Discussion Paper:

Immigrants and Returnees

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Overview and Summary of Research in Progress

With the help of Professors Gary Gereffi of Duke University, Anna Lee Saxenian of University of California at Berkeley, Guillermina Jasso of New York University, and Richard Freeman of Harvard University, we have been researching the impact of globalization on the engineering profession and U.S. competitiveness.

Our initial research focused on graduation rates of engineers in India, China and the U.S. and revealed that the statistics commonly used in the outsourcing debate had no basis. This led us to research why companies were going offshore, the strengths and weaknesses of each workforce, and the long term trend. We learned that the driving force behind offshoring and outsourcing was cost saving -- and not the quality or skill of American workers. The trend was gaining momentum and the next types of jobs to go offshore would be in research and design. These new jobs would require a better educated workforce with higher level degrees. When we analyzed graduate and postgraduate data, we found that China was racing ahead of the U.S. and India in the production of masters and PhD's in engineering – as well as in bachelors degrees.

Taken at face value, the data show that China should be the country that U.S. firms gravitate to for engineering research and design, and that India should be losing momentum. Yet our interviews with the executives of multi-nationals and local tech firms in China and India showed the opposite. We learned that companies experienced the greatest difficulties in hiring in China, followed by U.S. and India. India is building tremendous momentum in becoming a base for research and innovation. So it became clear that there is a different dimension that needs to be explored.

To understand the big picture and the sources of U.S. competitiveness, we switched gears to look at the success of immigrants in the engineering and technology professions in the U.S.

We documented that one in four engineering and technology companies founded between 1995 and 2005 had an immigrant founder. We found that these companies employed 450,000 workers and generated $52 billion in revenue in 2006. Indian immigrants founded more companies than the next four groups (from U.K., China, Taiwan, and Japan) combined. Furthermore, these companies' founders were very highly educated in science, technology, math, and engineering-related disciplines, with 96 percent holding bachelor's degrees and 75 percent holding master's or PhD degrees.

Our analysis of the World Intellectual Property Organization (WIPO) database showed that foreign nationals residing in the United States were named as inventors or co-inventors in 25.6 percent of international patent applications filed from the United States in 2006. This increased from 7.6 percent in 1998. Indians and Chinese dominated the foreign national group.

To understand why the numbers of foreign nationals filing U.S. global patent applications had increased so dramatically, we researched the immigration backlog. We found that the number of skilled workers waiting for visas is significantly larger than the number that can be admitted to the

United States. This imbalance creates the potential for a sizeable reverse brain-drain from the United States to the skilled workers' home countries.

Our current research shows that the shift of research and innovation to India and China is being aided by the increasing numbers of returnees to these countries from the U.S. When you combine the growing economic opportunities in India and China with the flawed immigration policies of the U.S., you set the stage for a serious competitiveness problem for the U.S.

Work in Progress at Duke and Harvard:

With the support of the Kauffman Foundation, we are currently researching U.S. competitiveness and the potential for a reverse brain-drain from multiple perspectives:

1. An analysis of all WIPO patent applications filed globally for the last 28 years. We are determining the address of every inventor in the world that was named on a patent application. We expect to show how intellectual property creation has shifted globally – from the U.S. to Europe and now to India/China.

2. Creation/definition of a set of global value chains for the following industries:
   - Pharmaceuticals
   - Automotive
   - Aerospace
   - Cell Phones
   - Computer networking
   - Semiconductors

3. An analysis of the type of innovation that is now happening in India and China. This is based on detailed interviews with executives of multi-nationals and local firms in these countries.

4. An estimate of the numbers of U.S. trained and educated workers who have returned to India and China over the past 7 years. Our focus is on the industries with the largest numbers of returnees in India and China.

5. Surveys of 500 returnees to India and China to determine why they returned and how their work and experience compares.

6. Surveys of 1000+international students studying science and engineering in the U.S. to learn whether they intend to stay after they graduate and what their concerns are.

7. The correlation between education and entrepreneurship in American born founders. We are surveying several hundred native born tech and engineering founders to understand their educational background. We hope to learn if education and entrepreneurship in this group has the same correlation we saw with immigrant company founders.

Findings from Previous Research Projects:

Graduation Rates of Engineers in India, China and the U.S.

Various articles in the popular media, speeches by policymakers, and reports to Congress have stated that the United States graduates roughly 70,000 undergraduate engineers annually, whereas China graduates 600,000 and India 350,000. Even the National Academies and the U.S. Department of Education have cited these numbers. Such statements often conclude that since China and India collectively graduate 12 times more engineers than does the United States, the United States is in trouble. The remedy that typically follows is for the United States to graduate more engineers.

What we learned was that no one was comparing apples to apples.

In China, the word "engineer" does not translate well into different dialects and has no standard definition. We were told that reports sent to the China Ministry of Education (MoE) from Chinese provinces did not count degrees in a consistent way. A motor mechanic or a technician could be considered an engineer, for example. Also, the numbers included all degrees related to information technology and to specialized fields such as shipbuilding. It seems that any bachelor's degree with "engineering" in its title was included in the ministry's statistics, regardless of the degree's field or associated academic rigor. Ministry reports also included "short-cycle" degrees typically completed in two or three years, making them equivalent to associate degrees in the United States. Nearly half of China's reported degrees fell into this category.

In India, data from NASSCOM were most useful. The group gathers information from diverse sources and then compares the data to validate projections and estimates. However, NASSCOM's definition of engineer includes a wide variety of jobs in computer science and fields related to information technology, and no breakdown is available that precisely matches the U.S. definition of engineer, which generally requires at least four years of undergraduate education. Still, the group's data provide the best comparison. Data from the three countries are presented in Table 1.

Table 1: Four-Year Bachelors Degrees in Engineering, Computer Science, and Information Technology Awarded from 1999 to 2004 in the United States, India, and China

	1999-2000	2000-01	2001-02	2002-03	2003-04	2004-05
United States	108,750	114,241	121,263	134,406	137,437	133,854
India		82,107	109,376	129,000	139,000	170,000
China, MoE and CERN				282,610	361,270	
China, MoE Yearbook	212,905	219,563	252,024	351,537	442,463	517,225

Note: Gray highlighted data may constitute a substantial overestimate

Industry trends in outsourcing

We surveyed 58 U.S. corporations engaged in outsourcing engineering jobs. Our findings include:

Degree requirements. We were surprised that the majority of respondents said they did not mandate that job candidates possess a four-year engineering degree. Forty percent hired engineers with two- or three-year degrees, and an additional 17% said they would hire similar applicants if they had additional training or experience.

Engineering offshore. Forty-four percent of respondents said their company's U.S. engineering jobs are more technical in nature than those sent abroad, 1% said their offshore engineering jobs are more technical in nature, and 33% said their jobs were equivalent. Thirty-seven percent said U.S. engineering employees are more productive, whereas 24% said U.S. and offshore engineering teams are equivalent in terms of productivity. Thirty-eight percent said their U.S. engineering employees produced higher quality work, 1% said their company's offshore engineering employees produced higher quality work, and 40% said the groups were equal.

Reasons for going offshore. India and China are the top offshoring destinations, with Mexico in third place. The top reasons survey respondents cited for going offshore were salary and personnel savings, overhead cost savings, 24/7 continuous development cycles, access to new markets, and proximity to new markets.

Workforce issues. Given the graduation numbers we collected for China and India, we expected to hear that Indian corporations had difficulty hiring while Chinese companies did not. Surprisingly, 75% of respondents said India had an adequate to large supply of well-qualified entry-level

engineers. Fifty-nine percent said the United States had an adequate supply, while 54% said this was the case in China.

Future of engineering offshore. The vast majority of respondents said the trend will continue and their companies plan to send an even wider variety of jobs offshore. Only 5% said their overseas operations would stabilize or contract.

To complement our survey, we also met with senior executives of a number of U.S. multinationals, including IBM, Microsoft, Oracle, and GE in India and China. All of them talked of major successes, expressed satisfaction with the performance of their groups, and foresaw significant expansion. They said their companies were responding to the big opportunities in these rapidly growing markets. They expected that R&D would be moved closer to these growth markets and that their units would be increasingly catering to worldwide needs.

Graduate and postgraduate engineering education

Business executives in India and China told us that for higher-level jobs in R&D, they preferred to hire graduates with master's or PhD degrees. They did not mandate a PhD for research positions, and they said they often found many capable master's-level graduates. Chinese executives said it was getting easier to hire master's and PhD graduates, but Indian executives said it was getting harder. In both countries, they reported seeing an increasing number of expatriates returning home and bringing extensive knowledge and experience with them.

We gathered extensive data on Masters and PhD graduation rates to understand the comparative advantages of each country.

Table 2 shows our comparative findings related to master's degrees, and Table 3 shows our findings related to PhD degrees:

Table 2: Ten-Year Trend in Engineering and Technology Master's Degrees in the United States, China, and India (Actual and Estimated Data)
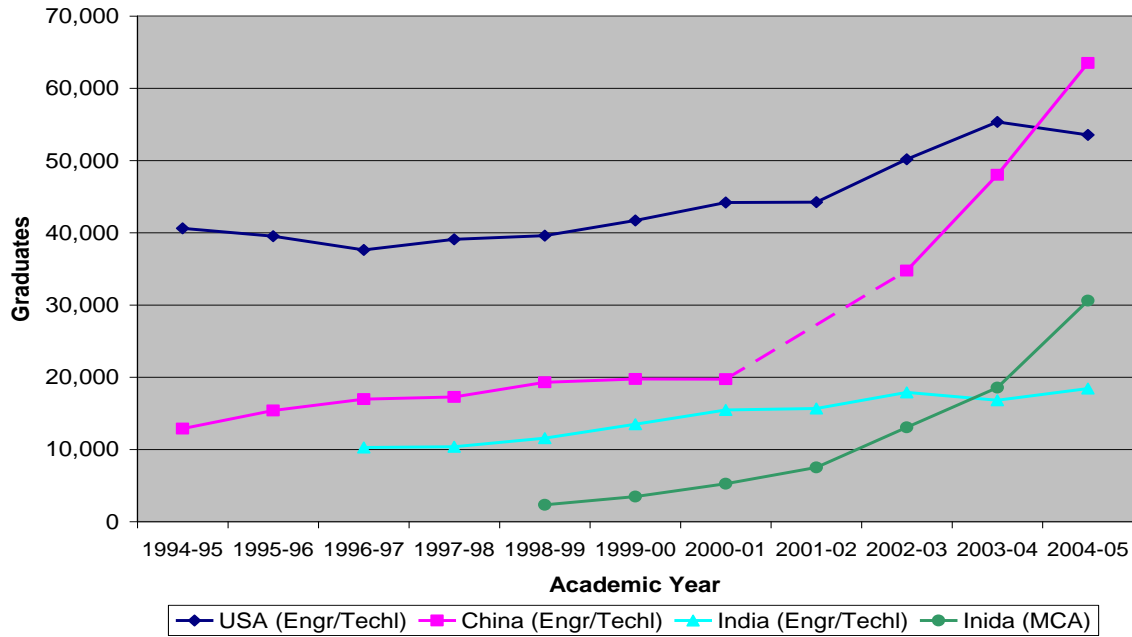
Note: 2001-02 Chinese data (hashed line) from the Ministry of Education represents a significant outlier and thus was removed from our analysis.

Table 3: Ten-Year Trend in Engineering and Tech PhD Degrees in the United States, China, and India
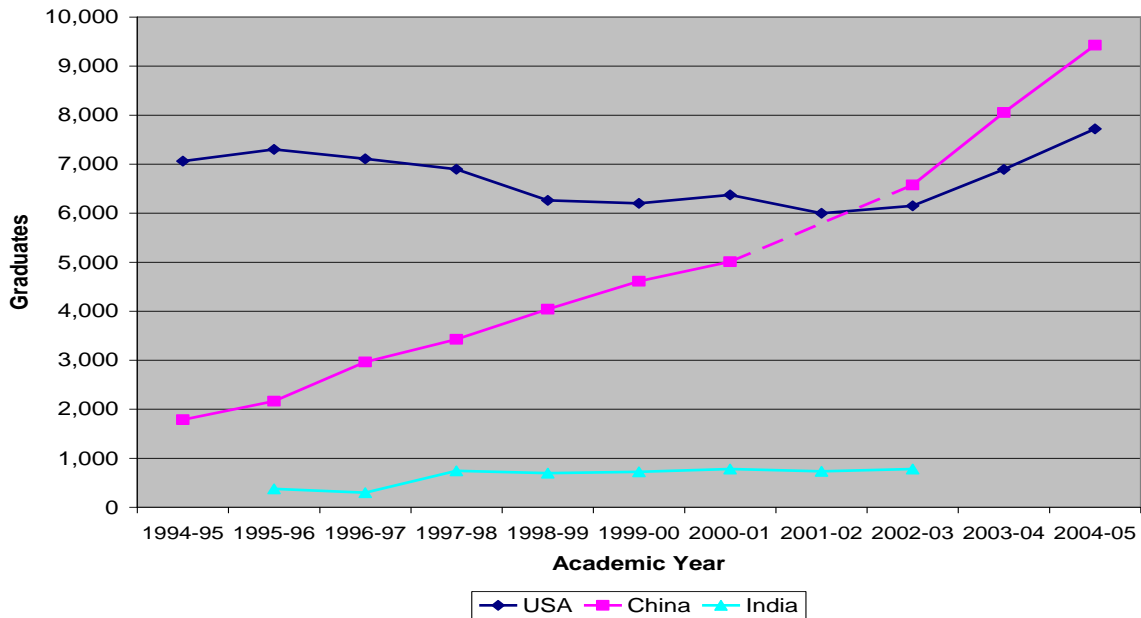
Note: 2001-02 Chinese data (hashed line) from the Ministry of Education represented a significant outlier and was removed from our analysis.

Economic Contributions of Skilled Immigrants to the U.S.

In 1999, AnnaLee Saxenian of the University of California, Berkeley, published a study showing that foreign-born scientists and engineers were generating new jobs and wealth for the California economy. But she focused on Silicon Valley, and this was before the dot-com bust. To quantify the economic contribution of skilled immigrants, we set out to update her research and look at the entire nation.

We examined engineering and technology companies founded from 1995 to 2005. Our objective was to determine if their chief executive officer or chief technologist was a first-generation immigrant and, if so, the country of his or her origin. We made telephone contacts with 2,054 companies. Overall, we found the trend that Saxenian documented in Silicon Valley had become a nationwide phenomenon:

- In 25.3% of the companies, at least one key founder was foreign-born. In the semiconductor industry, the percentage was 35.2%.

- Nationwide, these immigrant-founded companies produced $52 billion in sales and employed 450,000 workers in 2005.

- Almost 80% of immigrant-founded companies were within two industry fields: software and innovation/manufacturing-related services. Immigrants were least likely to start companies in the defense/aerospace and environmental industries.

- Indians have founded more engineering and technology companies during past decade than immigrants from Britain, China, Taiwan, and Japan combined. Of all immigrant-founded companies, 26% have Indian founders.

Foreign-National Contributions to U.S. International Patent Applications

- Foreign nationals residing in the United States were named as inventors or co-inventors in 25.6 percent of international patent applications filed from the United States in 2006. This represents an increase from 7.6 percent in 1998.

- Foreign-national contributions to international patent applications were highest in California, Massachusetts, and New Jersey.

- Foreign nationals and foreign residents contributed to more than half of the international patents filed by a number of large, multi-national companies, including Qualcomm (72 percent), Merck & Co. (65 percent), General Electric (64 percent), Siemens (63 percent), and Cisco (60 percent). Foreign nationals contributed to relatively smaller numbers of international patent applications at other firms, such as Microsoft (3 percent) and General Motors (6 percent). Forty-one percent of the patents filed by the U.S. government had foreign nationals or foreign

residents as inventors or co-inventors. (Foreign-national inventors are individuals with foreign citizenship working in the United States. Foreign resident inventors have foreign citizenship and are not based in the United States.)

Indian and Chinese Inventors

- In 2006, 16.8 percent of international patent applications from the United States had an inventor or co-inventor with a Chinese-heritage name, representing an increase from 11.2 percent in 1998. The contribution of inventors with Indian-heritage names increased to 13.7 percent from 9.5 percent in the same period.

- Chinese inventors tended to reside in California, New Jersey, and New York. Indian inventors chose California, New Jersey, and Texas.

- Both Indian and Chinese inventors tended to file most patents in the fields of sanitation/medical preparations, pharmaceuticals, semiconductors, and electronics.

The Educational Background of Immigrant Founders

Immigrant founders are very well-educated, with higher degrees in Science, Technology, Engineering and Mathematics (STEM)-related disciplines.

- 96% held bachelors degrees and 74% held graduate or postgraduate degrees (26.8% held PhDs and 47.2% held Masters degrees).

- 75% of their highest degrees were in STEM fields: applied sciences (10.2%), engineering (43.5%), mathematics (2.8%), and CS and IT (18.5%).

Proportion of immigrant founders educated in the U.S.

More than half (53%) of the immigrant founders of U.S.-based technology and engineering companies completed graduate and postgraduate degrees in U.S. universities.

Motivation and timing of immigrant founders' move to the U.S.

The majority of immigrant founders came to the U.S. as students. They ended up staying in the U.S. after graduation, and they founded companies an average of 13 years after their arrival.

- 52.3% of immigrant founders initially came to the U.S. primarily for higher education, 39.8% entered the country because of a job opportunity, 5.5% came for family reasons, and only 1.6% for entrepreneurship.
- 76.7% of immigrant founders entered the U.S. after 1980.

Undergraduate education in India, China, and Taiwan

There is a common belief that most Indian and Chinese entrepreneurs in the U.S. are graduates of a small cadre of elite institutions in their native countries such as the Indian Institutes of Technology (IITs) in India, and Peking and Tsinghua Universities in China. In reality:

- 88% of Indian founders completed their undergraduate degrees in their home country, as did 35.1% of Chinese and 96.5% of Taiwanese founders in the U.S.

- Indian and Chinese founders graduated from a diverse set of schools in their native countries, many of which are considered second- or third-tier universities.

- Only 15% of Indian founders were graduates of the IIT.

- Chinese founders who were educated in China were somewhat more likely to hold degrees from Peking University (20%) or Shanghai Jiao Tong University (15%) than other Chinese universities.

- A majority of Taiwanese entrepreneurs (55%) received bachelors degrees from two elite universities (National Taiwan University and National Chiao-tung University.)

The Growing Immigration Backlog

We estimate that as of 30 September 2006 there were 500,040 principals in the main employment-based categories and an additional 555,044 family members awaiting legal permanent resident status in the United States.

- The number of employment-based principals waiting for labor certification—the first step in the U.S. immigration process—was estimated at 200,000 in 2006.

- The number of pending I-140 applications—the second step of the immigration process—stood at 50,132 in 2006. This was more than seven times the total in 1996 (6,743).

- The number of employment-based principals with approved I-140 applications and unfiled or pending I-485s—the last step in the immigration process—was estimated at 309,823 in 2006, representing almost a three-fold increase from the previous decade.

- Overall, we estimate that the number of employment-based principals (in the three main employment visa categories—EB-1, EB-2, and EB-3) waiting for legal permanent residence in the United States in 2006 was 500,040.

- The total number of employment-based principals in the focal employment categories and their family members waiting for legal permanent residence in the United States in 2006 was estimated at 1,055,084. We further estimate that 126,421 residents abroad were also waiting for U.S. legal permanent residence, giving a worldwide total of 1,181,505.

We also gathered estimates of the numbers of students and skilled temporary workers. There is some overlap between this group and the estimates above; the two totals, therefore, cannot be added together.

- In the 2005-2006 academic year, 259,717 international graduate students were studying in the United States. In addition, 38,096 were in practical training, and at least some of these individuals were likely to be postdoctoral scholars.

- A previous study estimated the 2004 population of all H and L workers (all Hs except H4 spouses, plus L1) at 704,000.

The need for Further Research and Short-Term Policy Changes

It is becoming increasingly clear that globalization is the new reality. American businesses see tremendous opportunities abroad and will increasingly locate their operations closer to growth markets

They will also outsource research and development jobs to reduce costs and move their research functions closer to their offshore development sites. The long-term impact of this trend is not clear. The problem is that there are few facts in the globalization debate and some of the statistics in common use are incorrect.

New research is needed to correct the incorrect "facts", so that better national policies can be developed.

One of the most immediate issues that needs to be addressed is the immigration backlog and the potential for a reverse brain-drain. It is clear that returnees to India and China are giving those countries a competitive advantage by accelerating the offshoring of research and innovation. There are over one million skilled immigrants already in the U.S. working for U.S. companies who have applied for permanent residence status. It is in our interests to keep these workers in the U.S. Additionally, there are nearly 300,000 students and postdocs. We also need to keep the best and brightest of these.

References:

Our detailed research papers can be found on our website – www.GlobalizationResearch.com