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Abstract

An important element of technology globalization is the rise of technology-based entrepreneurs in China, India, Mexico and other emerging economies. Increasingly, these techno-entrepreneurs are strategically important as part of the innovation value chain of multinational enterprises (MNEs). Some of these linkages began as MNEs sought to cut costs by outsourcing activities to offshore firms. More recently, however, MNEs are globally dispersing more and more of their engineering work, and increasingly the MNEs are having emerging economy techno-entrepreneurs do much of their higher-level engineering and technology development work.

This has major potential consequences for the MNEs, their home countries, their host countries, and the on-going development of global technology value chains. Before assessing these potential consequences, however, we need a much clearer understanding of how these local entrepreneurial firms fit into the strategies of the MNEs and of the processes by which the entrepreneurial firms come into being and develop as key parts of global technology creation chains. We need to understand better the role the new entrepreneurial firms are playing in the development of technologies that the MNEs use to serve customers not just in the emerging economies, but around the world.

The specific organizational form of Techno-entrepreneurship, the inter-firm linkages, the growth trajectories as well as the implications for national policies have been underconceptualized in the existing literature. Technology entrepreneurship that is linked to MNEs is, we hypothesize, different from the general category of entrepreneurship. Further, we consider the extent to which linkages with offshore techno-entrepreneurs are complements to, and the extent to which they are substitutes for, MNE linkages with techno-entrepreneurs in their home country. The implications for MNEs and national competitiveness are also examined.

Based on field work carried out in the U.S., EU, Japan, China, India, and Mexico by the authors and their collaborators from these countries, this paper presents brief case descriptions of the processes by which technology entrepreneurs from the emerging economies are becoming part of worldwide technology value chains.

Introduction

Multinational enterprises are fostering research and advanced engineering activities in many of the emerging economies. This development of new centers for the creation of advanced technology is attracting growing attention. The business press frequently showcases the development of new technological capabilities in the emerging economies by technological entrepreneurs – local entrepreneurs working with multinationals to develop indigenous technological capabilities. While local technological entrepreneurs seem to be of increasing importance in the development of national innovation systems in China, India, Brazil, Mexico, and other countries, we do not have a clear understanding of who these entrepreneurs are, where they come from, what they contribute to the multinationals, and what they contribute to the technological infrastructures of their home countries.

The specific form of entrepreneurship examined in our study is that of entrepreneurial firms in emerging economies that are engaged in technology development involving high-end engineering, and that are linked to Multinational Enterprises, typically as part of the MNE's technology development value chain. In this respect, these technological entrepreneurial (TechEntre) firms operate within a network of firms, as part of a global innovation system and, at least to some degree, as part of the MNE's globally-distributed engineering system. As such, we hypothesize that these firms have entrepreneurial characteristics and business dynamics different from other types of entrepreneurial firms that are more independent from larger organizations and global networks. Although there is a large body of research on entrepreneurship dynamics and on government entrepreneurship policies, relatively little is known about the development of TechEntre firms in the emerging economies, particularly in how they resemble and differ from other types of entrepreneurial firms (e.g., cf. Aldrich and Ruef, 2006).

Background: The globalization of technology creation as a convergence of trends

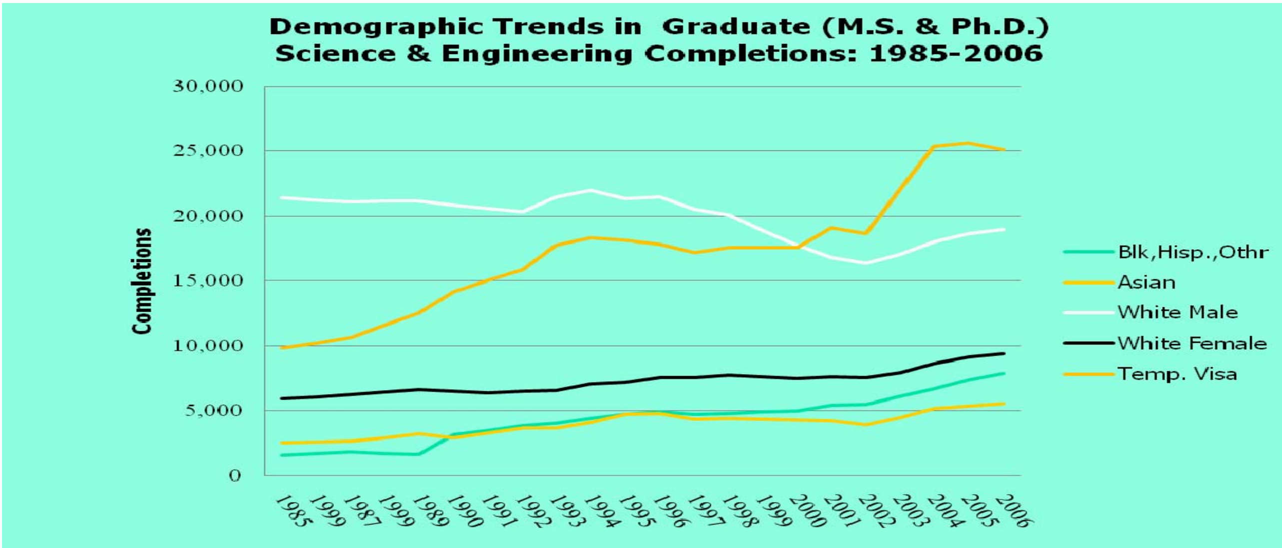
The development of global technology value chains resulted from the convergence of at least three sets of major trends: one related to developments in the migration of human capital in science and technology, a second related to the reconfiguration of the activities of multinational enterprises, and a third related to the fast rise in the technological capabilities of some of the emerging economies (see Lynn and Salzman, 2004, 2005, 2006, 2007a, 2007b, and forthcoming for more detail). An understanding of this convergence of trends provides a framework for interpreting our cases, and also derives from the cases.

Human capital. Offshoring and the global diffusion of innovation/engineering has its roots in a twenty to thirty year-long history of human capital migration.

As can be seen in Figure 1, in the past two decades, there has been a dramatic increase in the number of students in U.S. graduate programs who are foreigners on temporary visas.[1]

Figure 1. Demographic Trends in Graduate (MS and Ph.D) Science and Engineering Completions: 1985-2006

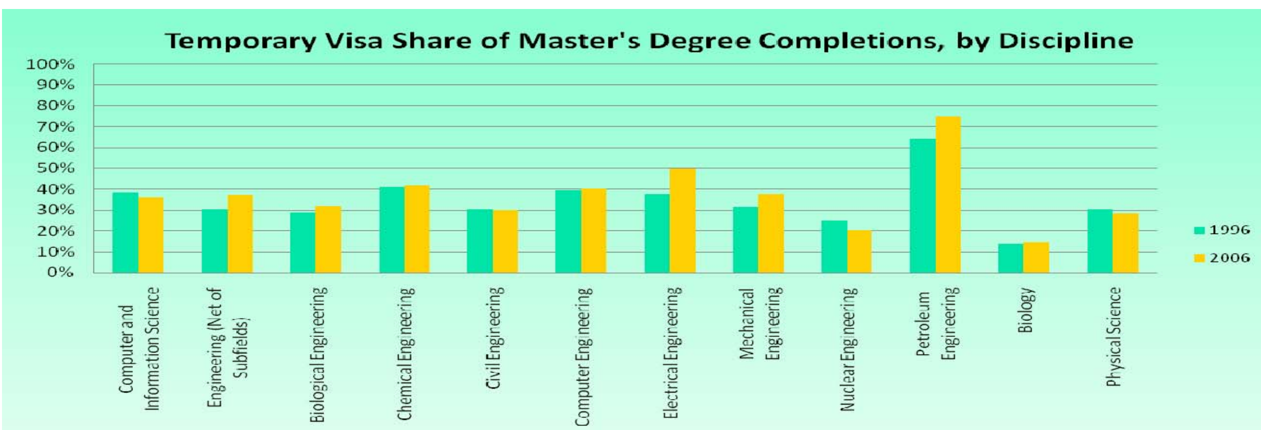
[1] This is different from the number of foreign born students in graduate programs; it includes only students who come to the United States directly for graduate school. Undergraduate temporary visa enrollments are relatively small.



Source: IPEDS, tabulations by authors

And, as shown in Figure 2, these visa holders are concentrated in particular fields, even within technology fields and industries.

Figure 2. Discipline of Temporary Visa Holders



Source: IPEDS; tabulation by authors.

After graduation, large numbers of these recent immigrants (temporary visa holders in universities) have entered U.S. firms. Over the course of the last ten to twenty years the science, technology, engineering, and management ranks have become international to a significant degree. In 2000 there were 124,000 workers in U.S. science and engineering occupations with a bachelors degree or higher who had been born in China, and 195,700 from India (about eight percent of the total).[2]

The importance of an international workforce, in addition to specific skills and talents they may have, is their knowledge, linkages, and experience in what are the global growth

[2] NSF, 2007.

markets. This background provides firms with a level of “comfort” in locating important operations in these countries. In our cases we find in almost every instance, the offshoring of engineering activity was facilitated and managed by a foreign national from that offshore region. In the initial stages of offshoring, there appear to be a number of seemingly idiosyncratic factors that lead to offshore linkages, such as managers and technical staff who are familiar with the offshore region and the availability of expatriate or globally-experienced senior managers who can staff the offshore sites. These factors are important elements of what is an emergent, iterative development of innovation offshoring that only retrospectively is seen as “strategy.” These leading firms pave the way by demonstrating apparent success in offshoring core operational areas. The experiences of these leading firms becomes elevated to a “strategy” and then this type of offshoring is pursued by other firms, sometimes under pressure from financial analysts.

Growing Technological Capabilities in Emerging Economies. The second important factor in technology globalization is the rapid upgrading of technological capabilities in some of the emerging economies.

Since 1990 the ratio of higher education degrees earned to the size of the college-age population has more than doubled in Asia, increasing from 1.2 per hundred in 1990 to 5.0 per hundred in 2003 in the case of China. China’s output of science and engineering bachelors degrees doubled. In 1989 just over one thousand science and engineering doctorates were awarded in China and just over four thousand in India. In 2003 these numbers had increased to 12,238 and 6,318, respectively (compared to nearly a half million U.S. science and engineering bachelors degrees awarded that year, of which 92 percent were U.S. citizens or permanent residents). To be sure, these dramatic increases start from a relatively small base and questions have been raised about the quality of some of the degrees – yet they are indicative of a sharp increase in the S&E human resource base in many Asian countries (Lynn and Salzman, 2007a, NSF, 2007).

Table 1. Gross expenditures on research and development, by selected region and country/economy: 1990–2004

(Millions of current purchasing power parity dollars)

Year	Asia	China	Japan	Singapore	South Korea	Taiwan	EU-25	United States
1990	NA	NA	62,865	NA	NA	NA	115,239	152,389
1991	86,763	12,495	66,942	NA	7,325	NA	121,281	161,388
1992	92,388	14,938	69,096	NA	8,354	NA	123,770	165,835
1993	95,675	16,658	69,107	NA	9,910	NA	125,964	166,147
1994	100,056	17,463	69,921	632	12,041	NA	128,860	169,613
1995	117,683	18,410	78,668	740	13,681	6,183	138,416	184,077
1996	128,818	20,340	85,470	985	15,282	6,742	139,159	197,792
1997	141,530	25,384	90,754	1,116	16,637	7,638	145,365	212,709
1998	143,086	27,939	90,508	1,358	14,789	8,493	152,509	228,109
1999	153,527	33,940	92,774	1,584	15,793	9,437	163,028	245,476
2000	174,008	44,771	98,850	1,810	18,395	10,182	182,567	267,768
2001	190,501	52,418	104,161	2,007	21,166	10,749	194,759	277,820
2002	209,936	65,154	108,248	2,202	22,247	12,085	205,263	276,260
2003	229,628	76,891	112,715	2,255	24,274	13,494	210,168	292,437
2004	NA	93,992	NA	2,678	NA	14,951	NA	312,535

Source: OECD

R&D spending in China, India and other emerging economies has also grown dramatically (See Table 1). In the case of China, for example, spending rose from about twelve and a half billion dollars (conversion based on purchasing power parity) in 1991 to nearly ninety-four billion dollars in 2004. In 1991 Chinese R&D spending was about one-fifth the level in Japan, a tenth the level in the EU, and one-twelfth the level of the U.S. By 2003 it was more than two-thirds the Japanese, a third the EU and more than one-quarter the U.S. level. Science and technology output measures are notoriously difficult to interpret, but the share of science and engineering articles contributed by Chinese authors increased from less than one percent in 1988 to more than four percent in 2003. China's triadic patent filings (those filed in Europe, Japan and U.S.) increased from 17 in 1988 to 177 in 2002, India's rose from 10 to 78. Again these dramatic percentage increases are on a small base and these numbers are quite small compared to the thousands filed by inventors in the U.S., EU and Japan, still there is clearly a significant rise in the economic value of intellectual property being created in some of the emerging economy (NSF, 2007).

"Unlocking" of multinationals. The third important factor is a change in the prevailing conventional wisdom of what constitutes efficient organizational design. Management theorists, consultants, investors, and managers have espoused a set of notions that in broad terms suggest: 1. a firm should break down and analyze all of its activities; 2. it should decide which activities are "core," and thus must be done within the firm; 3. it should decide which activities can be done at lower costs by others, and outsource these activities; 4. it should further analyze its core and low cost activities to seek cost reduction opportunities by moving these activities to lower cost areas; 5. whenever possible it should consider redesigning its activities so as to allow modularization – which would allow a further wave of outsourcing (aspects of this prevailing view are conveyed in Baldwin and Clark, 1997; 2000; Barney, 1991; Chesbrough, 2006; Kenney, 2002; Lynn and Salzman, 2005; Prahalad and Hamel; 1980; Schilling, 2000; Sturgeon, 2002 amongst many others).

This process of decomposing and "unlocking" the activities of business firms began to take off in the late 1980s and through the 1990s, with a sharp increase in domestic outsourcing. While the initial driver was primarily cost savings, it was soon found that in some cases there were other advantages. Sometimes the new suppliers or new sites created new production processes, designs, or offered enhanced quality. As the MNEs pursued the increased modularization and international dispersion of technology development, they bolstered the technological strengths of firms in emerging economies, and frequently were instrumental in the creation and fostering of new technology entrepreneurs in these countries.

American MNEs had long been faulted for being afflicted with the NIH ("not invented here") syndrome in which outside sources of innovation were generally ignored in favor of in-house or even on-site innovation). This began to change, and arguably may even have reversed in some instances to policies that discriminate *in favor of* NIH innovations.

While firms have found many positive returns from these developments, our cases suggest the need for caution both for managers and for those designing policies to protect the national interest. First of all, we find that the processes by which the globalization of technology development is occurring is by no means "strategic"; that is, these processes are not guided by carefully thought out plans that take into account both short and long-term benefits for the firm. Feedback loops that might result in mid-course corrections tend to be non-systematic, and often are non-existent. Nor has much consideration been given to the longer term social implications of offshoring – either by managers or by architects of public policy. Rather, our cases show how offshoring can take on a life of its own, going beyond the intent of MNE managers. We have addressed this issue more broadly elsewhere (Lynn and Salzman, 2007b); here our focus is on the aspect of offshoring related to technological entrepreneurship.

Research methods and sample

To explore the implications of this convergence of trends, we undertook a series of case studies of MNEs developing technology in emerging economies.[3] Our sample included Triad (U.S., Japan and EU) MNEs with engineering facilities in China, Latin America, and/or India, and technology suppliers to these firms (N=25 MNE sites and 14 small firms in 9 countries). Our respondents were managers and engineers (N>200). The industries included were electrical/mechanical/power systems; autos and aerospace (OEM and component/parts suppliers); and information technology (hardware and software). At each site we conducted a number of interviews, each of which was at least an hour in length. In some cases we gave preliminary reports and presentations of our findings to firms where interviews had been conducted. This allowed us to correct misimpressions and to collect elaboratory data.

We worked with partners at ISF-München, Universidad de las Américas, Puebla, and collaborators in China, Central Europe, India, Mexico, Brazil. In this paper we will report on cases that exemplify trends we saw in our interviews. In the cases from our research in the U.S., India and China confidentiality was promised, so company names are disguised. In the cases from Mexico, Slovenia, and those from China based on published research or research carried out by our colleagues where confidentiality was not promised, actual names are used.

The Cases: India[4]

Technology entrepreneurship in India has developed through several pathways, shaped by government policy, the education system, and through interaction with multinationals in ways quite different from China and the other countries in our study. In very abbreviated summary, historically the Indian education system has been superb at selecting high achieving and highly motivated undergraduate students but very weak at providing strong technical and industry-relevant education at the graduate level. Education migration was a result of this factor in combination with limited opportunities for domestic leading-edge technology work.

The Indian government has gone through several different "phases" of policy for foreign direct investment (Kumar, 1994; Balasubramanyam and Mahambare, 2003).

Following independence in 1947, the Indian government enacted a number of different policies and individual, case-by-case reviews of foreign investment that were selectively restrictive on some industries but did not prevent foreign companies from entering India. As Balasubramanyam and Mahambare (2003) explain, "although the regime was marked by extensive regulation of trade and investment, it did not shun FDI participation in the economy." It was the 1968 through 1979 period that was most restrictive, effectively limiting foreign equity to a maximum of 40 percent in a firm. Other restrictions during this period further limited MNE

[3] The methods used in the study are described in greater detail in Lynn and Salzman, 2007b.
[4] This section is based on the chapter, "Indian Techno-entrepreneurship" by Pamela Meil and Hal Salzman in L. Lynn and H. Salzman, *Technology Entrepreneurs in the Emerging Economies*, Edward Elgar Publishing, forthcoming

operations and expansion in India, and a number of U.S. companies divested their Indian operations, most notably Coca Cola and IBM.

Policies were liberalized somewhat during the 1980 to 1990 period, and in 1991 foreign ownership of up to 51% of a joint venture was permitted in specific capital intensive and high technology industries (and up to 75% in a small number of other industries on a case-by-case basis). India has continued to liberalize FDI and other industry policies, particularly in certain sectors such as export software services and businesses in special enterprise zones. In the late 1990s, offshoring by MNEs to India for software and, to a lesser extent, engineering in other industries began to increase, quite dramatically after 1999 (beginning with Y2K remediation, then for back office and software services).

These factors, in combination, shaped the current stage of technology entrepreneurship in India, distinct in many ways from that of other countries though also sharing several common characteristics with TechEntre firms globally. The Indian cases reflect the specific migration patterns of the technology entrepreneurs and their technical and management staff, founders, directors, the nature of the opportunities created by government policy toward multinationals, and both the historical roots of electronics development and the recent history of software development in India. The following cases illustrate some of these dimensions in the development and growth of technology entrepreneurial firms. The three technology entrepreneurial firms discussed here also illustrate the somewhat different trajectories followed by Indian TechEntre Firms. These firms are Engineering Development & Design (EDD), NewTec, and TechWare (all pseudonyms).

EDD's founder followed the now-familiar education and career path leading to success for ambitious young Indians -- an undergraduate degree from an elite Indian university and then a graduate degree in electrical engineering in the United States in the mid-1980s. However, unlike many of his peers, EDD's founder returned to India, becoming the managing director of an India-U.S. joint venture that had been created as a result of India's domestic ownership policy. In the early 1990s he left that company and founded his own IT firm, a joint venture with another U.S. IT company. This firm was created primarily as a sales and marketing firm. Using this joint venture as a source of core revenue and investment funds, he expanded the scope of his business. He founded separate operating companies, with a management team of expatriates with similar backgrounds: most had elite Indian undergraduate education, graduate education in the U.S., and a range of work experience in the United States and at joint venture companies in India.

Initially the operating companies focused on outsourced IT work, but they also developed products for the Indian domestic finance industry. After the dot-com collapse in the United States, they decided to expand outside of the IT industry. Building on their engineering and development strengths, they developed engineering design and development capabilities in several industrial sectors in a separate operating company, EDD. EDD provided dedicated engineering and design capacity for foreign companies, with a dedicated engineering staff located in a separate physical space for each of its clients. This model protected the client's IP and served, in essence, as the offshore operation of the MNE. This model was successful in providing a means for MNEs to "try out" higher-skilled, higher value-added offshore engineering and development (i.e., for high level work rather than just the lower level, more routine work that was typically offshored at that time). The success convinced some MNEs to expand their Indian operations, but to do so at their own sites. Under the terms of its agreement with EDD, the MNE later took over the entire dedicated EDD engineering group that had been supporting its activities. Although EDD loses business and staff when MNEs decide to in-source their engineering to their own Indian sites, through this model EDD gains expertise across a broad range of engineering development and design areas and industries. A natural progression would be to move up the technology value chain as MNEs outsource greater amounts of engineering. Whether this model, which has been typical in electronics, will apply across a wider range of industries remains to be seen.

The second technology entrepreneurial firm, "NewTec," was started in the mid-1990s in India by two men. One was a returning Indian national who had gone to the United States for a graduate education. After working for a U.S. firm, he decided to return home because he was "bored with working in a large company." He also wanted to be near his family. The other founder was a high-level developer/analyst at the main development site of PC-Products (PCP), a global producer of software for computer applications. This programmer had gone to graduate school in the United States, but now also wanted to return to India. He proposed establishing a small office that would do tools development to support product development at PCP's main research campus. With a team of a few other Indian expatriates and some local hires he set up the Indian office.

These two men formed NewTec as a product company, but NewTec also did sales and service work to fund the product development. It was a sales vendor for PCP, but because it had deep development capacity, it began to do some maintenance, testing, and development work for PCP on subroutines. NewTec's own products found a market niche, but, these products did not generate high sales volume. Meanwhile, the demand for service work (testing, localization) by PCP and others was growing rapidly, so NewTec shifted its focus to work for U.S. MNEs. Its founders and many of its high-level technical staff still harbor the goal of becoming a product company. NewTec continually proposes expansion of its work for PCP, seeking to do greater portions of the component products and, through this knowledge and expertise, develop new product modules for PCP's products. It is still too early to know whether PCP's offshore development site limits the amount of higher-end work that now goes to NewTec.

For some expatriates, India offered better career opportunities than those available in the United States. Some saw fewer promotion opportunities in the United States and found U.S. MNEs becoming increasingly staid. Furthermore, India was changing, offering more efficient services and less government bureaucracy. As one of the Indian managers who had gone back said: "It's exciting to be here. It's like Silicon Valley in part. Bangalore feels the same way."

TechWare's history is somewhat different from EDD and NewTec. It was initially established as a software division of a large Indian industrial company in the mid-1980s. The restrictive environment for foreign MNEs and emphasis on local development discouraged foreign entry and provided an opportunity for domestic firms to diversify and fill local product niches. TechWare was thus established as a separate software product company in which the Indian industrial firm had equity but TechWare was run by an independent management team. Unlike the founding management in the other TechEntre firms, TechWare's management team came from other Indian firms and nearly all had completed both their undergraduate and graduate education in Indian colleges (primarily colleges in the top two tiers).

TechWare had a large product catalog for the Indian market, such as financial software for different businesses, and various utilities. Most of the products were not successful and the lax intellectual property laws at that time and the slow-growing computer market led them to change strategy. Instead of developing stand alone products they shifted to localization packages for existing U.S. software products. Some of their own products and the localization packages were successful, but did not generate significant growth. In the early 1990s TechWare decided to use its sales channels and software experience to become the Indian distributor of several U.S. software products. It developed a technical staff to provide support for those products. In the mid-1990s one of their major U.S. customers asked TechWare to do more software development for the Indian market, initially localization projects.

In the late 1990s, TechWare saw rapid growth opportunities in the delivery of offshore software services, and established a wholly-owned subsidiary in the United States. TechWare have since expanded throughout the United States and Europe, built multiple Indian sites, and purchased a European technology company.

The common elements in these three Indian companies (and in others that we studied but are not reporting here) is that they were established to fill niches created by restrictive Indian FDI policies, either as Joint Ventures or to develop products that foreign companies were not actively developing or selling in India. EDD and NewTec were true independent entrepreneurial companies established by expatriate Indians, with college degrees from the United States, whereas TechWare was established by a large Indian company and staffed with graduates from Indian colleges. All three companies had a strong product focus and/or high level engineering design/development focus though relied initially on revenues from providing offshore services. The understandable desire of Indian nationals to return to India, once opportunities were available there, was a major factor in the transfer of technology.

The Cases: China

Chinese technology policies also moved from giving priority to fears of dominance by foreigners to recognizing the advantages to be derived from openness. In the 1950s the country followed the Soviet Model. Soviet technology, know-how, and technical experts were imported on a large scale. Triad MNEs were kept out. Important reforms were introduced in the 1980s. Scientists took control of the Chinese Academy of Sciences, bureaucratic controls were loosened. Greater encouragement was given to FDI. From 1979 to 1987, for example, 282 new agreements were signed for the establishment of joint ventures in Shanghai alone. Foxboro, Bell Telephone, Volkswagen, Squibb were just a few of the foreign firms that thus entered the Chinese market during that period. The State Economic Commission allocated funds specifically for the import of foreign technology. In the 1950s measures were taken to encourage the return of expatriate Chinese scientists and engineers, and out of a sense of patriotism many returned from prestigious positions in the United States and Europe. The returnees were treated with suspicion, however, and efforts to bring more back faltered and even ended with Chinese political turmoil, especially during the cultural revolution in the 1970s. Renewed and reinvigorated efforts were made beginning in the late 1980s. By the early 2000s more than eighty percent of the members of the Chinese Academy of Sciences and more than half the members of the Chinese Academy of Engineering were returnees from the U.S. and Europe. Efforts to foster technology start-ups were also initiated in the 1980s. Mechanisms were developed so that firms could be spun off from universities and other state-owned bodies. High technology parts were established, though with uncertain results (sources covering these topics include Keyan, 2004; Lynn, forthcoming; Lynn and Salzman, forthcoming; Saxeninan, 2006; Simon and Rehn, 1988).

Several of the Triad MNEs in our study were actively involved in supporting the development of TechEnt firms in China. PCP which as we saw was also involved in the development of TechEnt firms in India, supported the development of software development firms in various parts of China. Sometimes this was done because national or provincial Chinese government policies offered subsidies and other assistance for the local development of technology, but this support could only go to Chinese firms. PCP could gain by helping entrepreneurs form companies to take advantage of these subsidies. This support of entrepreneurs in various regions also helped PCP follow some of its MNE customers to newly developing regions of China. Another major motivation was that as a worldwide policy, PCP sought to develop a large global network of independent software firms that would allow PCP to instantly scale up for large projects without the need to add to its own head count. When projects were completed PCP could quickly reduce costs without laying off its direct employees.

PowerStar, a U.S.-based MNE that is often praised in management text books for its management strategy, was aggressively seeking new vendors at all of its new production sites in emerging economies, including both India and China. A Chinese national who had been working as a senior manager at PowerStar in the United States was instrumental in establishing the PowerStar facility we visited in China. Initially PowerStar needed to find local suppliers in China to support its production there. Increasingly at the time of our interviews in 2006 PowerStar was using Chinese suppliers for PowerStar manufacturing operations outside China as well. A problem was that few Chinese firms, even those with superior technical capabilities had the experience, language skills, and other capabilities needed to deal with MNEs, so PowerStar had to help them acquire these capabilities.

EnergySystems, the power systems division of a highly admired MNE with operations in Asia, North America and Europe, needed to incorporate local suppliers in its projects in order to satisfy Chinese government requirements. To ensure that the Chinese suppliers met EnergySystems needs for the reliable on-time delivery of high quality components, EnergySystems was teaching its vendors advanced quality control and product development techniques. EnergySystems managers in China noted the lesson learned from another MNE that had failed in the same area in part because it had not developed high quality local suppliers. All the four senior managers at the EnergySystems site we studied in China were Chinese nationals (including one from Taiwan) who had studied in the United States and begun their careers at EnergySystems there. All considered themselves to be part of EnergySystems's international management cadre, not specialists on China.

Other scholars have found other ways in which MNE activities in China have supported the development of local TechEntre firms. Fuller (forthcoming; a case that is part of our forthcoming book) used a comparative case study of two firms to show an advantage to foreign involvement in TechEnt firms in China. Both of these firms were established by Chinese Ph.D.s returning from the United States.[5] One, Howard Yang, established a series of new high tech firms with the support of foreign venture capital funds. In the process he had to convince the foreign financiers of the quality of technology his firms were offering and of his ability to manage the firms. Yang's firms, Montage and Newave, are credited with creating innovative new technologies. The other returnee, Chen Jin and his Hanxin Group, relied on state support. Chen convinced the Chinese Ministry of Information Industry, Ministry of Science and Technology, and the Shanghai government that he had created China's first digital signal processor. These government agencies provided Chen with more than twelve million dollars. Later it was discovered that the processors Chen claimed to have produced were really imports. Fuller observes that Chinese government agencies often lack even rudimentary capabilities to evaluate the high technology projects they fund.

[5] For a discussion of the importance of returnees to the enrichment of the Chinese technology base see Saxenian (2006). á

A growing literature suggests still other ways in which the presence of MNEs has contributed to the growth of TechEnt in China. TechFaith, a firm that now has some 1,800 engineers and designers working on handset designs for such MNEs as NEC and Kyocera, was originally established when sales managers at Motorola persuaded 13 of its designers and engineers to quit and start the new enterprise.[6] UltraPower Soft – now the biggest business service management firm in China was supported in its early development by HP, IBM and other MNEs. Smartdot, which started at Tsinghua University, has received training and troubleshooting support from the IBM Innovation Center, which among other things sent a technical manager to help with a technical development roadmap. Sina Corporation, a value added information service received finance from foreign venture capital funds which helped it to achieve high performance standards. Lenovo built credibility as distributor in China for HP and AST.[7] Guangdong Galanze which now has 40% of the global market for microwave ovens acquired key technology through a joint venture with Whirlpool.

The Cases: Mexico

In both India and China entrepreneurial firms rose to exploit opportunities provided by the newly globalized technology development chains of MNEs. Entrepreneurship in Mexico, however, is concentrated in low-risk, low-value added endeavors that require a minimum investment of capital. A shortage of risk capital discourages TechEntre efforts and shifts the focus of entrepreneurial efforts toward low-risk ventures that can quickly achieve positive cash flow. The shortage of risk capital also reduces incentives for entrepreneurs to build and document their performance and provide the transparency that is demanded by providers of risk capital. The opportunities and special incentives to evade taxes and other regulations in Mexico also motivate entrepreneurs to adopt non-transparent business practices, making them unattractive to risk-capital investors. Entrepreneurial efforts in Mexico are also impeded by a lack of quality, timely information in markets, demographics, competitors, prices and costs. Another barrier to entrepreneurship is that people in Mexico are relatively unable to leave existing employment to pursue high-value-added entrepreneurial ventures (Fabre and Smith, Acosta chapter, Lynn and Salzman interviews in Puebla Mexico, 2005)[8].

This does not mean, however, that the new opportunities being provided by the globalization of engineering are not being utilized by local firms. An example of a mechanism that may be functionally equivalent to TechEntre is provided by the fast rising manufacturer of automotive parts, SanLuis Rassini (SLR). After discussing SLR we will present a related case of Mexican TechEntre developed by our colleagues, Acosta and Rodriguez. This case illustrates some of the barriers that appear to have hampered the ability of a highly qualified entrepreneur to take full advantage of the opportunities presented by the global integration of technology value chains. It also shows how globalization, nonetheless, is promoting the development of local technological capabilities by integrating people into global technology networks.

[6] Discussion of TechFaith and Sina have appeared in various sources, e.g. Sull, 2005.
[7] The story of Legend/Lenovo has also been widely reported. One account appears in Woetzel, 2003. Another is in Ernst and Naughton, 2007.
[8] For a discussion of how some recent reforms have affected entrepreneurial activity in Mexico see Bruhm (2008).

SanLuis Rassini: Filling the Gap for technology entrepreneurship firms[9] The predecessor of SLR originated as a small suspension repair shop in the 1920s. It first became an OEM for a multinational in 1938, with the sale of leaf springs to Ford Motor Mexico.

The company's integration into global technology value chains proceeded slowly until the 1980s, when U.S. automakers began outsourcing more aggressively. In response to the new opportunities thus provided, in 1984, SLR's Mexican predecessor opened a design, sales and customer service office in Michigan. Four years later SLR was formed with an infusion of capital and technology from Corporación Industrial SanLuis. SLP soon initiated an aggressive transformation process. New plants were built and older plants were modernized. Other Mexican firms were acquired. In 1997 SLR formed a strategic alliance with Italian-based Brembo S.p.A., a global leader in state-of-the-art brake systems. SLR further expanded its suspension business through a joint venture with NHK Spring of Japan, and acquired two suspension system and component companies in Brazil. These moves advanced SLR's strategy to broaden its continental leadership as a world-class Tier 1 supplier.

In 1996 SLR obtained ISO-9001 and QS-9000 certifications. SLR used its alliance with the Italian firm to help gain recognition in Europe and America, to get help in getting quality certification, to learn how to purchase high tech machinery and equipment, and to gain experience in global markets. New state-of-the art capacity was added with equipment from Japan, Germany. Switzerland and Italy to meet the needs of General Motors. In 2000, SLR concluded a $5 million, 2-year investment program to acquire the most advanced testing equipment and software at its Michigan facility.

In 2001 a SLR facility obtained Clean Industry certification and made its debut as a high performance platform supplier providing the front and rear rotors for the Cadillac CTS and Dodge Viper. In 2004, SLR continued supplying new high performance platforms with front and rear rotors for the Corvette C6. Currently SLR-Brakes focuses its energies on OEM auto-parts.

SLR now is a global designer and producer of advanced-engineered, hi-tech brake discs, rotors and assemblies. It has a diversified product portfolio for a wide international customer base, including General Motors, Ford, DaimlerChrysler, Nissan, Volkswagen, Toyota, Mitsubishi, Honda, Delphi, Scania, Agrale, Continental Teves, Dana, PBR and TRW, among others. The company has received various customer awards and acknowledgements, including Ford's Q1; Nissan's Yushu Shoh, Quality Master, Most Improved Supplier and Zero Defects; Nummi's Achievement of Quality Target; Toyota's Certificate of Quality Achievement; and DaimlerChrysler's Gold Award. In addition, SLR has received General Motors' Supplier of the Year award for nine consecutive years, a feat accomplished by only 20 out of GM's 3,700 worldwide suppliers. In May 2003, SLR opened a new coil spring plant in the U.S. From 1995 to 2003 the company invested more than $370 million in new equipment and technologies.

New hiring, training and other personnel practices were also introduced to raise standards in SLR's plants. The abilities and knowledge required now (with new technology) are more sophisticated than before. Customers expect SLR to have important certifications such as ISO 14000. Customer information is handled via the internet by people from SLR's Quality, Logistics and Sales departments. Each customer has a web site with a requirement table that is

[9] This case is abridged from Carlos Acosta and Adoracion Rodriguez, "San Luis Rassini," in L. Lynn and H. Salzman, *Technology Entrepreneurs in the Emerging Economies*, Edward Elgar Publishing, forthcoming. The initial interviews for the case were carried out jointly by Salzman, Lynn and Acosta, with subsequent research done by Acosta and Rodriguez and their students.

changing continuously. In this way, SLR is attentive to all their announcements and requirements. SLR operators must have the IT knowledge in order to work with machines, robots and processes.

The Michigan Center studies vehicle characteristics, quotation, and product definition according to customer requirements. The Mexican plant is responsible for prototype build-up, testing of prototype and in-plant implementation. Over the last ten years, the casting and machinery plant engineers have produced 195 new models of brakes at the Puebla plant. The automotive assembly plants in Mexico have been asking their suppliers to take the responsibility to design and develop their components and modules. This technological outsourcing has allowed SLR to be more competent and to construct its own product alternatives. Once carmakers started to outsource the design and production of their parts and subassemblies, SLR faced the need to adapt to these new conditions. Through its alliance with Brembo, SLR obtained the know-how necessary to compete in the "big three" market.

SLR hires Industrial, Mechanical and Electromechanical engineers with at least three years of experience in the automotive industry. They must have knowledge of the job including technological tools such as the use of flow charts, FMEA, CNC cutting tools, and also knowledge of some specific software. As "Big Three" automakers curtailed operations in Mexico, they released a large number of highly qualified engineers. Many were hired by SLR to further enable SLR to work closely with the U.S. firms.

JLH Numeric Control S.A. de C.V.: A Mexican TechEntre firm[10] The relative paucity of TechEntre in Mexico does not mean that such firms do not exist, but simply that they do not play nearly as large a role as their counterparts in China and India. One such firm, JLH, came into existence to support the activities of SLR. Indeed, the founder and owner of JLH is José Luis Hernández, a former employee of SLR. Hernández, an industrial electrical engineer worked for SLR for seven years He became expert in QS-9000 and VDA standards, T.P.M, System Automation, CNC Machining Centers and Robots (programming, operation, and maintenance) and PLCs (Fanuc and Siemens). As an SLR employee Hernández participated in technology projects in Japan, Italy and Germany.

Hernández, left SLR because he wanted to experience some new challenges, but he maintained good relations with the company and SLR outsources engineering work to him.When Hernández established JLH in 2000, it was difficult to find sources of investment capital so he had to use his own funds and some family support. Initially Hernández was the only employee in the company.

JLH's products are: Engineering (improvement projects, poka yoke design and implementation, corrective actions and plant capacity increase projects always focusing on the client's cost reduction.), automation (integrating PLCs, electric-pneumatic devices, servomotors, robots, artificial vision systems, including design and CNC manufacturing. The main objective is process optimization.), Maintenance (equipment and component repair. Complete preventive maintenance programs and new machine assembly.), monitoring (Remote real-time monitoring of critical process variables in work stations or complete production lines using a PC and the intranet (LAN); automatic production part counting, automatic scrap part counting, and automatic standard time and down time measurement).

The company now has two programmers, two mechanical designers, and one industrial engineer. For equipment start-ups temporary employees are also hired (mechanics, electricians, programmers). All the employees must have experience in specific technical fields; according to

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[10] This case is abridged from Carlos Acosta and Adoracion Rodriguez, "San Luis Rassini," in L. Lynn and H. Salzman, *Technology Entrepreneurs in the Emerging Economies*, Edward Elgar Publishing, forthcoming.

their profiles, they are sent to training courses. The experience obtained in every project is part of the employee's motivation as well.

JLH has developed its own technology. Its main equipment suppliers are Festo, Wenlock and Siemens. It carries out projects in Puebla, Mexico City and Monterrey. Aside from SLR its major clients include Kautex, Federal Mogul, Saint Gobain, Motor Wheel and Big Cola. JLH offers complete service to its clients, starting with the concept idea and finishing when the concept becomes a reality.

Mr. Hernandez wants to patent some automation devices developed for certain clients and sell them as finished products. In ten to twenty years he hopes to have a major presence through the Latin American market. The company is now considering joint ventures with some German companies. Mr. Hernández also wishes to manufacture original parts for the automotive industry by establishing another company in the near future. It remains to be seen how much a lack of venture capital in Mexico will limit his ambitions.

The Cases: Slovenia[11]

In the decades following World War II various firms producing automotive components and assembling automobiles for Citroen, Austin, Renault and other firms developed in the Slovenian republic of the former Yugoslavia. These firms benefitted from restrictive domestic content laws and from rising living standards leading to growing auto sales. In 1991, however, Slovenia declared its independence from the former Yugoslavia, and Slovenian firms lost virtually the entire Yugoslavian market. These firms needed quickly to integrate into the global economy in order to survive.[12] Suppliers moved from manufacturing parts that were completely designed by assemblers to being "development suppliers," i.e. firms developing and producing systems, assemblies and modules for cars. Survival entailed that firms have adequate capital and human capital to carry out development work. They had to meet more stringent international quality standards.

Many of the Slovenian firms gained or accessed developmental capabilities by forming the "Slovenian Automotive Cluster." Cimos, a firm that had assembled vehicles for Citroen, was central to the cluster. Cimos converted itself to a development supplier in 1996 when it re-negotiated its relationship with Citroen (from assembler to development supplier) and also established new ties with other automakers. By 2005 Cimos was a development supplier of engine parts for Audi, BMW, Ford, Opel, Renault, Volvo and other auto assemblers. The Automotive Cluster helped Cimos develop its sub-suppliers and thus link them into global technology development chains.

The firms were supported by the government, which initiated a program for the "Promotion of Enterprise Networking, Production Chain Specialization, and Common Development of International Markets under the Cluster System." The Slovenian Ministry of the Economy commissioned research on cluster development. The Minister noted that in some countries, such as the Scandinavian countries, a top-down approach to cluster development had taken place, while in the U.S., Holland and some other countries a bottom-up approach had been followed. The Ministry opted for a bottom-up approach. Companies and institutes were invited to propose clusters. Experts from Holland were asked to help in the development of the clusters.

The Automotive Cluster of Slovenia includes manufacturing and service companies from a number of related industries (mechanical, metal industry, electronics, chemical), as well as

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[11] This case was developed by Prodan and Antoncic (forthcoming), Lynn and Salzman.

[12] Indeed the number of OEMs dropped from 36 in 1970 to 13 by the end of 2005.

institutes involved in R&D. The Cluster now includes 54 members – seven of which are R&D institutes. The major objectives of the Cluster are to allow members access to knowledge, technology and information and the opportunity to engage in joint development projects. The firms are helped to achieve international quality standards, shorten development times, develop higher level products, train global-level workers, enter international markets (through joint market research and market entry projects). The Cluster targets some 10-15 research projects annually. A data base on R&D and quality has been created for members. One driver is the perceived need for the cluster to compete with others emerging in Central Europe. New firms are encouraged to join the cluster at relatively low cost, assuming they can meet international standards.

Discussion

A number of points can be made about the developing roles of emerging economy technology entrepreneurs in global technology value chains. Some relate to the technology entrepreneurs, some to the technological capabilities of the emerging economies, some to the MNEs, and some to the home countries of the MNEs.

The expanding role of emerging economy TechEntre firms is being driven, sometimes more quickly than the MNEs might expect, by the creativity and ambitions of emerging economy entrepreneurs. Many of these people are highly trained both in technology and in managing in the global system, they are very smart and energetic, and they are determined to create opportunities for themselves and others in their home countries. In these cases it does indeed seem that the emerging economy TechEntre firms contribute to the development of indigenous technological capabilities and provide at least partial return on investments once thought to be lost in brain drains. (See Saxenian, 2006; Kapur and McHale, 2005). Policymakers in emerging economies might want to more explicit design policies that enhance brain circulation returns

The policies governing integration into the global economy varied considerably over time in India, China, Mexico and Slovenia, and also varied considerably amongst these countries. Restrictive trade and investment policies and political repression led to a professional and high skill Diasporas in India and Greater China, but the subsequent return migration of older, skilled expatriates who had worked in MNEs eventually facilitated the development of TechEntre firms. In Slovenia, Soviet-era constraints on emigration and high levels of investment in the development of education and technology provided a population that had the skills to develop supplier industries when Western European firms moved into central Europe in the post-Soviet era. The rather abrupt dismantling of protective barriers in Mexico and Slovenia, also resulted in the opening of high tech niches for entrepreneurs and entrepreneurial firms. Similar processes occurred though more slowly in China and India. Their huge size gives these countries a greater ability to resist international pressures for globalization. To a greater or lesser degree the modernization of legal regimes and financial systems provided supportive structures for entrepreneurship in all the countries we examined, though less so in Mexico than the other countries and perhaps less so in China than in India.

In considering the policy implications of entrepreneurship and the new globalization of technology development, it is important to note that these TechEntre firms draw on strong technology and innovative capacities, but are quite different from entrepreneurial firms in the MNE home countries that develop discrete innovations and are more independent from larger firms. Although aspects of the entrepreneurial environment important to entrepreneurs everywhere are also is important for these firms (e.g., government regulation that eases firm establishment, availability of capital, etc.), they are distinguished by their position in the MNE's technology value chain and as recipients of technology transfer from the MNE. In the cases of India and China, government policy was also important, though in different ways. In India, the restrictions on FDI seem to have created the basis for the early product innovation capabilities and MNE investment whereas in China it is government policy that requires MNEs to locate technology development in the country and provides financial and regulatory state support of TechEntre firms. In the case of India, it appears that TechEntre firms can now develop on their own, aided by the reverse migration of expatriates with experience in MNEs. In the case of China, government requirements and potential market size appear to be the most compelling factors for MNE technology transfer to MNE offshore sites and/or TechEntre sites in China. In a number of Chinese TechEntre firms, technology acquisition from MNEs appears to be part of their growth strategies, often to compete with the foreign MNEs

As we have noted elsewhere (e.g. Lynn and Salzman, 2007b), the development of global technology development chains may be initiated by Triad MNEs, but the process is by no means strategic nor is it well controlled. TechEntre firms are constantly seeking to expand their range of activities, and constantly offering to contribute more to global technology value chains. Conversely, MNEs often find that in the short term it makes sense to turn activities over to them. Outsourcing is in fashion, and the rapid press of events makes careful evaluation of long-term consequences difficult. We have argued elsewhere that many MNEs are failing to take into adequate account the long-term strategic implications of their offshoring policies. In our interviews we found little evidence of a comprehensive analysis of the costs of offshoring.

Aside from the possibility that the benefits of offshoring may be overestimated, there are other underappreciated risks for the MNEs. Linking with emerging economy TechEntre firms is not the same as linking with domestic TechEntre firms. Such issues as IPR protection, employee turnover, government policies, and differing economic growth rates can lead to trajectories that may become problematic for the MNEs. The "linked" TechEntre—MNE relationship in the United States and in Europe generally follows established practices and trajectories. In the MNE home countries TechEntre firms form symbiotic relationships with the MNE and rarely become direct competitors. In China in particular, but India also, because of laxer IPR protection and the high firm to firm mobility of S&E human capital, the TechEntre firm can become the vehicle for technology transfer and, indeed, may rapidly grow into a competitor. They may also represent a transfer of technology to the emerging economy with a number of underappreciated effects.

MNEs should take into account their role in changing human capital migration. With the development of entrepreneurship opportunities, not just the job opportunities offered by the MNEs in their offshore operations, the TechEntre firms participate in the development and retention of high skill human capital. It is in their interest that they increasingly become the preferred employer in those countries. With looming talent shortages in these countries, and the MNE's increased dependence on offshore labor forces (see Lynn and Salzman, 2007a), TechEntre firms may gain additional competitive advantages in their ability to attract skilled labor.

Another little appreciated change has been the increasing "stickiness" of human capital. There is a general preference to stay within one's own culture and near one's family and friends, and the emerging economies increasingly offer its high-skill population attractive opportunities to do so. We'd suggest more thought be given the potentially greater advantage of EE TechEntre firms in attracting and using offshore human capital. Particularly if U.S. or European MNEs weaken their home country innovation capabilities, they may find themselves at a disadvantage in global competition.

Whether offshore TechEntre are substitutes or complements to onshore TechEntre is difficult to answer. The answer seems to be that "it depends." To the extent that MNEs are transferring operations and innovation activity offshore, these linked TechEntre firms may find themselves in competition with offshore TechEntre. However, the atypical pattern of offshore TechEntre, the reverse migration, the older entrepreneurial founders who come from U.S.-based MNEs, may mean that there are still strong links to the U.S. To the extent that the offshore TechEntre firms provide a retention function that lowers out-migration of the most innovative and entrepreneurial, the U.S. may find itself at a disadvantage unless it can develop collaborative linkages. Until now this has been done via MNEs, but as offshore TechEntre firms become competitors with the MNEs, and/or acquire the MNEs or other U.S. firms, the globally-distributed technology systems of U.S.-based MNEs begins to fray.

Conclusion: Entrepreneurship and global technology value chains

Technology entrepreneurship linked to MNEs poses a special case of entrepreneurship, of technology transfer, and globalization. It also poses its own set of issues for developing national competitiveness strategies. Both TechEntre firms and MNEs are undergoing substantial evolution in the current period of globalization, with highly uncertain outcomes. This case-based field research identifies some of the dynamics of change and emergent outcomes. These cases illustrate the different trajectories we identified, and the current outcomes, but at this point we are not able to state with any certainty the ultimate outcomes.

The technology transfer that occurs when MNEs incorporate TechEntre firms into their technology value chains also has different impacts, or follows different trajectories in each of the countries. We observed two important developments. First, in the industries we studied, MNEs were combining several different strategies: offshoring and outsourcing high-level technology development. In the IT firms, for example, MNEs in the United States had *acquired* innovative technology firms but not outsourced development; similarly, IT service firms outsourced and offshored low level development at the same time but previously had never developed supplier relationships onshore. Yet, the model and strategy managers were using offshore was that of their onshore supply chain for lower-level work or an ill-defined emulation of OEM supplier strategies from other industries. The "strategies" pursued by the MNEs often combine with path dependent trajectories to result in outcomes that are decidedly unstrategic.

The consequence of the offshore technology sourcing from TechEntre firms is still emerging. However, we find a number of instances in which much greater technology transfer than anticipated occurred and greater reliance on these supplier firms for critical capabilities. In one IT firm, marketing meetings with major customers had to include a supplier to whom significant development was outsourced because developers in the supplier were the only ones who knew about critical technology in the product being sold. In several other cases, the TechEntre firm was starting to develop its own development capability that would allow it to compete with the MNE. There are now more than a few instances in which that has occurred (though not in our sample because we were studying firms that were still part of the MNE's value chain). Our findings suggest that the unintended outcome of creating a competitor is not fully appreciated by MNEs. In part this is due to the emergence of an offshoring model using TechEntre firms that was not previously done and in part due to increased pressure to outsource.

The role of technology entrepreneurs in globalization is not well understood. In part this is because it is still an emergent phenomenon and because it is the development of a new organizational form or type of firm. For the United States, these findings suggest that this form of entrepreneurship is increasingly global and increasingly located offshore because of MNE technology globalization. Whether this will lead to a shift in location of the standalone technology entrepreneurs is not known. It would be reasonable to expect the growing technology capacity in the emerging economies, the change in migration patterns, and the innovation needs and growth markets in those countries will provide the environment for freestanding innovation entrepreneurship. At the same time, it would not be reasonable to expect U.S. policies and innovation environment that led to dominating global technology entrepreneurship in the past to be effective in the current stage of globalization.

One implication is that narrow policy approaches to "competitiveness" need to be reformulated. Focusing on immigration policy, for example, may be important but should not be a primary strategy for U.S. policy. Instead, a much broader approach that addresses the fundamentally changed nature of globalization is needed. We advocate here, as we have elsewhere (Lynn and Salzman, 2006) that U.S. educational institutions, policymakers, and managers search more creatively for ways to achieve "collaborative advantage." Another implication is that policies to support technology entrepreneurship are different from more general entrepreneurship policy. Because of their linkages with MNEs, this type of entrepreneurship, and the types of innovation they do, they are much more globally mobile and offshore locations may hold advantages for many of them. Standalone innovative entrepreneurship, such as the classic Silicon Valley model, is not developing rapidly in the emerging economies. However, this linked techno-entrepreneurship may be emerging as a new form and one which challenges the traditional separation of large firm and small firm activities, innovation, and markets.

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