rebound after two years of stagnation. These two factors represent significant exogenous changes affecting the environment within which US firms operate. The results for the model estimated over the two sub-periods, pre- and post-2003, are reported in Table 9. Due to the limited size of the two subsamples, the number of industry and country dummies was reduced to control for differences between the two most important locations of offshore implementations (India and China) and other possible offshore regions, and for differences between technological and non-technological industries. The supply of S&E graduates and company past experience with offshoring are not significant in the sub-period analyses (same results as for the full model). However, with regard to the central question of this paper - the effect of accessing qualified personnel and sourcing skilled workers offshore - a striking difference between the two subsamples emerges. Although this strategic objective was not an important driver of firms' decisions to offshore PD up

[9] We tested the models also for pre 2003 and post 2004 subsample, and obtained very similar results. The correlation tables for the two sub-periods are very similar to those of the whole period and therefore are not reported. Results are available from the authors.

to 2002, it becomes highly positive and a significant determinant of the probability to offshore PD projects that are initiated as of 2003. Offshoring as part of the company global strategy is another determinant of the probability to offshore PD that becomes significant beginning in 2003. Conversely, the negative effect of labor cost savings loses significance in the post-2002 sub-period, suggesting that in recent years labor arbitrages objectives lost in importance as a differentiator between PD and-Non PD offshoring decisions. Finally, three changes in the significance of control variables should be noted. First, China used to have a location advantage for offshoring PD projects, probably because companies had a preference for locating engineering and product development capabilities in close proximity to existing manufacturing plants (Kenney and Florida, 1994; Murtha, *et al*., 2001), consistent with an HBE offshoring strategy. However, the findings suggest that China's profile in terms of the type of offshoring it attracts is converging to that of other regions. This can be due to two dynamics developing simultaneously: China is diversifying its economy and making national investments in human capital, and other regions are also improving their technical skills. Second, offshoring of PD in the post-2002 period is expanding to non-technological industries. Third, the importance of controlling PD activities through captive organizations is declining in later years (post 2002). This is the result of companies adopting globally flexible organizational structures for organizing and managing PD projects and at the same time of service providers (especially smaller ones) offering innovation outsourcing specializations.

Insert Table 9 about here

Finally, as in the case of the full sample, we ran the regressions with only the supply of S&E and company past offshoring experience as independent variables (Table 10). We find that they do affect the probability of offshoring PD, but only in the first sub-period up to 2003. Our results suggest that, between 1990 and 2003, offshoring of PD projects was driven by the objective of reducing costs (but not through labor arbitrage) and by the need to increase speed to market. In the post-2003 period, access to qualified personnel emerges as the strongest driver of offshoring PD projects. In other words, regardless of the domestic supply of S&E, companies are learning that workers offshore are highly qualified and they are adopting strategies and organizational capabilities to recruit talent any place in the world. Early anecdotal evidence suggests that innovation offshoring strategies are evolving to a new configuration that we define as flexible globally distributed (FGD) innovation activities and capabilities. This seems to be the case for large MNEs, such as pharmaceutical companies which, despite adopting offshoring later than other MNEs, have started experimenting with new R&D organizational configurations designed to simultaneously decrease the fixed footprint of R&D and increase the rate of new product development activities.

Insert Table 10 about here

5. Discussion: The global race for talent and offshoring innovation

Consistent with internationalization research, we show that firm strategy to search for and access talent globally is a further manifestation of firms internationalizing their operations by seeking assets or capabilities outside of their national boundaries (Wesson, 1993; Caves, 1998). Offshoring is a new variation of foreign direct investment (FDI), or international joint ventures, or partnerships for building firm-specific, location-specific or internalization advantages (Dunning, 1980). Dunning (1993) has identified market-seeking, resource-seeking, efficiency-seeking, and strategic asset-seeking, as motives for developing foreign operations. Within this framework, seeking and accessing talent globally is another example for seeking resources (*i.e.*, knowledge and qualified workers) and also seeking efficiency (*i.e.*, cost reduction).

However, in this paper we argue that talent is a different type of asset and the search for talent globally is emerging as a new phenomenon. Companies are not just diversifying their sources for talent, but are entering an era in which they must compete for talent (see the *Economist* special report of October 5, 2006). Consistent with the resource-based view of the firm, unobservable and inimitable organizational knowledge and processes are sources of firm competitive advantage and account for much of the variation in firm performance (Barney, 1991; Wernefelt, 1984). Talent is to a great extent an intangible resource that is embodied in individuals, groups and social networks, and learning to organize and manage talent globally becomes an idiosyncratic capability that is unobservable and difficult to imitate. Talent is an integral element of the knowledge base of the firm and consists of a wide range of highly specialized technical skills and knowledge (*e.g.*, process knowledge). The realization that the absence of a specific skill or expertise is critical for proceeding with a project often only becomes evident during the process of undertaking specific projects, especially in the case of product innovation. In comparison to typical physical assets, talent is characterized by a different kind of obsolescence (*e.g.*, embedded in geographic knowledge clusters or networks). It is also highly mobile and must be renewed on an ongoing basis by managing variation and through appropriate HR strategies such as training and retraining.

Furthermore, the dynamics of the supply of engineering and science talent are changing. In addition to the effect of the aging of the population, for reasons that are not well understood, fewer young people in western economies are selecting advanced degrees for entering careers in science and engineering. It is beyond the scope of this paper to review the many factors that affect this change in preferences except to note that this trend affects all the industrialized countries in the Triad (US, EU, and Japan). At the same time, Asian countries such as India and China and certain countries in Eastern Europe and in Latin America are becoming recognized as suppliers of highly qualified engineering and science talent. If companies are realizing, as the *Economist* special report of October 2006 argues, that they are facing a race for talent because of a growing shortage of talent, then the phenomenon under investigation is about companies competing for talent globally and not only about seeking engineering and science resources in low-cost countries (*e.g.* Belderbos and Heijltjes, 2005; Khanna and Palepu, 2004).

The rise in the frequency of companies citing access to global pools of qualified personnel and expertise as strategic drivers for offshoring product development applications and for selecting certain country locations may be indicative of companies recognizing the growing shortage of technical talent in the US. In this context, the increase in the H1B visa quota (between 1998 and 2002) can be understood as a response by policy makers to the lobbying by companies for relief from the growing engineering and science talent shortage. The empirical analyses presented in this paper support our argument that the drastic decrease in H1B visa quota in 2003 impacted the ability of many companies to execute their innovation strategies. In order to adapt to this significant change in their environment, companies entered a global search for talent (most likely unaware that they were entering a global race for talent) that led them to offshore product development activities to countries and cities where they could find sufficient pools of qualified personnel and expertise for increasingly advanced and complex PD projects.

Our conclusion is consistent with recent work on the growth of offshoring innovation by Ernst (2006) and Thursby and Thursby (2006), who argue that the US should remove obstacles to immigration of highly skilled workers and to enlarge the pool of knowledge workers by creating national incentives for entering careers in science and engineering. The relation between constraints on accessing talent and innovation sourcing decisions had already been recognized by Quinn (2000) who recommends outsourcing innovation to attract talent because companies may have difficulties attracting the most qualified people for their non-core activities. These workers are likely to prefer working for specialist companies where their expertise will be best recognized, used and rewarded. Today, a similar argument can be made about the offshoring of innovation, as Ernst (2006) notes when he concludes that companies offshore exciting R&D projects to "attract the best and brightest of the local talent pool," instead of falling back on "second-choice" workers at home. Interestingly, Florida (1997) finds that R&D FDI into the US is also driven by the desire of companies offshore to access scientific and technical human capital.

Although improving the efficiency of innovation processes is a major objective of firms offshoring PD, the results from our models support our argument that accessing global talent pools and reducing labor costs are two separate and different strategies driving offshoring decisions by companies. Accessing talent is linked to companies involved in product development-centered innovation, while labor cost savings are associated with companies seeking to replace high-cost workers (mostly lower skilled) with lower-cost workers. Cost savings from labor arbitrage is an important contingency driving the growth in adoption of offshoring practices that the ORN study documents. Nevertheless, the pattern of offshoring activities by American companies that emerge from the ORN study does not fit the traditional notion of companies simply trading non-core low-level workers in the US with low-cost labor offshore. First, offshoring increasingly involves core and technical activities performed by highly-trained workers (university graduates from science and engineering schools in particular). Second, on the basis of ORN data, less than one out of ten offshore implementations of technical activities have resulted in job losses in the US. Offshoring of product- and process-centered innovations have enabled companies, large and small, to increase the scale and scope of resources dedicated to their innovation efforts, with no consequential impact on employment of domestic engineering and R&D staffs. In other words, in the face of a global race for talent, when it comes to offshoring product development work necessary for a firm to maintain its technical leadership and increase its speed to market with new and improved products, labor cost is not the determining variable. Many other strategic considerations are involved and this paper shows that sourcing skilled workers and talent offshore is definitely a key element.

The results reported in this paper have to be placed in the context of the broader phenomenon of increased globalization of human capital (Friedman, 2005; Florida, 2005) and emerging global talent pool (Levin Institute, 2005). In the industrial economy, workers used to migrate from less developed regions towards more industrialized regions to seek jobs. In the knowledge, IT-enabled economy, entire segments of companies' value chains are relocated to where the requisite human capital is located as a necessary condition for executing certain business functions and processes. In one sense, offshoring creates the experimental basis through which companies are transforming themselves to create flexible global organizations that locate entire functions in the strategically most advantageous locations.

Conclusions

The co-evolutionary framework of the empirical study reported in this paper brought together arguments of managerial intentionality, path dependence, and environmental effects to explain the strategic decisions of firms to offshore product development work. The results confirm that access to qualified personnel offshore is a strong determinant of such decisions, partly driven by the decreasing supply of science and engineering graduates in the US. The idea of cumulative experience building is also validated, although managerial intentionality seems to be a stronger determinant of PD offshoring decisions than firms' past experience with offshoring. Among the managerial strategic objectives that lead firms to offshore product development projects, speed to market is a key factor underlying decisions to offshore various elements of their innovation process. Finally, the study offers a clarification of the role of cost savings in explaining innovation offshoring. Firms see PD offshoring as a unique opportunity to reduce the cost of their innovation activities, but mainly through new flexible globally distributed (FGD) strategies and only partly through HBR strategies, with labor arbitrage becoming a secondary driver. For small companies, access to lower-cost S&E talent globally enables them to augment their limited in-house R&D resources (HBA strategies).

This paper contributes to the debate on the growing shortage of technical talent and globalization of human capital, by providing empirical support to the argument of an impending global race for science and engineering talent triggered in part by events such as the 2003 cutback in the H1B visa quota from 195,000 to 65,000 visas annually and the diminishing interest in entering S&E careers as indicated by the decline in the number of US nationals earning advanced degrees in S&E. However, competing for science and engineering talent is unlike seeking markets or production platforms through FDI. Talent is different from other assets because it is highly mobile and because of high obsolescence. Accessing and managing talent in globally dispersed locations requires new recruiting and retention strategies as well as new organizational forms for locating talent (*e.g.*, in emerging geographic functional knowledge clusters, Manning, *et al.*, 2008), managing, sharing and exploiting knowledge.

Although this paper sheds light on a few important questions regarding the determinants of the decision by firms to offshore innovation activities, we wish to acknowledge some limitations and future extension of the present research. First, although this paper provides an analysis of the influence of three types of factors on companies' decisions to offshore product development, it is likely that these factors do not impact firms' decisions independently of one another. Interaction effects cannot be ruled out. For instance, firms with a low level of previous experience with offshoring may focus more on labor cost reductions objectives, even for product development work, while the effect of access to qualified personnel may be even stronger for more experienced firms. Offshoring PD as a means to increasing speed to market may also be more important to smaller firms, especially in knowledge-driven industries (Murtha, 2004). However, testing for all possible interaction effects in an appropriate way would have significantly complicated the model and interpretation of results (Hoetker, 2007). So as a first attempt to bring together managerial intentionality, path dependence and environmental factors for explaining firm offshoring decisions, we chose to focus on a simpler and cleaner model. Moreover, mimetic isomorphic pressures (DiMaggio and Powell, 1983) may also influence decisions by firms to offshore innovative work. As an additional possible path dependence effect, industry-level offshoring experience or even diffusion of offshoring practices at the function-level should also be tested for. Second, the impact of these variables may evolve over time, which would call for a panel data approach instead of a cross-section. At this stage, the main constraint for investigating this limitation is a lack of data. But as the data collection effort of the Offshoring Research Network progresses we should be able to respond to that issue as well. Finally, there is an opportunity for better accounting for the role of the developing pool of talent offshore using data on the availability and quality of S&E professionals in offshore locations. Unfortunately, such data are not readily available and would require a significant effort to construct. Indeed, the widely held assumption that China and India combined offer a seemingly unlimited supply of talent may need to be reexamined as there seems to be a growing shortage of high quality (A and B level) science and engineering graduates in these countries. Moreover, the low level of English language competency in China is a recognized barrier to offshoring innovation work. In sum, it is clear that understanding the dynamics of offshoring innovation, the implications for firm strategy and for national competitive advantage is still in its early phases, and research in these areas is expected to grow in the coming years.

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TABLES TO INSERT IN TEXT

TABLE 1
Sample descriptive statistics

	% of companies	**# offshore implementations**
Firm size (# employees)		
< 501	24%	208
> 500 < 2,001	8%	68
> 2,000	68%	604
Industry		
Business/IT services	11%	95
FMCG	3%	28
Financial services	17%	152
Health/Biotech/Pharma	4%	35
Manufacturing	15%	135
Other services	14%	123
Professional services	2%	12
Software & Programming	5%	48
Technology	29%	252

TABLE 2
Distribution of offshore implementations across functions and locations

Functions	**% of total (N)**	**Locations**	**% of total (N)**
	26% (230)	India	42% (366)
Product Development	11%	China	11% (98)
Engineering Services	10%	Latin America	8% (74)
R&D	5%	Philippines	8% (71)
Product Design	**26% (227)**	Western Europe	6% (55)
IT	**22% (196)**	Other Asia	6% (54)
Administrative	12%	Eastern Europe	6% (51)
Finance & Accounting	5%	Canada	5% (40)
Human Resources	4%	Other locations	4% (36)
Other back office	1%	Mexico	4% (35)
Legal Services	**17% (147)**		
Contact Centers	**5% (48)**		
Procurement	**4% (32)**		
Marketing & Sales			

TABLE 3
Strategic Drivers of Offshore Implementations (% 4 or 5 on 5 point Likert scale)

	Product development implementations	**Non-product development implementations**	**Chi-squared test**
Labor cost savings	91%	90%	0.088 Pr = 0.766
Access to qualified personnel	81%	71%	5.961 Pr = 0.015
Other cost savings	80%	69%	5.195 Pr = 0.023
Growth strategy	77%	69%	3.600 Pr = 0.058
Part of larger global strategy	75%	59%	8.280 Pr = 0.004
Competitive pressures	72%	59%	8.626 Pr = 0.003
Increasing speed to market	57%	41%	12.209 Pr = 0.000
Improving service levels	50%	52%	0.176 Pr = 0.675
Business process redesign	48%	51%	0.411 Pr = 0.521
Adopting an industry practice	41%	42%	0.050 Pr = 0.823
Differentiation strategy	36%	26%	3.738 Pr = 0.053
Access to new markets	32%	15%	21.127 Pr = 0.000
Enhancing system redundancy	28%	27%	0.073 Pr = 0.787

TABLE 4
Percentage (and Frequency) of Offshore Implementations by Industries and Offshore locations

	Product development implementations	**Non-product development implementations**	**% of product development implementations**
Industries			
Business/IT services	14% (31)	10% (64)	33%
FMCG	1% (1)	4% (27)	4%
Financial services	7% (16)	21% (136)	11%
Health/Biotech/Pharma	4% (10)	4% (25)	29%
Manufacturing	20% (45)	14% (90)	33%
Other services	7% (17)	16% (106)	14%
Professional services	3% (8)	1% (4)	67%
Software & Programming	10% (23)	4% (25)	48%
Technology	34% (79)	26% (173)	31%
Total	*100%(230)*	*100% (650)*	
Countries			
India	43% (100)	41% (266)	27%
China	19% (43)	8%(55)	44%
Latin America	6% (13)	9% (61)	18%
Philippines	3% (7)	10% (64)	10%
Western Europe	6% (14)	6% (41)	25%
Other Asian regions	8% (18)	6% (36)	33%
Eastern Europe	6% (13)	6% (38)	25%
Canada	3% (7)	5% (33)	18%
Mexico	2% (4)	5% (31)	11%
Other regions	4% (11)	4% (25)	31%
Total	*100% (230)*	*100% (650)*	

TABLE 5
Construction of Variables

Variables	Construction
<u>Dependent</u>	
PD	Dummy = 1 for product development implementations (R&D, product design and engineering services), 0 for other offshore implementations.
<u>Explanatory</u>	
lnSEH1B	Logarithm of sum of number of US nationals Science and Engineering graduates (Masters and PhDs) and of H1B visa quota in year offshore implementation is launched.
PAST_EXP_PD	Number of existing product development offshore implementations of the company when the new offshore implementation is launched.
QUAL_PERS	1 to 5 score attributed to “Access to qualified personnel” as a strategic driver of offshore implementation, as reported in ORN survey.
COST_LABOR	1 to 5 score attributed to “Labor cost savings” as a strategic driver of offshore implementation, as reported in ORN survey.
COST_OTHER	1 to 5 score attributed to “Other cost savings” as a strategic driver of offshore implementation, as reported in ORN survey.
SPEED	1 to 5 score attributed to “Increasing speed to market” as a strategic driver of offshore implementation, as reported in ORN survey.
GROWTH	1 to 5 score attributed to “Growth strategy” as a strategic driver of offshore implementation, as reported in ORN survey.
GLOBAL	1 to 5 score attributed to “Part of a larger global strategy” as a strategic driver of offshore implementation, as reported in ORN survey.
COMPETITION	1 to 5 score attributed to “Competitive pressures” as a strategic driver of offshore implementation, as reported in ORN survey.
<u>Controls</u>	
lnEmpl	Logarithm of number of employees in the company in year offshore implementation is launched.
Captive	Dummy = 1 for captive offshore implementations, 0 otherwise.
D2004	Dummy = 1 for offshore implementations launched in 2004 or after, 0 otherwise.
$Industry_p$ (p = 1 to 7)	7 dummy variables representing industry of operation of the company: Business/IT services, Financial services (reference group), Health/Biotech/Pharma, Manufacturing, Other services, Professional services, Software & programming, and Technology.
$Country_q$ (q = 1 to 9)	9 dummy variables representing the location of the offshore implementation: India, China, Latin America (reference group), Philippines, Western Europe, Other Asian regions, Eastern Europe, Canada, Mexico, Other regions.

Table 6
Descriptive statistics and correlations for explanatory variables

	Variable	Obs	Mean	St.Dev	Min	Max	1	2	3	4	5	6	7	8	9	10	11	12	13
1	PD	880	0.261	0.440	0	1	1.00												
2	lnSEH1B	487	12.172	0.311	11.82	12.56	-0.08	1.00											
3	PAST_EXP_PD	487	0.585	1.509	0	10	0.08	-0.19*	1.00										
4	QUAL_PERS	649	3.823	0.980	1	5	0.10*	0.03	-0.03	1.00									
5	COST_LABOR	652	4.471	0.823	1	5	-0.08	0.09	-0.23*	-0.05	1.00								
6	COST_OTHER	475	3.844	1.099	1	5	0.11	0.14	-0.07	-0.04	0.38*	1.00							
7	SPEED	651	3.218	1.310	1	5	0.13*	-0.05	0.05	0.09	-0.14*	0.01	1.00						
8	GROWTH	650	3.851	1.054	1	5	0.07	0.09	-0.13*	0.23*	0.12*	0.27*	0.21*	1.00					
9	GLOBAL	471	3.446	1.379	1	5	0.11	0.12	0.13	0.21*	0.02	0.27*	0.43*	0.32*	1.00				
10	COMPETITION	648	3.650	1.140	1	5	0.10	0.028	-0.13*	0.11*	0.12*	0.30*	0.06	0.20*	0.26*	1.00			
11	lnEmpl	913	8.397	3.252	0	12.74	-0.20*	0.05	0.17*	0.10	0.19*	-0.01	0.04	-0.01	0.24*	0.01	1.00		
12	Captive	808	0.490	0.500	0	1	0.12*	0.14*	0.10	0.04	-0.07	0.10	0.05	0.18*	0.24*	0.09	0.12*	1.00	
13	D2003	487	0.581	0.494	0	1	-0.02	-0.43*	0.23*	0.07	-0.12	-0.14	-0.02	-0.07	-0.03	-0.00	-0.04	-0.14*	1.00

Signification level: * <1%

TABLE 7: Estimation Results of Logit Model and Odds Ratios
Dependent Variable: Probability of Offshoring Product Development Projects

	1 – Coefficients	2 – Odd-ratios	3 – Coefficients	4 – -atios
lnSEH1B			-0.202 (0.684)	0.817 (0.559)
PAST_EXP_PD			0.051 (0.134)	1.052 (0.141)
QUAL_PERS			0.514** (0.214)	1.672** (0.357)
COST_LABOR			-0.475* (0.245)	0.622* (0.152)
COST_OTHER			1.075*** (0.266)	2.931*** (0.779)
SPEED			0.548*** (0.151)	1.730*** (0.261)
GROWTH			-0.443** (0.198)	0.642** (0.127)
GLOBAL			0.145 (0.177)	1.156 (0.205)
COMPETITION			-0.194 (0.169)	0.824 (0.139)
<u>Controls</u>				
lnEmpl	-0.145*** (0.038)	0.865*** (0.000)	-0.112* (0.063)	0.894* (0.075)
Captive	0.755*** (0.263)	2.127*** (0.004)	0.928** (0.390)	2.530** (0.017)
D2003	-0.192 (0.258)	0.826 (0.4579)	-0.184 (0.460)	0.832 (0.689
Business / IT services	2.053*** (0.463)	7.793*** (0.000)	2.656*** (0.685)	14.237*** (0.000)
Health / Biotech / Pharma	1.289* (0.673)	3.630* (0.055)	2.547*** (0.907)	12.767*** (0.005)
Manufacturing	1.641*** (0.469)	5.163*** (0.001)	1.756** (0.773)	5.792** (0.023)
Professional services	2.319*** (0.813)	10.164*** (0.004)	-	-
Other services	0.546 (0.488)	1.726 (0.263)	1.507** (0.721)	4.514** (0.037)
Software & programming	1.615*** (0.538)	5.028*** (0.003)	4.359*** (1.203)	78.143*** (0.000)
Technology	1.056*** (0.402)	2.875*** (0.009)	1.802*** (0.663)	6.064*** (0.007)
China	1.623*** (0.546)	5.066*** (0.003)	0.712 (0.761)	2.039 (0.349)
India	0.587 (0.482)	1.798 (0.224)	0.056 (0.668)	1.058 (0.933)
Canada	0.774 (0.752)	2.169 (0.303)	0.853 (1.154)	2.346 (0.460)
Mexico	-0.146 (0.916)	0.864 (0.873)	-0.844 (1.349)	0.430 (0.532)
Philippines	-1.959* (1.127)	0.141* (0.082)	-2.009 (1.293)	0.134 (0.120)
Eastern Europe	0.024 (0.698)	1.025 (0.972)	0.115 (0.922)	1.122 (0.901)
Western Europe	0.806 (0.612)	2.239 (0.188)	0.265 (0.878)	1.304 (0.761)
Other Asian regions	1.184* (0.632)	3.266* (0.061)	-0.039 (0.910)	0.962 (0.966)
Other regions	0.116 (0.878)	1.118 (0.899)	0.149 (1.096)	1.160 (0.892)
<u>Constant</u>	-1.827*** (0.572)		-4.184 (8.575)	
N	476		315	
LR chi^2	103.64		107.94	
Prob>chi^2	0.0000		0.0000	
Log likelihood	-221.205		-123.440	
McKelvey & Zavoina R^2	0.369		0.540	
McFadden's R^2	0.1898		0.3042	
Adj. McFadden's R^2	0.117		0.146	

*Standard Errors in brackets. Significance levels: *** <1%, ** < 5%, * < 10%, +<15%.*
- The dummy for Professional Services has been dropped due to collinearity.

TABLE 8: Estimation Results of Logit Model
Dependent Variable: Probability of Offshoring Product Development Projects

	1	2	3
lnSEH1B	-0.759* (0.4566) [0.468]		-0.668+ (0.463) [0.513]
PAST_EXP_PD		0.192** (0.0934) [1.212]	0.177* (0.094) [1.194]
Controls			
lnEmpl	-0.146*** (0.038)	-0.156*** (0.038)	-0.156*** (0.038)
Captive	0.768*** (0.265)	0.669** (0.267)	0.683** (0.268)
D2003	-0.397 (0.289)	-0.352 (0.272)	-0.523* (0.299)
Business / IT services	1.938*** (0.469)	2.025*** (0.467)	1.925*** (0.472)
Health / Biotech / Pharma	1.083+ (0.683)	1.286* (0.680)	1.100+ (0.690)
Manufacturing	1.574*** (0.472)	1.474*** (0.481)	1.425*** (0.483)
Professional services	2.219*** (0.826)	2.3441*** (0.816)	0.506 (0.494)
Other services	0.477 (0.490)	0.570 (0.493)	2.250*** (0.826)
Software & programming	1.577*** (0.540)	1.560*** (0.543)	1.533*** (0.545)
Technology	1.039*** (0.404)	1.060*** (0.407)	1.042** (0.408)
China	1.665*** (0.550)	1.536*** (0.548)	1.581*** (0.552)
India	0.599 (0.484)	0.563 (0.483)	0.576 (0.485)
Canada	0.800 (0.750)	0.737 (0.752)	0.767 (0.751)
Mexico	-0.142 (0.920)	-0.103 (0.915)	-0.102 (0.918)
Philippines	-1.984* (1.128)	-2.320** (1.161)	-2.303** (1.158)
Eastern Europe	0.114 (0.698)	0.009 (0.704)	0.094 (0.704)
Western Europe	0.794 (0.617)	0.726 (0.617)	0.721 (0.620)
Other Asian regions	1.170* (0.638)	1.151* (0.635)	1.144* (0.641)
Other regions	0.028 (0.887)	0.019 (0.892)	-0.050 (0.898)
Constant	7.560 (5.666)	-1.652*** (0.575)	6.592 (5.740)
N	476	476	476
LR chi^2	106.47	107.95	110.07
Prob>chi^2	0.0000	0.0000	0.0000
Log likelihood	-219.792	-219.050	-217.993
McKelvey & Zavoina R^2	0.379	0.387	0.393
McFadden's R^2	0.1950	0.1977	0.2016
Adj. McFadden's R^2	0.118	0.121	0.121

Standard Errors in brackets. Odd Ratios in square brackets.
*Significance levels: *** <1%, ** < 5%, * < 10%, +<15%.*

TABLE 9: Estimation Results of Logit Model (pre and post 2003 sub-samples)
Dependent Variable: Probability of Offshoring Product Development Projects

	[1990-2002]	Odd-ratios	[2003-2006]	Odd-ratios
lnSEH1B	-0.220 (1.042)	0.803 (0.833)	-0.872 (0.877)	0.418 (0.320)
PAST_EXP_PD	-0.093 (0.319)	0.912 (0.771)	0.096 (0.134)	1.101 (0.475)
QUAL_PERS	-0.124 (0.272)	0.883 (0.648)	1.527*** (0.353)	4.603*** (0.000)
COST_LABOR	-0.780** (0.360)	0.458** (0.030)	-0.373 (0.279)	0.688 (0.180)
COST_OTHER	0.679** (0.329)	1.973** (0.039)	0.917*** (0.311)	2.502*** (0.003)
SPEED	0.678*** (0.260)	1.969*** (0.009)	0.402** (0.184)	1.495** (0.029)
GROWTH	-0.514* (0.308)	0.598* (0.095)	-0.452* (0.251)	0.636* (0.072)
GLOBAL	-0.181 (0.250)	0.834 (0.470)	0.633*** (0.234)	1.883*** (0.007)
COMPETITION	-0.316 (0.231)	0.729 (0.172)	-0.219 (0.245)	0.803 (0.372)
Controls				
lnEmpl	-0.214** (0.106)	0.807** (0.043)	-0.250*** (0.074)	0.779*** (0.001)
Captive	1.314** (0.586)	3.723** (0.025)	-0.147 (0.528)	0.863 (0.781)
India	0.722 (0.664)	2.058 (0.277)	0.134 (0.506)	1.143 (0.791)
China	1.275^{+} (0.781)	3.577^{+} (0.103)	0.947 (0.730)	2.577 (0.195)
tech_ind	2.089*** (0.733)	8.076*** (0.004)	0.347 (0.545)	1.415 (0.524)
Constant	3.557 (12.816)		1.445 (10.445)	
N	125		190	
LR chi^2	45.98		70.17	
Prob>chi^2	0.0000		0.0000	
Log likelihood	-49.1610		-70.0790	
McKelvey & Zavoina R^2	0.531		0.617	
McFadden's R^2	0.3186		0.3336	
Adj. McFadden's R^2	0.111		0.191	

*Standard Errors in brackets. Significance levels: *** <1%, ** < 5%, * < 10%, +<15%. .*
Tech_ind = Dummy variable equals to 1 for Health/Biotech/Pharma, Manufacturing, Software & Programming, Technology; 0 otherwise.

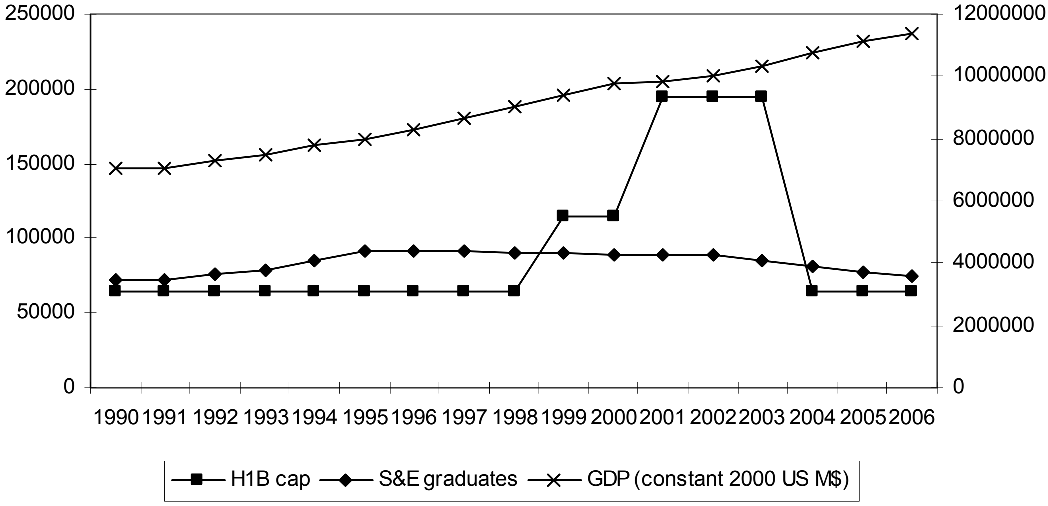
TABLE 10: Estimation Results of Logit Model (pre and post 2003 sub-samples)
Dependent Variable: Probability of Offshoring Product Development Projects

	[1990-2002]	Odd -ratios	[2003-2006]	Odd-ratios
lnSEH1B	-1.839** (0.744)	0.159 (0.118)	-0.591 (0.544)	0.554 (0.301)
PAST_EXP_PD	0.604** (0.301)	1.830 (0.551)	0.112 (0.084)	1.119 (0.094)
Controls				
lempl	-0.222*** (0.059)	0.801 (0.047)	-0.174*** (0.045)	0.841 (0.038)
India	1.022** (0.428)	2.778 (1.188)	0.115 (0.331)	1.122 (0.371)
China	2.085*** (0.582)	8.042 (4.678)	1.089** (0.447)	2.971 (1.328)
tech_ind	0.900** (0.403)	2.459 (0.992)	0.008 (0.317)	1.008 (0.319)
captive	1.108*** (0.407)	3.028 (1.232)	0.531+ (0.328)	1.701 (0.558)
Constant	21.464 (9.134)		6.852 (6.529)	
N	201		275	
LR chi^2	54.01		28.12	
Prob>chi^2	0.0000		0.0002	
Log likelihood	-90.9499		-140.8552	
McKelvey & Zavoina R^2	0.379		0.144	
McFadden's R^2	0.2289		0.0908	
Adj. McFadden's R^2	0.161		0.039	

*Standard Errors in brackets. Significance levels: *** <1%, ** < 5%, * < 10%, +<15%.*
Tech_ind = Dummy variable equals to 1 for Health/Biotech/Pharma, Manufacturing, Software & Programming, Technology; 0 otherwise.

FIGURES TO INSERT IN TEXT

FIGURE 1
US S&E graduates and change in H1B visa policy



Data on Master and PhD degrees in sciences and engineering come from the US National Science Foundation. Data for H1B visa quota come from the US Citizenship and Immigration Services.

FIGURE 2
Cumulative percentage of firms initiating offshoring of functional category (1990-2006)