DUKE
MASTER OF ENGINEERING MANAGEMENT PROGRAM

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SCHOOL OF ENGINEERING

UC Berkeley
School of Information

America's New Immigrant Entrepreneurs

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Introduction and Overview

Two of the most important questions now being debated in the U.S. are the effects of globalization and immigration on the nation's economy. Globalization is accelerating and it is still not clear whether trends like outsourcing will erode U.S. competitiveness or provide long-term benefits. The focus of the immigration debate is on the plight of millions of unskilled immigrants who have entered the U.S. illegally. Overlooked in the debate are the hundreds of thousands of skilled immigrants who annually enter the country legally.

In 1999 AnnaLee Saxenian published a groundbreaking report on the economic contributions of skilled immigrants to California's economy. This study, entitled "Silicon Valley's New Immigrant Entrepreneurs", focused on the development of Silicon Valley's regional economy and the roles of immigrant capital and labor in this process. Saxenian's study also went beyond a quantitative analysis to focus on the social, ethnic and economic networks of new U.S. immigrants. One of her most interesting findings was that Chinese and Indian engineers ran a growing share of Silicon Valley companies started during the 1980s and 1990s and they were at the helm of 24% of the technology businesses started from 1980 to 1998. Saxenian concluded that foreign-born scientists and engineers were generating new jobs and wealth for the California economy. Even those who returned to their home countries to take advantage of opportunities there were building links to the U.S. and spurring technological innovation and economic expansion for California.

A team of student researchers in the Master of Engineering Management program of the Pratt School of Engineering at Duke University has been researching the impact of globalization on the U.S. economy and the engineering profession. The team is led by Executive in Residence Vivek Wadhwa, Research Scholar Ben Rissing, and Sociology Professor Gary Gereffi. Earlier research focused on the education and graduation rates of engineers in the U.S., China and India, and an analysis of the experiences of U.S. firms engaged in outsourcing their engineering operations.

The Duke researchers were concerned about the growing momentum in outsourcing and its impact on U.S. competitiveness—and sought to understand the sources of the U.S. global advantage as well as what the U.S. can do to keep its edge. To better understand the contributions of skilled immigrants to the competitiveness of the U.S. economy, they decided to expand and update Saxenian's study.

The goal of this research was to document the economic and intellectual contributions of immigrant technologists and engineers at the national level. To understand the economic impact, the study looked at a large sample of all engineering and technology companies founded in the last ten years, to determine whether a key founder was an immigrant. To understand the intellectual contribution, they analyzed the World Intellectual Property Organization Patent Cooperation Treaty database for international patent applications filed in the United States.

The results show that the trend Saxenian documented for Silicon Valley, a pattern of skilled immigrants leading innovation and creating jobs and wealth, has become a nationwide phenomenon. Here are some characteristics of the engineering and technology companies started in the U.S. from 1995 to 2005.

- In 25.3% of these companies, at least one key founder was foreign-born. States with an above-average rate of immigrant-founded companies include California (39%), New Jersey (38%), Georgia (30%), and Massachusetts (29%). Below-average states include Washington (11%), Ohio (14%), North Carolina (14%), and Texas (18%).
- Nationwide, these immigrant-founded companies produced $52 billion in sales and employed 450,000 workers in 2005.
- Indians have founded more engineering and technology companies in the US in the past decade than immigrants from the U.K., China, Taiwan and Japan combined. Of all immigrant-founded companies, 26% have Indian founders.
- Chinese (Mainland- and Taiwan-born) entrepreneurs are heavily concentrated in California, with 49% of Mainland Chinese and 81% of Taiwanese companies located there. Indian and U.K. entrepreneurs tend to be dispersed around the country, with Indians having sizable concentrations in California and New Jersey and the British in California and Georgia.
- The mix of immigrants varies by state. Hispanics constitute the dominant group in Florida, with immigrants from Cuba, Columbia, Brazil, Venezuela, and Guatemala founding 35% of the immigrant-founded companies. Israelis constitute the largest founding group in Massachusetts, with 17%. Indians dominate New Jersey, with 47% of all immigrant-founded startups.
- Almost 80% of immigrant-founded companies in the US were within just two industry fields: software and innovation/manufacturing-related services.
- Immigrants were least likely to start companies in the defense/aerospace and environmental industries. They were most highly represented as founders in the semiconductor, computer, communications, and software fields.

We estimate, based on an analysis of the World Intellectual Property Organization (WIPO) patent databases, that foreign nationals residing in the U.S. were named as inventors or co-inventors in 24.2% of international patent applications filed from the U.S. in 2006. Unlike the company founder survey, this count does not include such immigrants who became citizens before filing a patent. We therefore classified the foreign nationals as "immigrant non-citizens". WIPO PCT applications represent a subset of those filed with the U.S. Patent and Trademark Office but are likely to have a high global utility and contribute to U.S. competitiveness.

- The trend has been dramatic; according to our estimates the contribution of non-citizen immigrants to these international patent applications increased from 7.3% in 1998 to 24.2% in 2006.
- The largest group of immigrant non-citizen inventors were Chinese (Mainland- and Taiwan-born). Indians were second, followed by the Canadians and British.

- Immigrant non-citizens filed more theoretical, computational and practical patents than mechanical, structural or traditional engineering patents.

To understand the role of regional technology centers in fueling the growth of engineering and technology companies, we did a special analysis of Silicon Valley, CA and Research Triangle Park, NC. Here are the findings of our analysis of engineering and technology companies founded from 1995 to 2005 in these regions:
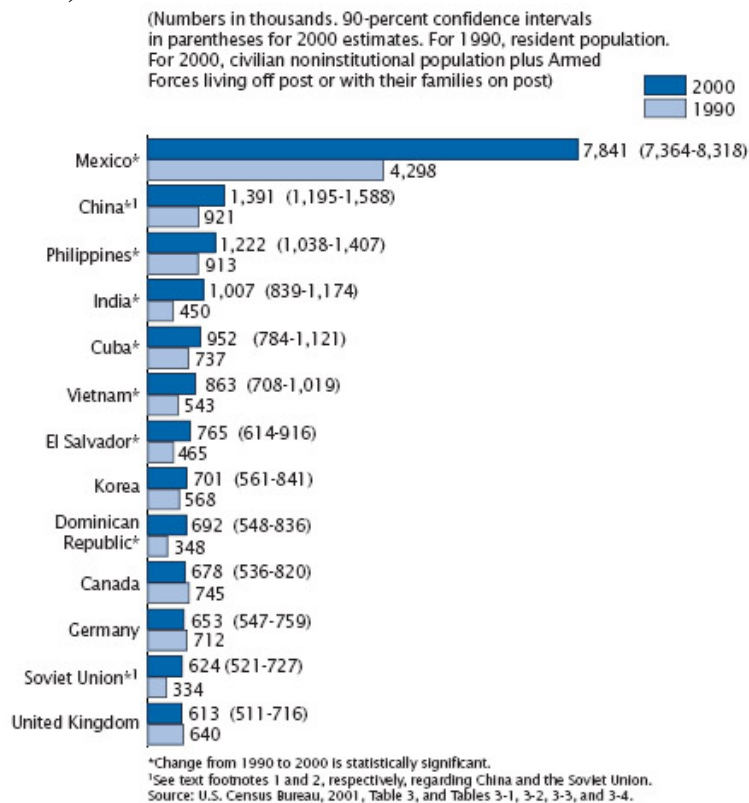
- Over half (52.4%) of Silicon Valley startups had one or more immigrants as a key founder, compared with the California average of 38.8%.
- A comparison with Saxenian's 1999 findings shows that the percentage of firms with Indian or Chinese founders had increased from 24% to 28%. Indian immigrants outpaced their Chinese counterparts as founders of engineering and technology companies in Silicon Valley. Saxenian reported that 17% of Silicon Valley startups from 1980-1998 had a Chinese founder and 7% had an Indian founder. We found that from 1995 to 2005, Indians were key founders of 15.5% of all Silicon Valley startups, and immigrants from China and Taiwan were key founders in 12.8%.
- In Research Triangle Park, 18.7% of startups had an immigrant as a key founder, compared with the North Carolina average of 13.9%. Indians constitute the largest immigrant founding group, with 25% of startups, followed by immigrants from Germany and the U.K., each with 15%.

What is clear is that immigrants have become a significant driving force in the creation of new businesses and intellectual property in the U.S. — and that their contributions have increased over the past decade.

Background on U.S. Immigration

March 2003 U.S. Census data show that 11.7% of the U.S. population was foreign-born.[1] Immigrants from Latin America make up the largest portion of this group at 53.3%, followed by Asia (25.0%) and Europe (13.7%). Figure 1 displays the countries of birth for foreign born individuals living in the U.S. in 1990 and 2000.

Figure 1: Countries of Birth of the U.S. Foreign-Born Population in 1990 and 2000 (Includes Data from Groups with 500,000 or More Individuals Living in the U.S. in 2000)[2]

(Numbers in thousands. 90-percent confidence intervals in parentheses for 2000 estimates. For 1990, resident population. For 2000, civilian noninstitutional population plus Armed Forces living off post or with their families on post)

	2000
	1990

Country	2000	1990
Mexico*	7,841 (7,364-8,318)	4,298
China*[1]	1,391 (1,195-1,588)	921
Philippines*	1,222 (1,038-1,407)	913
India*	1,007 (839-1,174)	450
Cuba*	952 (784-1,121)	737
Vietnam*	863 (708-1,019)	543
El Salvador*	765 (614-916)	465
Korea	701 (561-841)	568
Dominican Republic*	692 (548-836)	348
Canada	678 (536-820)	745
Germany	653 (547-759)	712
Soviet Union*[1]	624 (521-727)	334
United Kingdom	613 (511-716)	640

*Change from 1990 to 2000 is statistically significant.
[1]See text footnotes 1 and 2, respectively, regarding China and the Soviet Union.
Source: U.S. Census Bureau, 2001, Table 3, and Tables 3-1, 3-2, 3-3, and 3-4.

It is noteworthy that immigrants from China and India both constitute much less than 1% of the total U.S. population.
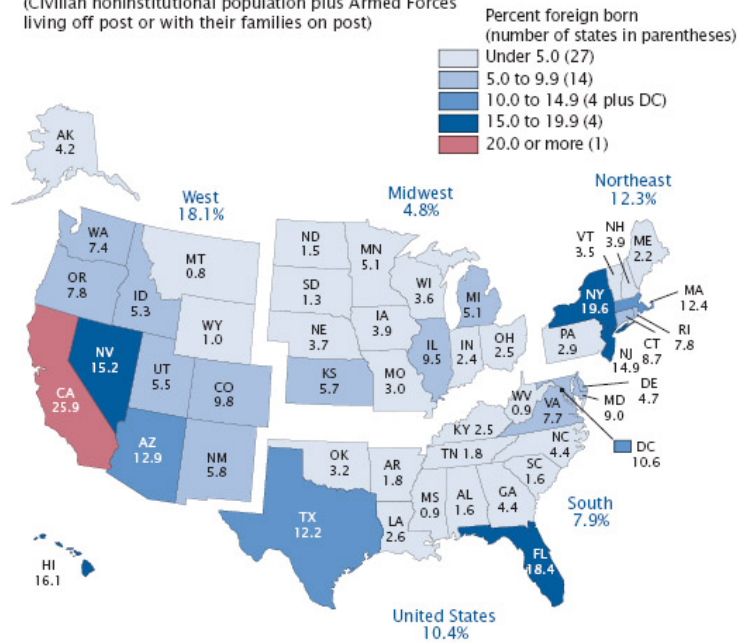
Immigrant populations vary considerably by state. California has the highest percentage, with 24.9% of the state's 2000 population being foreign-born, followed by New York, with 19.6%; Florida, with 18.4%; and Nevada, with 15.2%. The lowest foreign-born state populations are in west/midwest and southern states. A full state breakdown of this Census data can be found in Figure 2.

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[1] Larsen, Luke (August 2004). The Foreign-Born Population in the United States: 2003. P20-551. Retrieved from the World Wide Web: <http://www.census.gov/prod/2004pubs/p20-551.pdf>
[2] U.S. Census Bureau (December 2001). Profile of the Foreign-Born Population in the United States: 2000. Retrieved from the World Wide Web: <http://www.census.gov/prod/2002pubs/p23-206.pdf>

**Figure 2: Foreign-Born Population for Individual States: 2000**

According to the Census bureau, a higher proportion of the foreign-born Asian population than the total foreign-born population came to the United States over the past two decades. The majority of the foreign-born Asian population had entered the United States since 1980. See Figure 3 for this breakdown.

Figure 3: Foreign-Born Asians by Year of Entry to the U.S. in 2000[3]
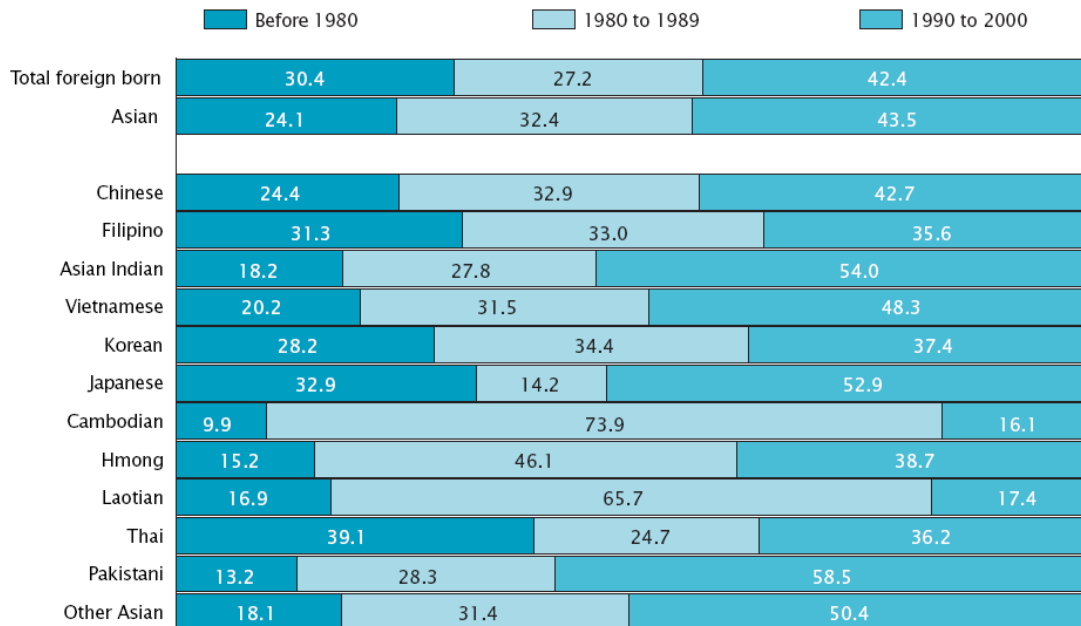
Source: U.S. Census Bureau, Census 2000 special tabulation.

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[3] U.S. Census Bureau (2000). "Figure 6: Nativity and Citizenship Status: 2000", Census 2000 special tabulation.

Methodology – Immigrant Key Founder Data

Data Acquisition

To quantify the economic contributions of immigrant entrepreneurs to the U.S. economy we sought to identify the direct involvement of immigrants in the founding of engineering and technology companies. We obtained a list of all such companies founded in the U.S. in the last ten years (1995-2005) from Dun & Bradstreet's (D&B) Million Dollar Database. This contains U.S. companies with more than $1 million in sales, and 20 or more employees, and company branches with 50 or more employees. This database is commonly used by researchers and is considered a source of reliable data.

This D&B database search produced a listing of 28,766 companies. A very small portion of these were older companies with recent changes in control or corporate restructurings/mergers, so these were omitted from our dataset. Included below is a list of key data that D&B provides:

- Company name
- Type of company
- City, state, zip code
- Phone number
- Company website
- Sales

- Total number of employees
- Select executive officer information
- Primary standard industrial classification

For the purposes of our study, the words technology and engineering indicate that the main work of the company is to use technology or engineering to design or manufacture products or services. Our definition of engineering and technology firms thus includes the following industry groups, defined with 3- and 4-digit U.S. Government Standard Industrial Classification (SIC) codes: semiconductors, computers/communications, biosciences, defense/aerospace, environmental, software, and innovation/manufacturing-related services. A full listing of the SIC codes associated with each industry group is present in appendix A. These are the same engineering and technology SIC codes used in Saxenian's original research. We excluded some professional services SIC codes which were included in Saxenian's 1999 study, but were outside the purview of the engineering and technology disciplines.

Company entries within each SIC code were randomized using a Microsoft Excel random number assignment. Researchers were then assigned random listings of 500 companies, with representative entries from each of the main engineering and technology industry groups.

Our research team then made thousands of unsolicited phone calls to these companies. We asked whether one or more immigrant key founders had established the company and if so, what their nationality was. This became the source of the data presented in this report.

Definition of Key Founder

In most engineering or technology companies, the key founders are the President/Chief Executive Officer or the head of development/Chief Technology Officer. An individual can simultaneously perform both of these roles. Other roles such as finance, marketing, HR, and legal can be very important in startups. For the purposes of our research, however, we chose to use a narrow definition of key founder and exclude the latter roles.

Definition of an Immigrant and Immigrant-Founded Company

An immigrant is a person who was born as a citizen of another country and subsequently moved to the United States at some point in his or her lifetime. Immigrant-founded companies are those having one or more immigrants as key founders.

Data Collection

A team of fifteen graduate students and research assistants telephoned CEOs, HR managers and other knowledgeable company employees. After a two-sentence introduction of the student researcher, Duke University and the research project, they were asked:

> (1) Were any of your company's key founders immigrants to the United States? If "Yes" they were asked:
> (2) In what country was he or she born?

They followed the first question with the definition of "key founder" and "immigrant founded company".

Quality Assurance and Data Analysis

After all of the data had been collected, we performed quality assurance on our records. Two criteria in particular were chosen ensure the veracity of the collected data. First, companies listed in the D&B database with zero employees at their US headquarters were omitted from consideration. Second, companies with 2005 sales greater than 100 million dollars were double checked to make certain that they had been founded after 1995.

Methodology – WIPO Patent Records

Data Acquisition

To gauge the intellectual property contributions of immigrants, we first attempted to analyze the United States Patent and Trademark Office (USPTO) database. Unfortunately the USPTO does not record citizenship data an application for a patent.

With the assistance of Neopatents — a Raleigh, North Carolina based patent research and analytics firm — we determined that we could obtain information on inventor nationality by examining a different database: Patent Cooperation Treaty (PCT) applications published by the World Intellectual Property Organization (WIPO). WIPO is based in Geneva, Switzerland, and coordinates the filing of international patents. These are the patents that likely have high global utility. Neopatents provided our research team access to its proprietary Spore® Search software package to query the WIPO patent database.

Limitations/Definition of Immigrant Non-citizen

The WIPO database records information on inventors' nationalities and the countries in which they resided at the time of filing a PCT application. The drawback of this comparison is that it imposes a conservative definition of "immigrant" on our patent analysis. The only patent data available are for foreign nationals who currently reside in the United States. We classified these as "immigrant non-citizens" to differentiate from the criteria we used for immigrant company founders.

To put this in perspective, according to the 2000 U.S. Census, from 1990 to 2000, 12.5 million foreign-born citizens were granted U.S. citizenship.[i] Any U.S. naturalized citizens who have filed a PCT application after becoming a citizen are not counted. As a result, our findings represent a conservative estimate of the contributions of immigrants.

Additionally, we limited our search to patents awarded from 1998 to 2006. Although the PCT databases include records since 1978, we found that prior to 1998 the database contains far fewer records.

For our research, we examined all PCT application records that had been filed through the U.S. PCT Receiving Office. We extracted all records for published patents that contain one or more applicants of non-U.S. nationality who were residing in the U.S. at the time of filing the application. Patents meeting these criteria and published between 1998 and 2006 (inclusive) were identified. During this period, WIPO published approximately 340,000 PCT applications filed by U.S.-resident applicants through the U.S. receiving office.

An explanation of our WIPO search strings using Spore® Search can be found in Appendix B of this report.

Data Analysis – Immigrant Key Founder Data

We obtained responses from 2,054 engineering and technology companies founded in the U.S. from 1995 to 2005. Of these companies, 25.3% reported that at least one of their key founders was an immigrant. Extrapolating from this sample, we estimate that all companies founded by immigrants from 1995 to 2005 produced $52 billion dollars in sales and employed 450,000 workers in 2005. A breakdown of our survey statistics and response rates can be found in Table 1 below:

Table 1: Founder Survey Statistics and Response Rates

	Count	Variable
Total "Yes" Responses:	520	a
Total "No" Responses:	1534	b
"Decline to Comment/Participate" Responses: Too Busy, Unwilling to Provide Information, No Data/Knowledge	407	c
"Missing Data": Bad Phone Numbers, Disconnected Calls, Hang Ups, Requests for Call Backs and Answering Machines	2128	d
Total Companies Approached:	4589	e

Response Rate R_1 (The proportion of survey responses obtained out of total survey delivery attempts) [(a+b)/e]	44.8%
Response Rate R_2 (The proportion of survey responses obtained out of total surveys actually delivered) [(a+b)/(a+b+c)]	83.5%

Revenue and Employment Data

To infer information on all of the 28,776 companies founded in the last ten years, we employed a sampling distribution of a proportion, and performed a finite population correction. Using this method, we can say with 95% confidence that $25.3\% \pm 1.8\%$ of the 28,776 engineering and technology companies founded from 1995 to 2005 had an immigrant key founder. This equates to $7,283 \pm 518$ companies. These 7,283 companies produced more than $52 billion dollars in 2005 sales and in 2005 had just under 450,000 employees.

Immigrant-Founder Origin Data

The immigrant founders of U.S. engineering and technology companies come from all over the world. Our data identified immigrant founders from more than 60 different countries. The top 10 are listed in Chart 1.

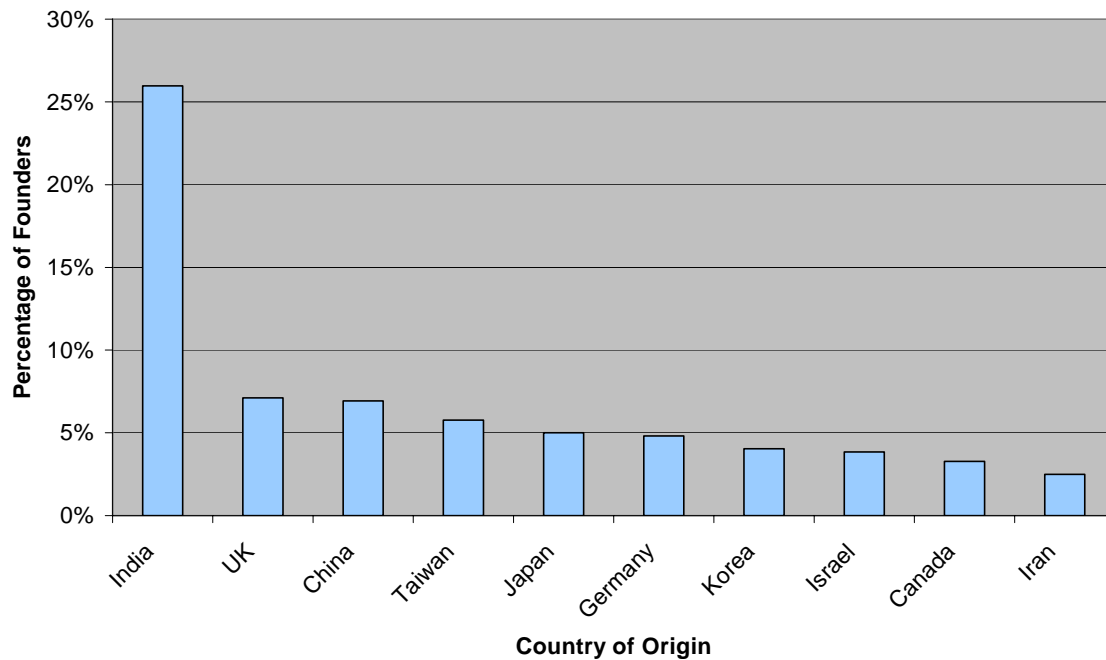**Chart 1: Birthplace of Engineering and Technology Immigrant Founders**

Chart 1 shows Indian immigrants have founded more engineering and technology companies from 1995 to 2005 than immigrants from the U.K., China, Taiwan and Japan combined.

State-Wise Distribution of Immigrant Founder Data

We analyzed the responses based on the location of each company's headquarters as listed in the D&B database. This allowed us to group responses by state and determine whether immigrant engineering and technology founders had a propensity to gravitate towards certain U.S. states when starting new companies. We were only able to report results from 19 states where we had a high enough sampling density to be confident of our findings. Table 2 indicates the percentage of companies founded by immigrants in each of these states. The study's average immigrant founding rate is also presented to illustrate the extent of a state's deviation from the national average.

Table 2: U.S. States Where Immigrants are Founding Engineering and Technology Companies
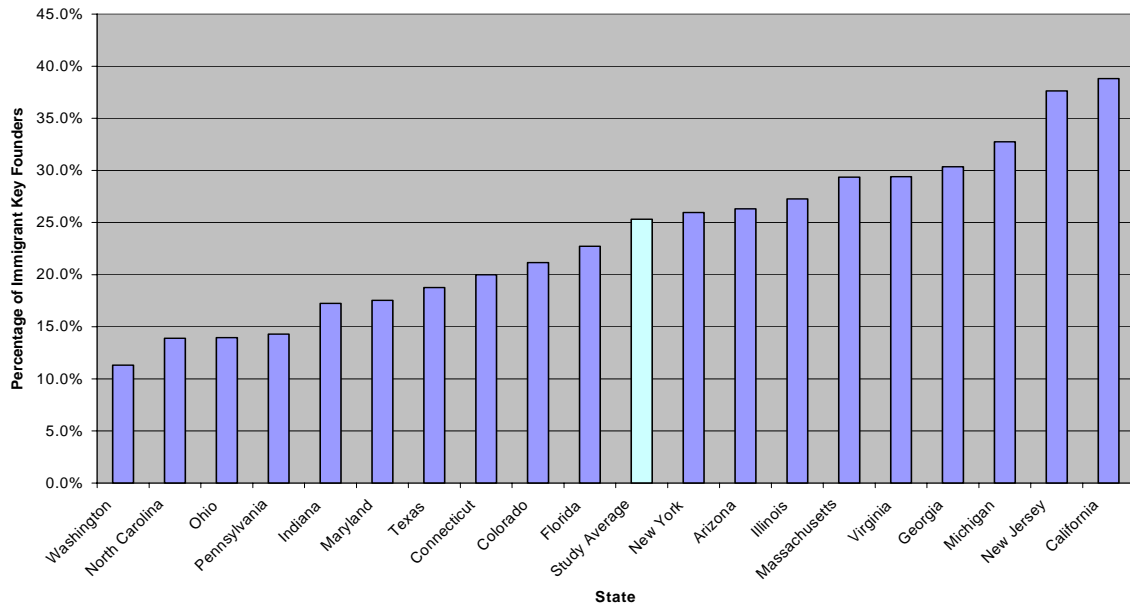
It is not surprising to see California leading this group, with 38.8% of its companies having been established by immigrant key founders. High percentages for New Jersey (37.6%) and Michigan (32.8%) were interesting findings, as was the relatively low performance of Washington state (11.3%) and North Carolina (13.9%).

Chart 3 details where immigrant founded engineering and technology companies were located. Once again, California dominates, with 34% of all U.S.-immigrant-founded companies. The next ranked state is New Jersey, with only 7.3%.

Chart 3: Breakdown of Engineering and Technology Companies Founded by Immigrants from 1995 to 2005 by State
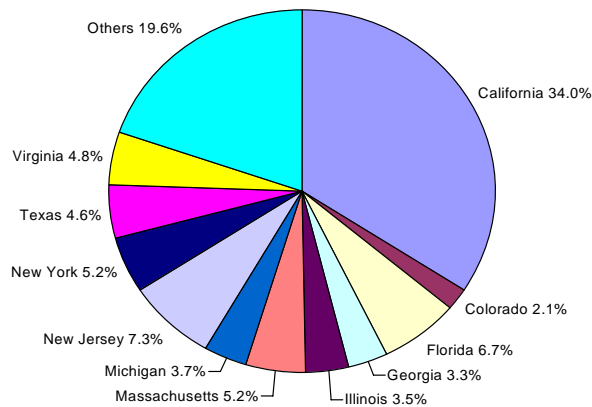
Using this same state breakdown of immigrant founder data, it is possible to determine the states where immigrant entrepreneurs from specific ethnic groups are concentrated. Charts 4a – 4d detail these statistics for the four largest immigrant groups: those from India, the U.K., China, and Taiwan.

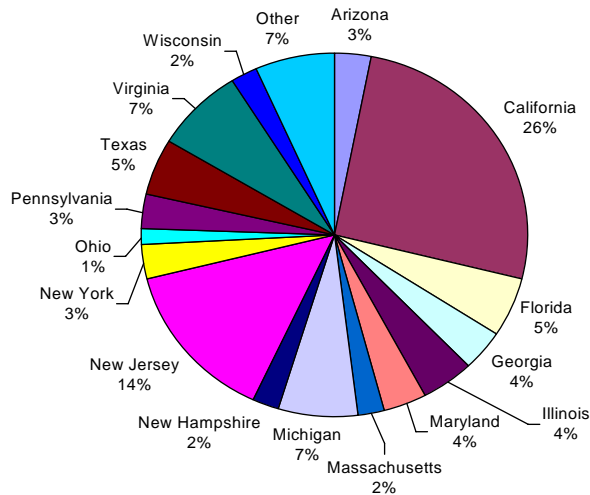**Chart 4a: Where are Immigrants from India Founding Engineering and Technology Companies?**

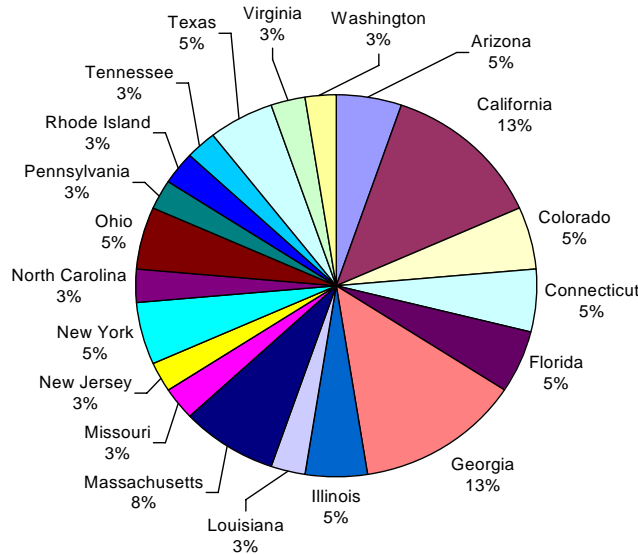**Chart 4b: Where are Immigrants from the U.K. Founding Engineering and Technology Companies?**

Chart 4c: Where are Immigrants from China Founding Engineering and Technology Companies?
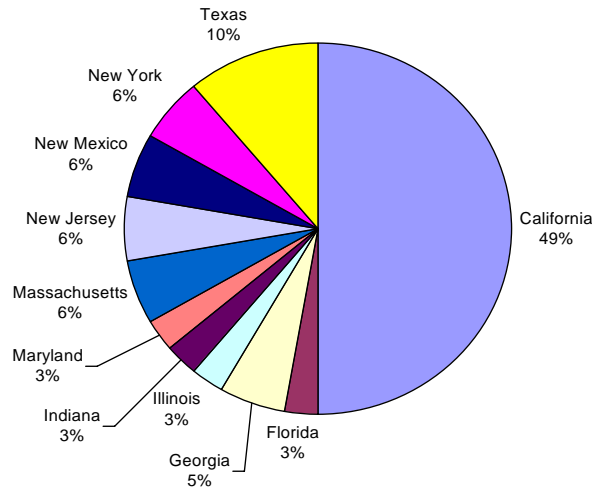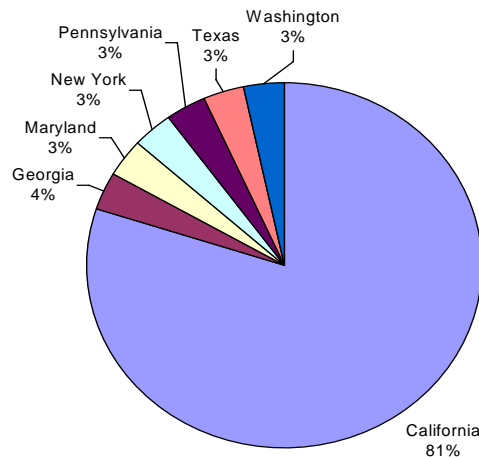

**Chart 4d: Where are Immigrants from Taiwan Founding Engineering and Technology Companies?**

These data reveal a high level of ethnic clustering by immigrant-founded engineering and technology companies. 40% of Indian founders favored locations in California and New Jersey. Founders from the U.K. displayed the greatest dispersion, showing no centralized founding locations, with the exception of slightly higher rates in California and Georgia. Chinese (both Mainland- and Taiwan-born) founders were heavily concentrated in California, with 49% of those from China and 81% of those from Taiwan establishing companies in this state. This clustering reflects the self-reinforcing nature of immigrant social and technical networks in the state, which are probably also factors that continue to draw Indian immigrant-founders disproportionately to California and New Jersey.

Grouping the data by state reveals both the distinct spatial clustering of immigrant-founders and the diversity of immigrant-founders in the same states. Graphs 5a – 5g display the immigrant groups founding engineering and technology companies in the states with our highest response profiles: California, Florida, Massachusetts, New Jersey, New York and Texas.

Graph 5a underscores the dominance of Asian immigrant-founders of engineering and technology companies in California, particularly those from India (20%), Taiwan (13%), and China (10%) The profile of immigrant founders in Florida is quite different, and largely appears to reflect geographic proximity. Graph 5b shows the dominance of South and Central American immigrant founders in Florida, with Cuba (10%), Venezuela (8%), and Colombia (8%) along with India (18%.)

Graph 5a: Immigrant Groups Founding Engineering and Technology Companies in California
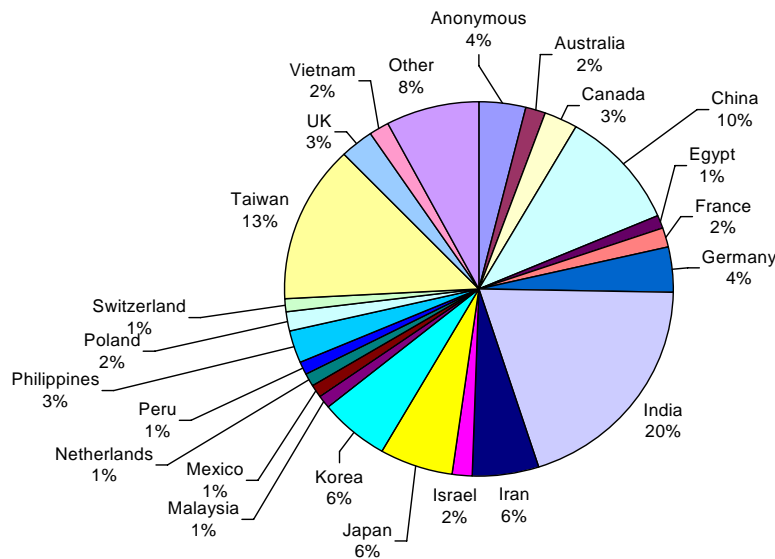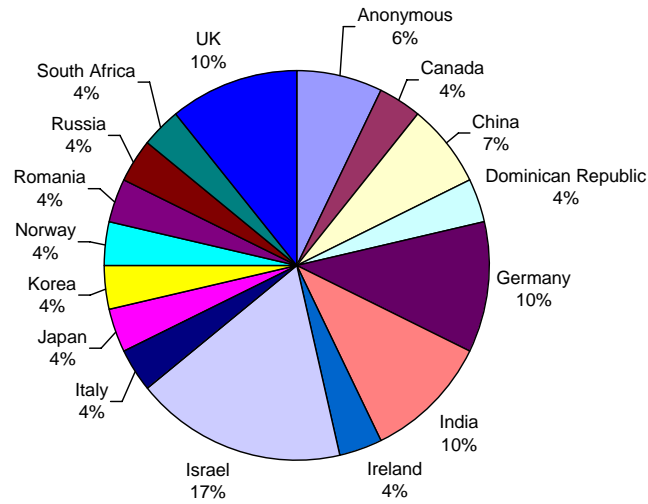

Graph 5b: Immigrant Groups Founding Engineering and Technology Companies in Florida
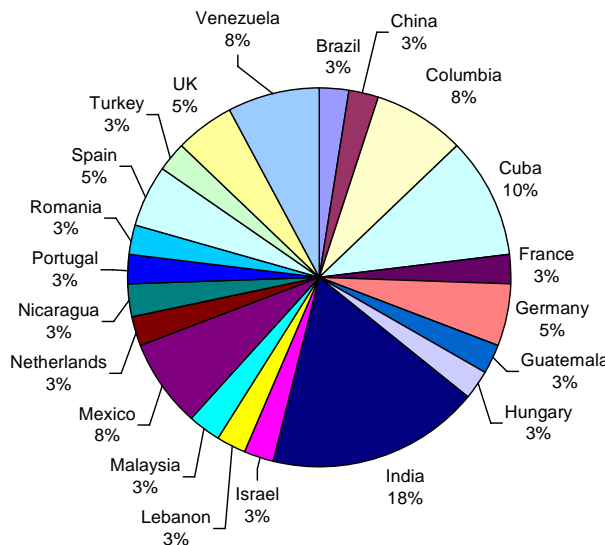
Graph 5c shows that Massachusetts is home to large numbers of Israeli- (17%), German- (10%), and British- (10%) immigrant founders. Graph 5d reveals the dominance of Indian-immigrant founders (47%) in New Jersey.

Graph 5c: Immigrant Groups Founding Engineering and Technology Companies in Massachusetts
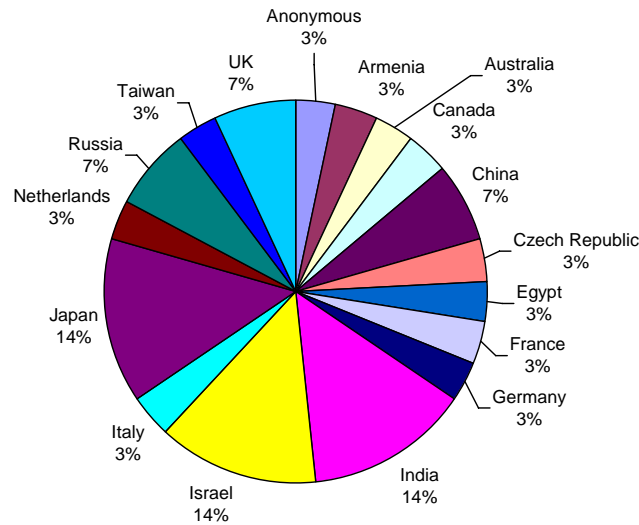

Graph 5d: Immigrant Groups Founding Engineering and Technology Companies in New Jersey
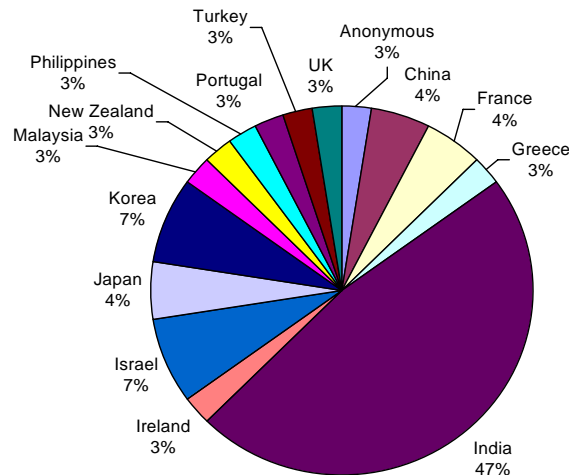

Japanese, Indian, and Israeli founders are equally well-represented in New York, where they each account for 14% of the immigrant-founded engineering and technology companies (Graph 5e) Immigrant-founders from India (25%) and China (14%) dominate in Texas (Graph 5f).

Graph 5e: Immigrant Groups Founding Engineering and Technology Companies in New York

Graph 5f: Immigrant Groups Founding Engineering and Technology Companies in Texas
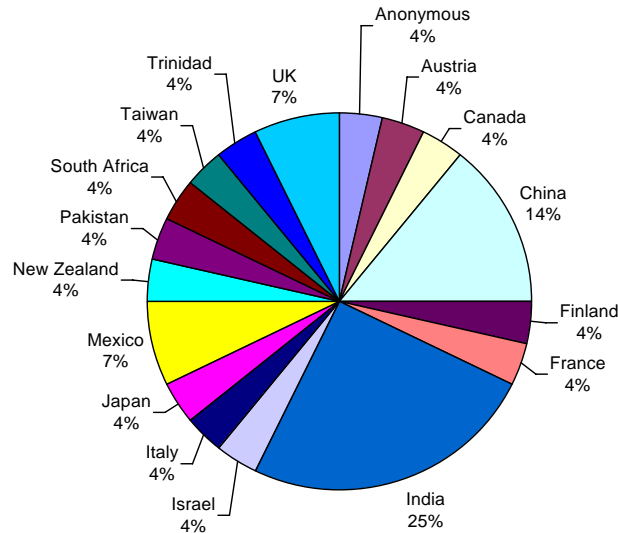
In conclusion, Indian immigrant-founders were well represented in California, Florida and Texas, and they accounted for almost half the immigrant founders in New Jersey, yet they represented only 10% of the immigrant founders in Massachusetts. Immigrant founders from Latin American countries such as Mexico, Columbia, Venezuela and Cuba were better represented in Florida. Israeli founders were concentrated in New York and Massachusetts.

Industry Specific Immigrant Founder Data

Our definition of "engineering and technology companies" extends to companies practicing in the fields of bioscience, computers/communications, defense/aerospace, environmental, innovation/manufacturing-related services, semiconductors, and software as defined by a company's primary SIC code (see Appendix A for a more in depth description of the included SIC codes). This section explores the concentrations of immigrant entrepreneurs in particular engineering and technology industries. From 1995 to 2005 almost 80% of immigrant-founded companies were within just two business fields: innovation/manufacturing-related services (46%) and software (33%). A full breakdown of immigrant founding activity across all seven business fields appears in Chart 6.

Chart 6: Breakdown of Engineering and Technology Companies Founded by Immigrants from 1995 to 2005 by Industry
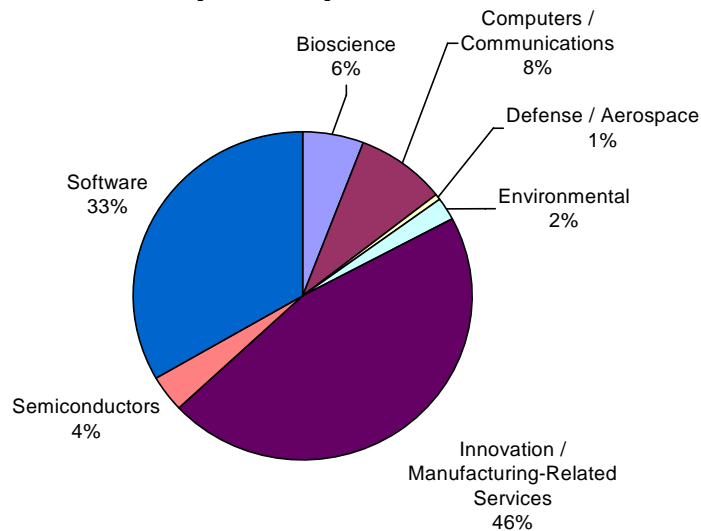

The low immigrant participation in the founding of defense/aerospace companies is likely due to the present restrictive environment for government contracts, which often limits work to individuals with U.S. citizenships and security clearances. The software field contains computer programming services, prepackaged software, integrated system design, processing services and information retrieval companies.   The innovation/manufacturing-related services field includes a variety of electronics, computer and hardware design and service companies in addition to engineering services, research and testing.

Immigrant entrepreneurs are not evenly represented across these seven technology fields. Of all the companies we surveyed, 25.3% had one or more immigrant founder; but this average varied by up to 18 percentage points between engineering- and technology-industry classifications. Immigrant founders were more heavily concentrated in the semiconductor (35.1%), computer/communications (31.7%), and software (27.9%)

industries than in other engineering and technology fields. A graphic representation of these data can be found in Chart 7.

Chart 7: Industry Breakdown of Immigrant Founded Companies
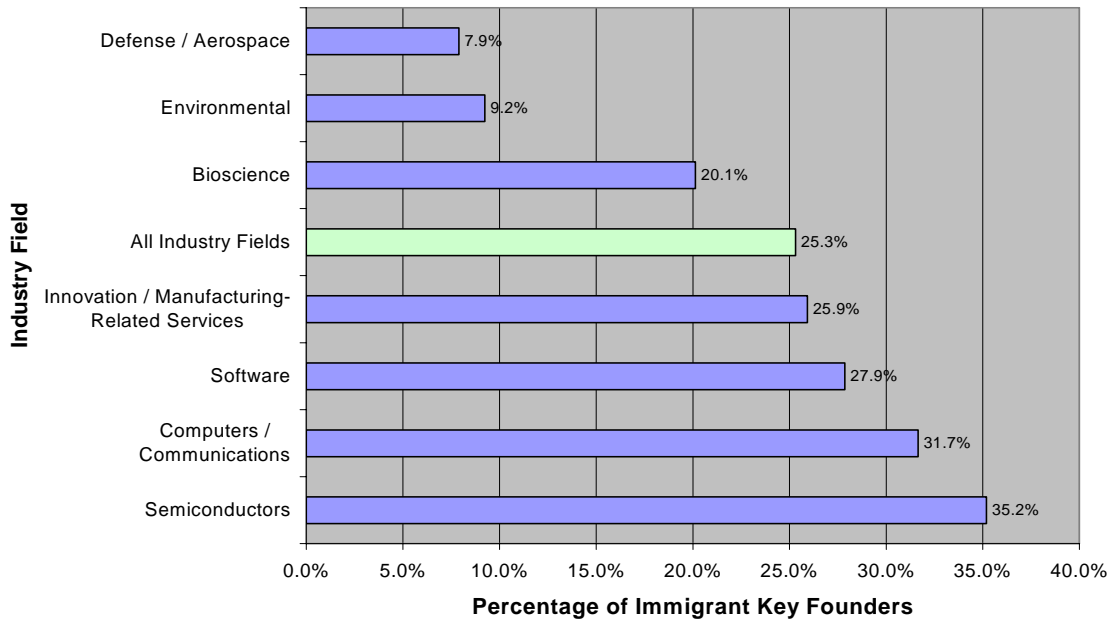
By cross-referencing our industry-field and immigrant-founder–nationality data, we can determine the propensity of specific immigrant ethnic groups to found new companies in distinct industry fields. Tables 8a to 8d display the industries in which immigrants from India, the U.K., China, and Taiwan have founded companies from 1995 to 2005.

Chart 8a: Industries in which Immigrants from India are Founding Companies
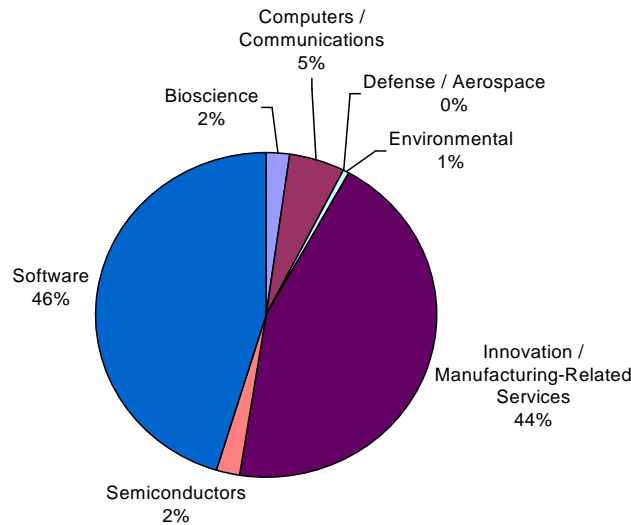
Chart 8b: Industries in which Immigrants from the U.K. are Founding Companies

Bioscience
5%

Computers /
Communications
8%

Defense / Aerospace
0%

Environmental
0%

Software
43%

Innovation /
Manufacturing-Related
Services
44%

Semiconductors
0%
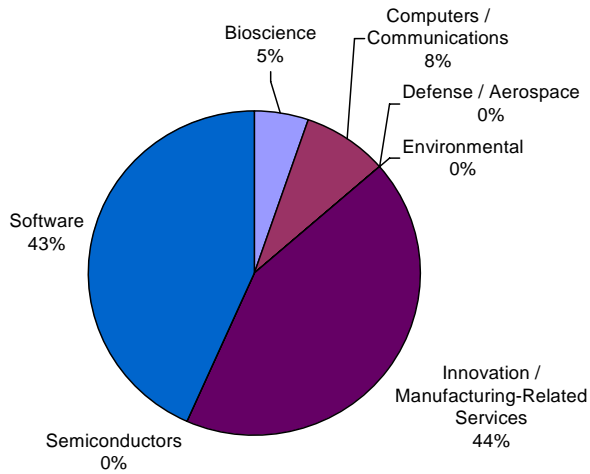
Chart 8c: Industries in which Immigrants from China are Founding Companies

Bioscience
0%

Software
19%

Computers /
Communications
25%

Semiconductors
8%

Defense / Aerospace
0%

Environmental
6%

Innovation /
Manufacturing-Related
Services
42%
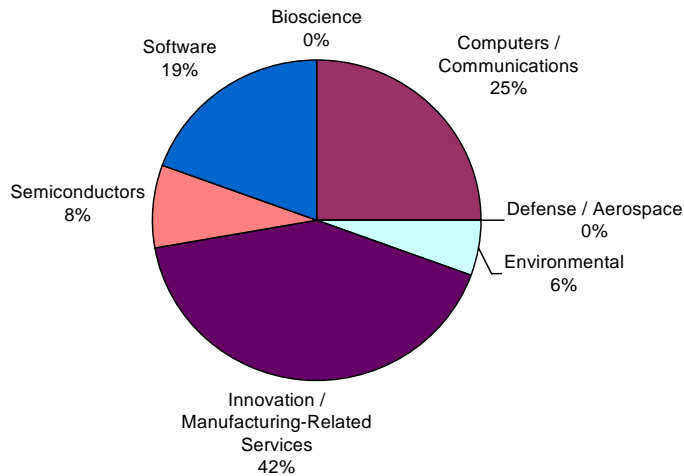
Chart 8d: Industry Fields in which Immigrants from Taiwan are Founding Companies

Bioscience
3%

Software
17%

Computers /
Communications
27%

Semiconductors
7%

Defense / Aerospace
0%

Environmental
0%

Innovation /
Manufacturing-Related
Services
46%
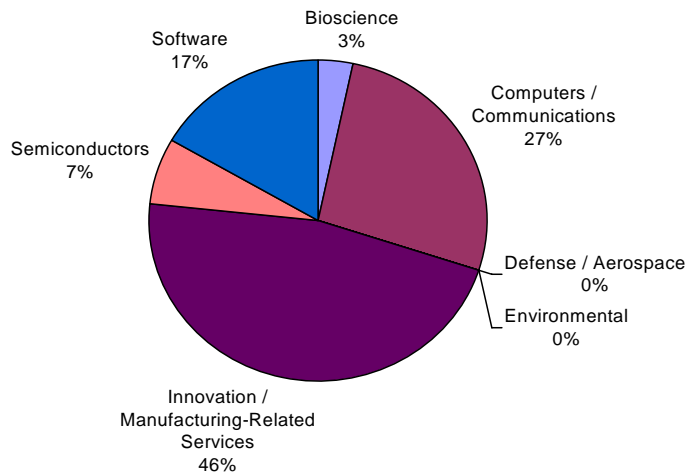
These data show that all four immigrant groups founded innovation/manufacturing-related service companies in similar proportions over the past decade (accounting for 42% to 46% of all engineering and technology companies founded by each group). Entrepreneurs from India and the U.K. gravitated as well toward the software industry, which accounted for 46% and 43%, respectively, of their startups; but they were minimally represented in hardware-oriented sectors such as semiconductors and computers/communications.

Immigrant founders from China and Taiwan started companies in a broader range of industries, and were more likely to start computers/communications (with 25% and 27% respectively) and software companies (19% and 17%). In addition, they were more likely to be founders of semiconductor companies (8% and 7%) than their Indian or U.K. counterparts.

In a final analysis of this industry-specific data, we present a breakdown of the immigrant groups founding companies in distinct industry fields. Due to the relatively low immigrant activity in defense/aerospace and environmental industry fields, data on these groups will not be presented. Breakdowns of the remaining five industry groups can be found in Charts 9a to 9e.

Chart 9a: Immigrant-Founder Origins in the Innovation/Manufacturing-Related Services Field

Immigrants Founded Companies in the Innovation/Manufacturing-Related Field in the Last Ten Years
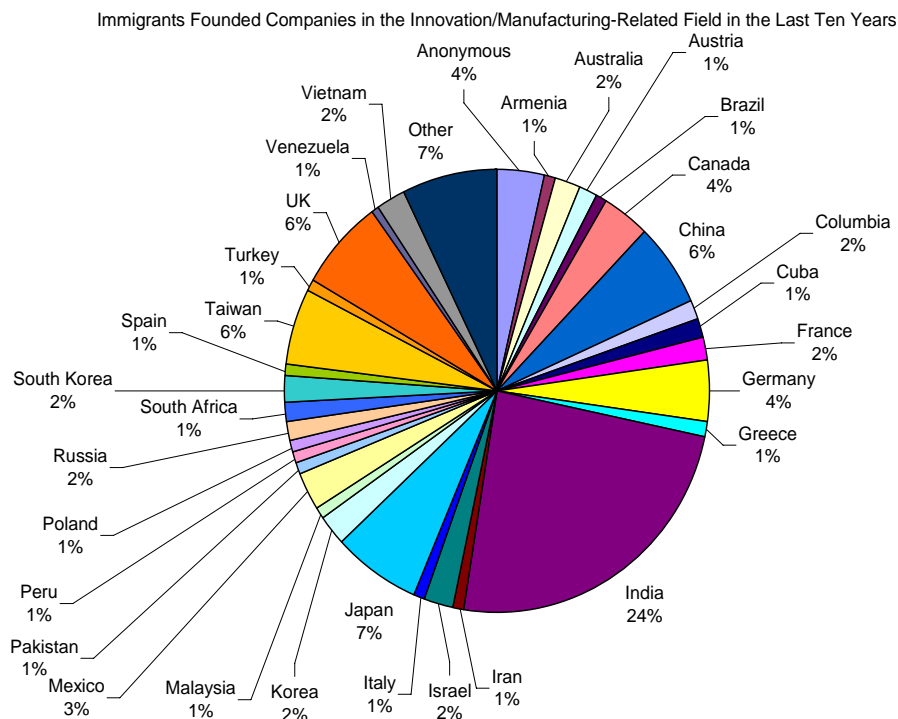
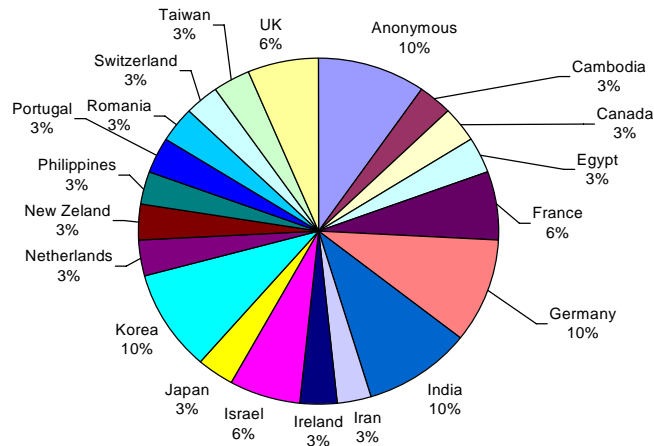**Chart 9b: Immigrant-Founder Origins in the Biosciences Field**

Chart 9c: Immigrant-Founder Origins in the Computers/Communications Field
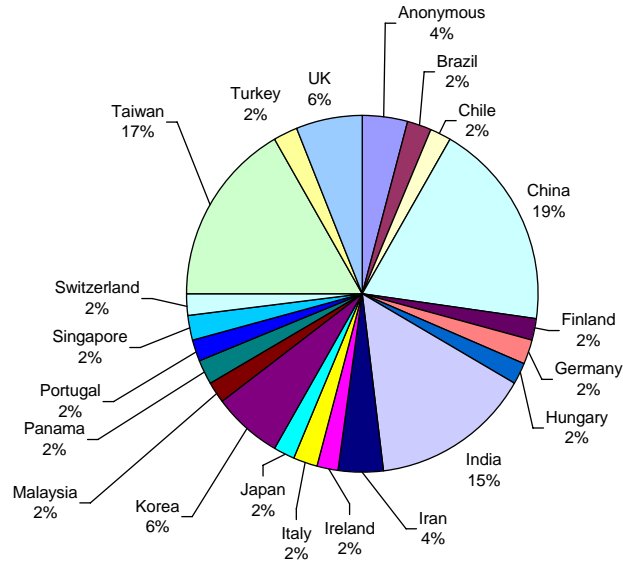
Chart 9d: Immigrant-Founder Origins in the Semiconductors Field
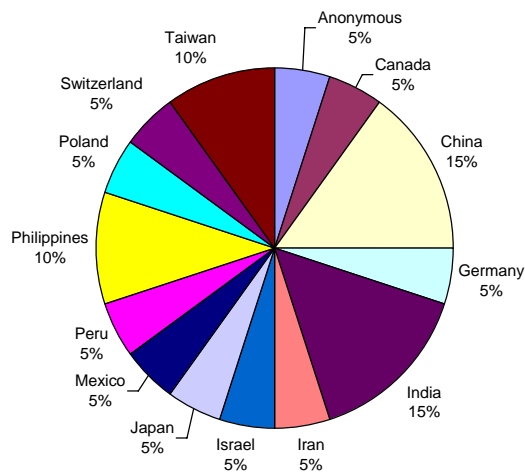
Chart 9e: Immigrant-Founder Origins in the Software Field
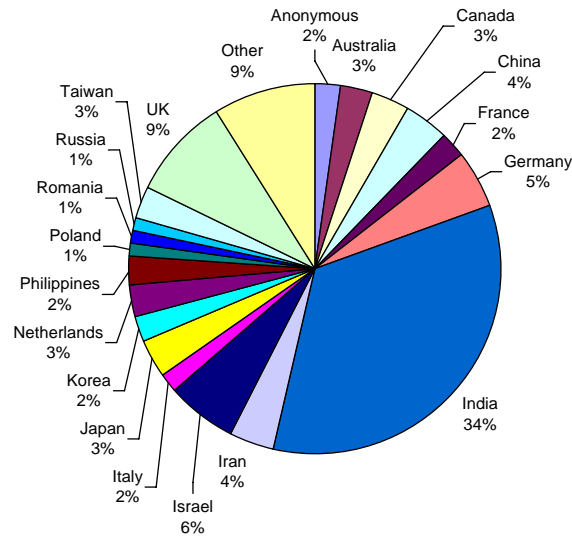
Indian immigrants are the primary founders of immigrant companies in the innovation/manufacturing-related services fields. Just under a quarter of the immigrants who founded companies in this field are from India, followed at a considerable distance by Taiwan and China at 6% each. The Indian immigrant group contributes as well to the biosciences and computers/communications fields but is not a dominant force. In biosciences, India and Germany each contribute 10% of the companies founded by immigrants; the U.K., France, Israel and Korea trail at 6%.

In the computers/communications field, India-, Taiwan-, and China-born founders together accounted for just over 50% of all the immigrant start-ups from 1995 to 2005. India- and China-born immigrant entrepreneurs each founded 15% of the immigrant-founded semiconductors companies from 1995 to 2005. These contributions were trailed by those of immigrant founders from the Philippines (10%) and Taiwan (10%). Finally, within the software field, Indian immigrants established 34% of the immigrant founded software companies from 1995 to 2005.

Data Analysis – WIPO Patent Records

In this study we also examined the intellectual-property contributions of immigrant non-citizens. These are foreign nationals who currently reside in the U.S. but have not received citizenship. We analyzed the World Intellectual Property Organization (WIPO) Patent Cooperation Treaty (PCT) records for the U.S. based international patent filings of U.S. resident inventors. A PCT application is a type of international patent application that allows for an applicant to seek patent protection simultaneously in many countries.

We found that U.S. immigrant non-citizen inventors and co-inventors appeared on 14.8% of these patent filings from 1998 to 2006 (a small proportion of these records include pre-1998 filings). We estimate that in 2006, 24.2% of PCT applications had immigrant non-citizen inventors or co-inventors. This is a dramatic increase from an estimated 7.3% in 1998.

WIPO PCT Applications by U.S. Immigrant Nationality

To learn more about the intellectual property contributions of distinct U.S. immigrant groups, we subdivided our data by nationality. This allowed us to identify the total number of PCT applications awarded to immigrants from various countries from 1998 to 2006. These data are reflected in Chart 10. Please note that the data in this table are not mutually exclusive -- that is to say if a single patent has U.S. immigrant inventors from China and India, both nationality totals would receive recognition for this patent.

Chart 10: Intellectual Property Contributions of U.S. Immigrant Non-citizens – PCT Applications by Nationality – 1998 to 2006
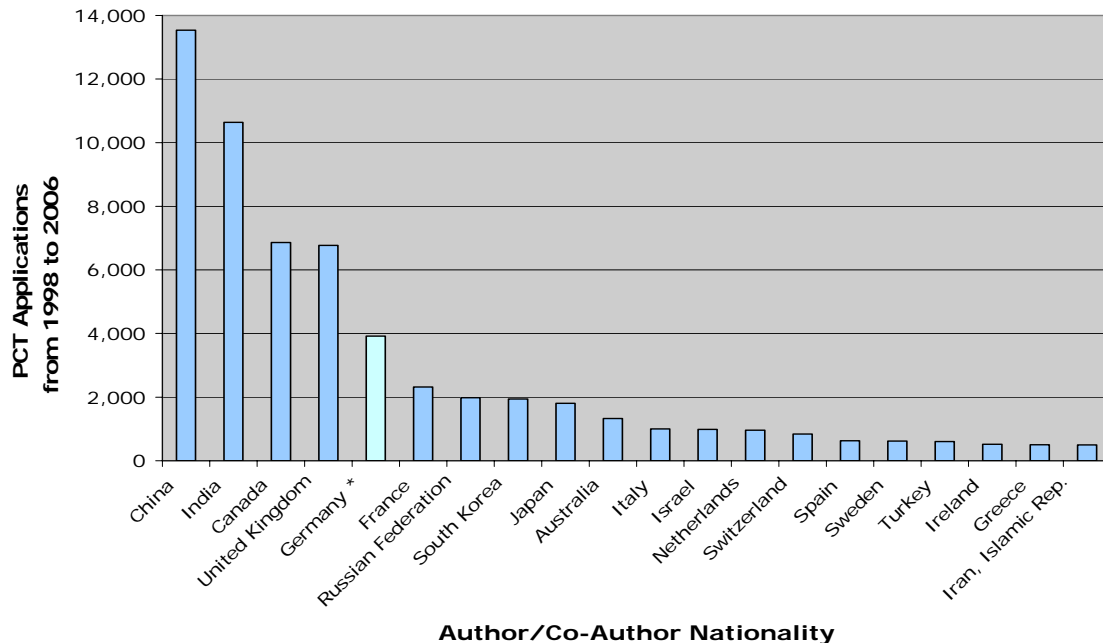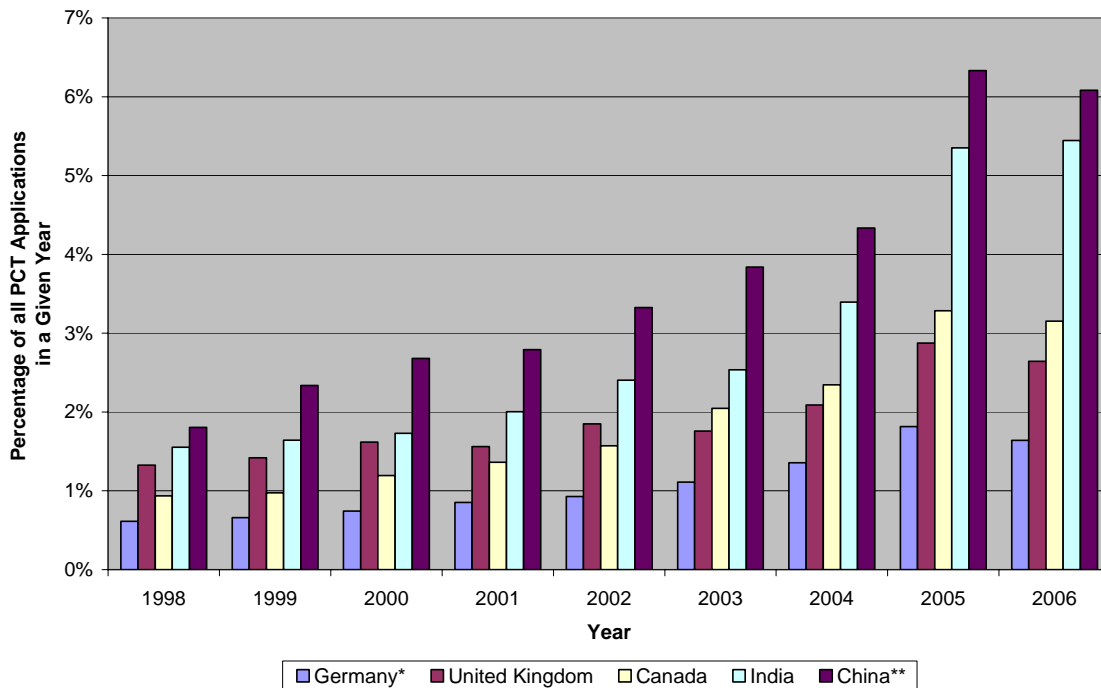

* PCT applications within the field "China" also include applications from Taiwan.** PCT applications awarded to within the field "Germany" have been calculated using a unique search string; please refer to the Methodology – WIPO Patent Records section for more details.

The data presented in Chart 10 show that U.S. immigrants from China (and Taiwan) have filed the greatest number of PCT applications over the last nine years, followed by India, Canada and the U.K.

To understand how their relative contributions have changed over years, we analyzed the yearly trend for the top five contributing nationalities. This is shown in Chart 11.

Chart 11: Annual PCT Applications by U.S. Top Five Contributing Immigrant Non-Citizens Nationalities from 1998 to 2006

* PCT applications awarded to Germany have been calculated using a unique search string; please refer to the Methodology – WIPO Patent Records section for more details.
** PCT applications represented within the field "China" also include applications from Taiwan.

WIPO PCT Application Trend Analysis of Immigrant Non-Citizen Filings

We wanted to better understand the yearly trend in the percentage of U.S.-based PCT applications with immigrant non-citizen inventors or co-inventors. Our search of the WIPO database provided inventor-centric data and one patent application can have multiple inventors. Therefore, the total number of PCT applications within a year is less than the count of the number of inventors. So we needed to create an estimate. We did this by dividing the total number of U.S, based immigrant non-citizen PCT applications from 1998 to 2006 by the inventor counts over the same yearly range to calculate an estimation factor. This factor was then applied to the yearly inventor counts to obtain estimated annual PCT application numbers. Finally, the estimated annual counts were then converted to yearly percentages. Chart 12 shows the results.

**Chart 12: Intellectual Property Contributions of Immigrant Non-Citizens --
Estimated Percentage of PCT Applications from 1998 to 2006**
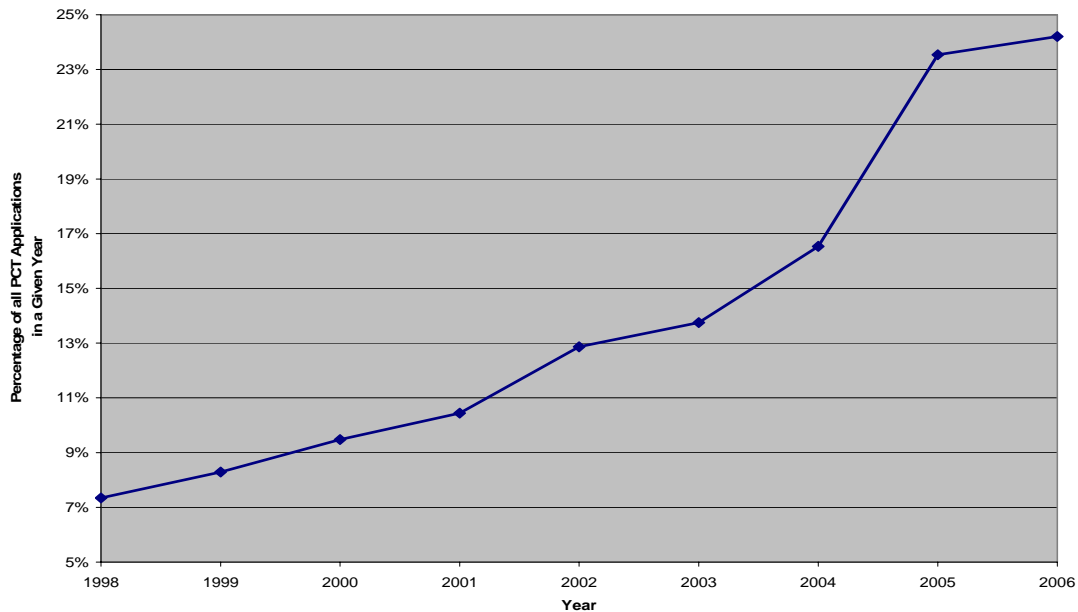
This chart highlights the dramatic increase in the filings by immigrant non-citizen inventors. In 1998, this group contributed to 7.3% of PCT applications. By 2006, this number had increased to 24.2%. The most rapid increase was between 2003 and 2005, from 13.8% to 23.5%.

To put this into perspective, even though WIPO PCT applications are a subset of all the patents filed with the USPTO, these are the patents that are likely to have the highest global utility and contribute to U.S. competitiveness.

WIPO PCT Application Analysis by International Patent Classification Codes

WIPO classifies PCT applications into eight distinct groups using International Patent Classification (IPC) sections. During our research, we pulled records from all eight groups, using the IPC, Eighth edition, allowing us to subdivide PCT applications with U.S. immigrant inventors across broad IPC fields. A detailed explanation of the intellectual property included in each group can be found in Table 2.

Table 2: WIPO International Patent Classification Sections

IPC Section	Section Header	Patent Topics Included
Section A	Human Necessities	Agriculture, Food, Tobacco, Apparel, Furniture, Medical, Life-Saving, Fire-fighting, Sports, Amusement
Section B	Performing Operations, Transporting	Separating, Mixing, Physical/Chemical Processes, Apparatus, Crushing, Centrifugal Processes, Spraying, Metal-work, Casting, Metallurgy, Grinding, Decorative Arts, Vehicles, Railways, Ships, Aircraft, Nano-Technology
Section C	Chemistry	Inorganic Chemistry, Water Treatment, Glass, Cements, Explosives, Organic Chemistry, Dyes, Petroleum, Spirits, Metallurgy, Electrolysis, Crystal Growth
Section D	Textiles	Threads, Yarns, Weaving, Braiding, Sewing, Ropes, Paper-making
Section E	Building	Roads, Hydraulics, Water-supply, Sewerage, Doors, Rock drilling
Section F	Mechanical Engineering	Engines, Pumps, Machines, Combustion, Lighting, Steam Generation, Combustion, Heating, Refrigeration, Furnaces, Heat Exchange, Weapons,
Section G	Physics	Instruments, Optics, Photography, Horology, Computing, Signaling, Information Storage, Nuclear Physics
Section H	Electricity	Generation, Circuitry, Communications

We sorted U.S. immigrant non-citizen inventors by the IPC code of their patent applications. This analysis allowed us to determine which IPC fields typically contain PCT applications with U.S. immigrant inventors and co-inventors. The average percentage of all PCT applications filed in the U.S. receiving office with a U.S. resident inventor that also contain a U.S. immigrant non-citizen inventor across all eight IPC fields was 14.76%. Chart 13 shows the significant drift from this mean between across the eight categories presented in Table 2.

Chart 13: Percentage of Immigrant-Authored Patents by IPC* Code Category (1998 to 2006 Average)
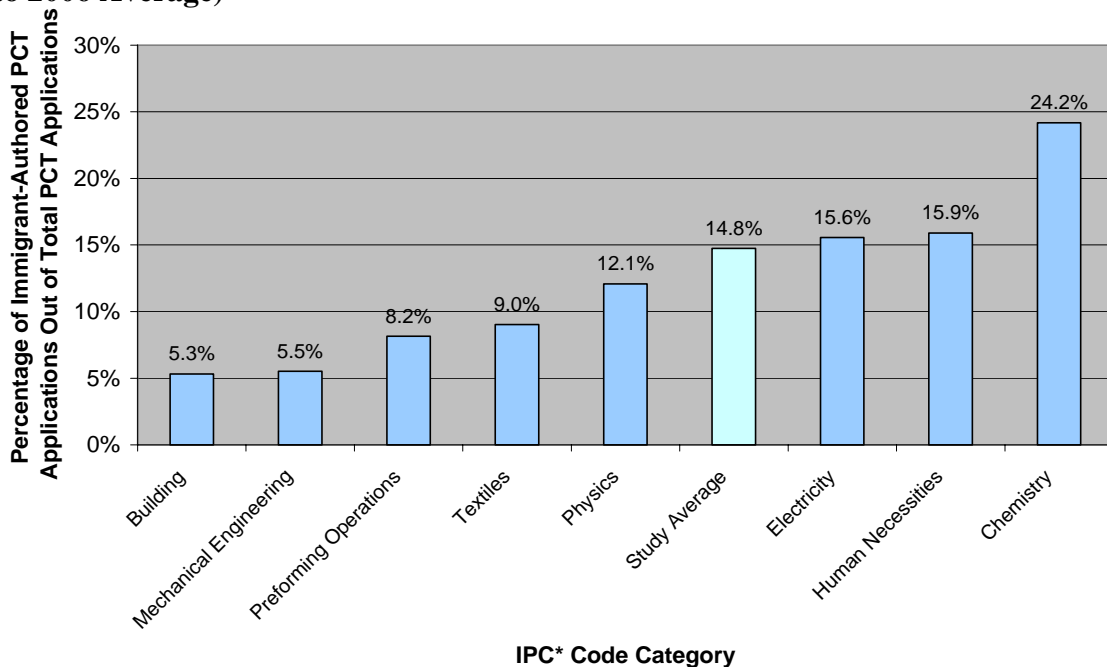
The results displayed in Chart 13 suggest that U.S. immigrant inventors and co-inventors are more likely to appear on theoretical, computational and practical patents (such as electricity, human necessities and chemistry), than engineering patents (building, mechanical engineering, performing operations, structural).

A final analysis of our patent data was conducted to determine in which IPC fields U.S. immigrant non citizens from India, China and Taiwan, Canada and the U.K. were inventing. Charts 14a to 14d display a breakdown for these four immigrant groups across the eight IPC categories.

Chart 14a: WIPO IPC Patent Categories Containing Immigrant Inventors and Co-Inventors from India

Pie chart data:
- No IPC Code 1.7%
- A: Human Necessities 23.7%
- H: Electricity 23.9%
- B: Performing Operations, Transporting 5.7%
- G: Physics 20.1%
- C: Chemistry 23.2%
- F: Mechanical Engineering 1.2%
- E: Building 0.2%
- D: Textiles 0.4%
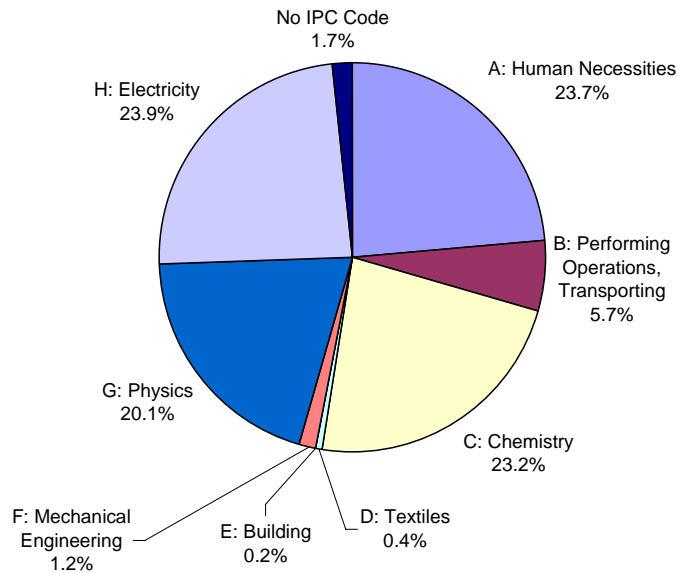
Chart 14b: WIPO IPC Patent Categories Containing Immigrant Inventors and Co-Inventors from China and Taiwan

Pie chart data:
- No IPC Code 1.6%
- H: Electricity 13.7%
- A: Human Necessities 27.8%
- G: Physics 14.6%
- B: Performing Operations, Transporting 5.4%
- F: Mechanical Engineering 0.9%
- E: Building 0.3%
- D: Textiles 0.4%
- C: Chemistry 35.3%
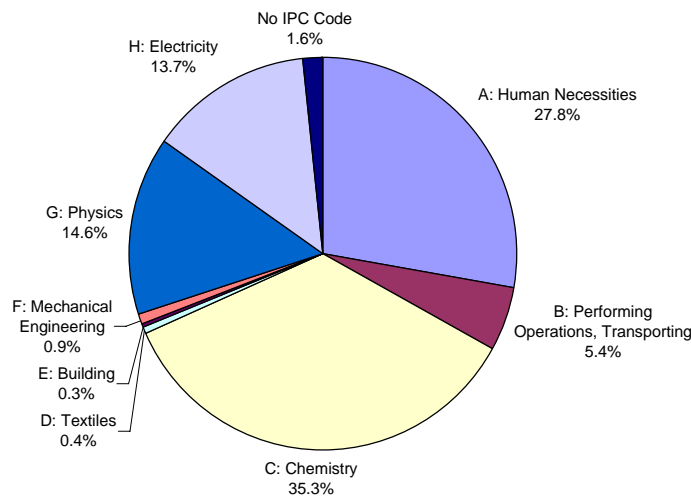
Chart 14c: WIPO IPC Patent Categories Containing Immigrant Inventors and Co-Inventors from Canada

No IPC Code
1.9%

H: Electricity
15.6%

A: Human Necessities
28.2%

G: Physics
15.9%

B: Performing
Operations, Transporting
7.2%

F: Mechanical
Engineering
1.2%

E: Building
0.7%

D: Textiles
0.5%

C: Chemistry
28.7%
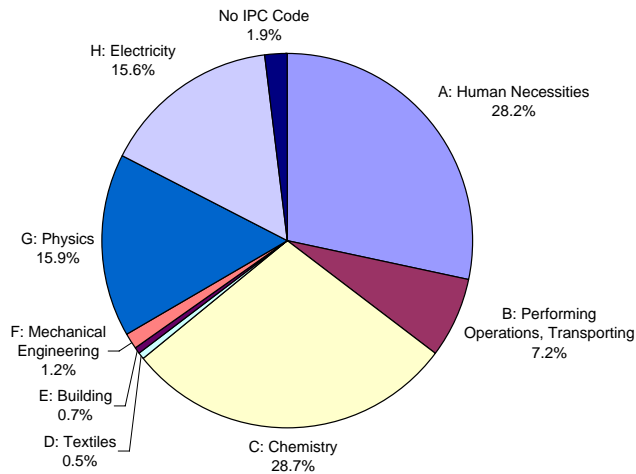
Chart 14d: WIPO IPC Patent Categories Containing Immigrant Inventors and Co-Inventors from the U.K.

No IPC Code
1.7%

H: Electricity
10.7%

A: Human Necessities
32.1%

G: Physics
13.9%

F: Mechanical
Engineering
1.5%

E: Building
0.7%

D: Textiles
0.4%

B: Performing
Operations, Transporting
7.7%

C: Chemistry
31.3%
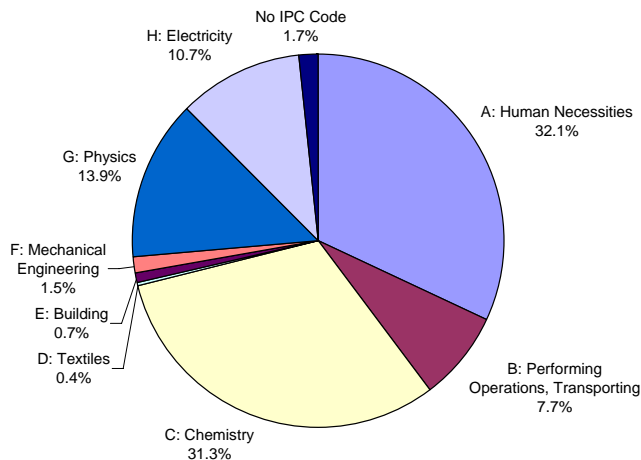
By comparing the IPC breakdowns present in Charts 14a to 14d, we can see that U.S. immigrant non-citizen inventors from China and Taiwan, Canada and the U.K. have very similar distributions among the eight IPC categories. Inventors from all three nationalities have high contributions (~30%) to sections C and A, chemistry and human necessities, respectively. They also have moderate contributions to Sections H, electricity, Section G, physics, and minor contributions to Section B, performing operations, transporting. When compared to the average distributions of all U.S. residents inventors (immigrant and U.S citizens) across IPC codes we see that Chinese, Canadian and U.K. inventors are contributing to more human-necessity and chemistry patents and generally less to electricity, physics, performing operations, and transportation patents. In contrast to the similar IPC distributions for Chinese, Canadian, and U.K. inventors, Indian inventors displayed a unique distribution. The IPC fields of electricity, human necessities, physics, and chemistry were all well-represented for PCT applications granted to Indian inventors and co-inventors. Approximately 91% of PCT applications by Indian inventors are granted within these four IPC fields.

Special Analysis – Silicon Valley, CA

We analyzed Silicon Valley data by selecting zip codes in the following counties: Santa Clara, Alameda, San Mateo and Santa Cruz. We received responses from 126 companies that fit these criteria. Of these, 52.4% reported that their key founders were immigrants -- significantly higher than the California average of 38.8%. The breakdown of nationalities can be found in Chart 15 below.

Chart 15: Origins of Engineering and Technology Company Immigrant Founders in Silicon Valley, CA
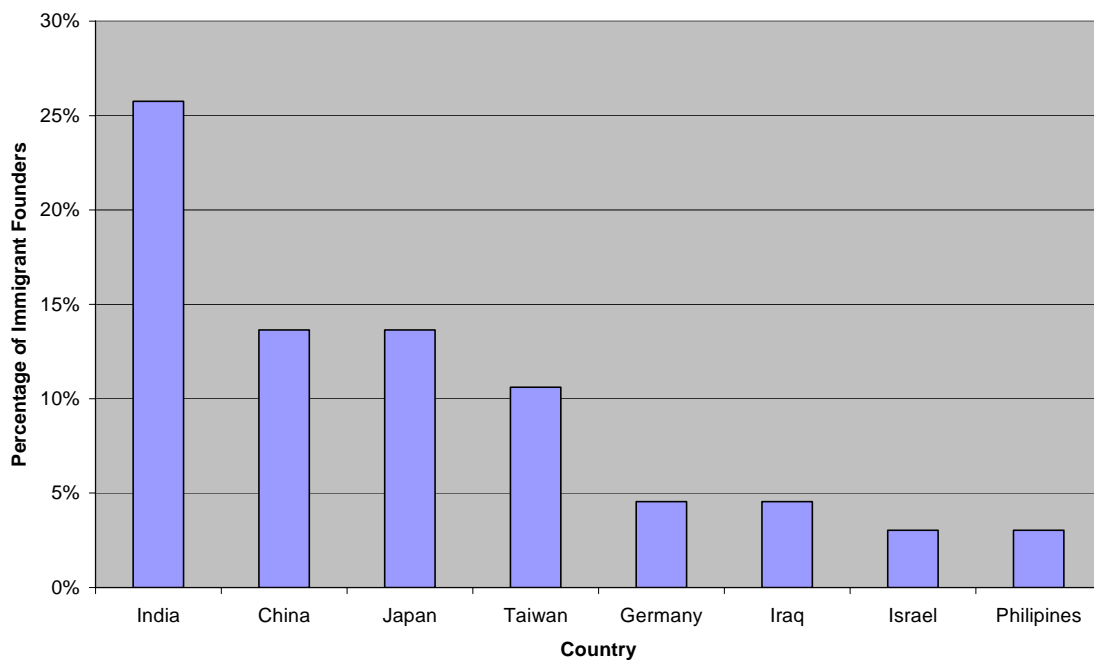
Saxenian reported in her 1999 paper that Chinese (both Mainland- and Taiwan-born) were running 17% of all Silicon Valley high-technology companies started in the period from 1980 to 1998, while Indians were at the helm of 7%. Our analysis documents the accelerated growth of Indian entrepreneurship since that time. From 1995 to 2005, Indians were key founders of 15.5% of all Silicon Valley startups (or 25.8% of the immigrant group), and immigrants from China and Taiwan were key in founders in 12.8% of all Silicon Valley startups (or 24.4% of the immigrant group).

Silicon Valley is the nation's leading center of immigrant technology entrepreneurship largely because it continues to attract more foreign-born scientists and engineers than does any other technology region in the country. In 2000, 53% of Silicon Valley's science and engineering (S&E) workforce was foreign-born. In other technology regions, such as Austin; Texas; and Boston, Massachusetts, less than a quarter of the S&E workforce is foreign-born.

Between 1990 and 2000, the population of Indian scientists and engineers (S&E) in Silicon Valley grew by 646% (while the total foreign-born S&E workforce grew by 246% and the region's total population of S&E, both native and foreign-born, grew by only 103%).[ii] In short, the growth of Indian entrepreneurship reflected the influx of Indian scientists and engineers to the region.

Silicon Valley's immigrant entrepreneurs led the nation in the 1990s by starting dynamic technology businesses that generate substantial wealth and employment in the U.S. Today they are contributing to the creation of new centers of technology and skill in their home countries. As these entrepreneurs collaborate with former classmates and colleagues in once peripheral economies like India and China, they are providing access to the markets and know-how that are critical to success in today's global economy.[iii]

Special Analysis – Research Triangle Park, NC

As our data showed, North Carolina has one the lowest percentages of immigrant-founded engineering and technology companies (13.9% vs. a national average of 25.3%). We believe this is for several reasons: its economic strengths for much of the past century were in traditional manufacturing and agricultural products (textiles and apparel, furniture, and tobacco); it has had very small venture capital markets; and until recently, it had relatively low numbers of immigrants.

Research Triangle Park (RTP) has been a flourishing hub of high-technology activity in the last few decades however, especially in the information technology (I.T.) and biotechnology areas. While the initial companies that were associated with these two sectors were large-scale enterprises (such as IBM and SAS in I.T., and big pharmaceuticals in the biotechnology sector), in recent years there has been a spate of new decentralized technologies connected with IT and biotechnology that have led to the proliferation of entrepreneurial opportunities in RTP.

We wanted to determine if RTP had a higher concentration of immigrant entrepreneurs than the rest of the state. Our random sample from the primary survey did not provide enough data for this analysis. So we created an additional dataset from the D&B database and conducted a new survey of this area.

We received responses from 107 companies, and 18.7% of these reported that they had an immigrant as a key founder. This compares to the state average of 13.9%.

A breakdown of our survey statistics and response rates can be found in Table 3 below.

Table 3: Founder Survey Statistics and Response Rates for RTP, NC

	Count	Variable
Total "Yes" Responses:	20	a
Total "No" Responses:	87	b
"Decline to Comment/Participate" Responses: Too Busy, Unwilling to Provide Information, No Data/Knowledge	5	c
"Missing Random Data": Bad Phone Numbers, Disconnected Calls, Hang Ups, Requests for Call Backs and Answering Machines	66	d
Total Companies Approached:	178	e

Response Rate R_1 (The number of survey responses obtained out of total survey delivery attempts) [(a+b)/e]	60.1%
Response Rate R_2 (The number of survey responses obtained out of total surveys actually delivered) [(a+b)/(a+b+c)]	95.5%

Chart 16: Birthplace of Engineering and Technology Immigrant Founders in RTP, NC
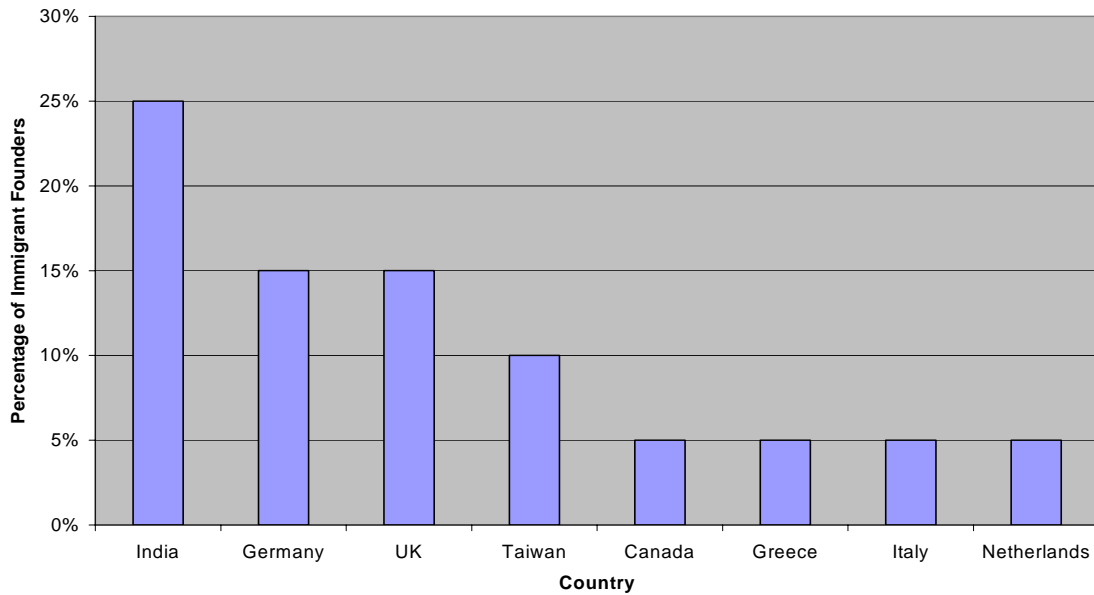
Chart 16 details the origins of the immigrant founders of these companies. These reflect the trend in immigration to this region. Many of the skilled immigrants came as students. In addition, a large number of Indian immigrants migrated to North Carolina to work in the technology and biotechnology industries.

Venture capital still lags behind more established states (such as New York, Massachusetts, and California), but the existence of a core group of public and private universities in the Research Triangle is providing a good foundation for the accelerated growth of immigrant-founded companies in recent years.

Summary of Results and Conclusion

This purpose of this research was to assess the contribution of skilled immigrants in the creation of engineering and technology businesses and intellectual property in the United States.

We found there was at least one immigrant key founder in 25.3% of all engineering and technology companies established in the U.S. between 1995 and 2005 inclusive. We estimate that together, this pool of immigrant-founded companies was responsible for generating more than $52 billion in 2005 sales and creating just under 450,000 jobs as of 2005. These immigrants come to the U.S. from all over the world to take advantage of the business, technology and economic opportunities in the country. Almost 26% of all immigrant-founded companies in the last ten years were founded by Indian immigrants. Immigrants from the U.K., China, and Taiwan contributed to 7.1%, 6.9% and 5.8% of all immigrant-founded businesses, respectively.

These immigrant-founded businesses are unevenly located across the country. California and New Jersey represented hot spots for immigrant-founded engineering and technology business; Washington and Ohio possessed relatively low percentages of immigrant-founded businesses. Some immigrant groups displayed tendencies to start businesses in a particular state. For example, 81% of businesses founded by Taiwanese immigrants were located in California. These immigrant-founders were most likely to start companies in innovation/manufacturing related services, computers/communications, and semiconductors, and less in the defense/aerospace and environmental industries.

We also gathered extensive data from the World Intellectual Property Organization's PCT database on the international patent filings of U.S. residents who are also foreign nationals. This analysis allowed us to gauge the contributions of immigrants to intellectual property that likely has high global utility.

In the period 1998 to 2006, immigrant non-citizen inventors and co-inventors appeared on 14.76% of U.S. PCT applications. The trend has been dramatic; according to our estimates the contribution of non-citizen immigrants to these international patent applications increased from 7.3% in 1998 to 24.2% in 2006.

U.S. immigrants who were named as inventors or co-inventors on PCT applications often were so named in the IPC fields of chemistry, human necessities and electricity, and are less likely to invent in the fields of building, mechanical engineering, performing operations and textiles.

This research shows that immigrants have become a significant driving force in the creation of new businesses and intellectual property in the U.S. — and that their contributions have increased over the past decade.

The key to maintaining U.S. competitiveness in a global economy is to understand our strengths and to effectively leverage these. Skilled immigrants are one of our greatest advantages.

Author Biographies

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Dr. Gary Gereffi is Professor of Sociology and Director of the Center on Globalization, Governance & Competitiveness at Duke University. He holds a B.A. from the University of Notre Dame and a Ph.D. from Yale University. He has published several books and articles on business-government relations in various parts of the world. His recent books include: *The Value of Value Chains: Spreading the Gains from Globalization* (special issue of the *IDS Bulletin*, vol. 32, no. 3, July 2001), *Free Trade and Uneven Development: The North American Apparel Industry after NAFTA*, (Temple University Press, 2002); and *The New Offshoring of Jobs and Global Development* (International Labor Organization, 2006).

Ben Rissing
Ben Rissing is a Research Scholar with Duke University's Pratt School of Engineering and the Project Manager of Duke's engineering outsourcing and immigration research teams. He has a Bachelor's in Mechanical Engineering from the University of Virginia and a Masters in Engineering Management from Duke. He has been involved in a variety of initiatives ranging from engineering design/technology commercialization to cardiovascular laboratory research and public-policy development in Washington DC. Mr. Rissing has traveled extensively, enjoys multiculturalism, and is a nationally ranked competitive fencer.

Dr. AnnaLee Saxenian
AnnaLee Saxenian has made a career of studying regional economies and the conditions under which people, ideas, and geographies combine and connect to hubs of economic activity. Her latest book, *The New Argonauts: Regional Advantage in a Global Economy* (Harvard University Press, 2006), explores how and why immigrant engineers from Silicon Valley are transferring their technology entrepreneurship to emerging regions in their home countries—China and India in particular—and launching companies far from established centers of skill and technology. The "brain drain" she argues, has now become "brain circulation"—a powerful economic force for the development of formerly peripheral regions that is sparking profound transformations in the global economy. Saxenian is also the author of *Regional Advantage: Culture and Competition in Silicon Valley and Route 128* (Harvard University Press, 1994.) She is currently Dean and Professor at the U.C. Berkeley School of Information, and she has a PhD from MIT and a BA from Willams College.

Vivek Wadhwa
Vivek Wadhwa is a technology entrepreneur and an Executive in Residence/Adjunct Professor for the Pratt School of Engineering at Duke University. He is an active mentor and advisor to various startups and is also a columnist for BusinessWeek.com. Wadhwa was named a "Leader of Tomorrow" by Forbes.com, and his company Relativity Technologies was named as one of the 25 "coolest" companies in the world by Fortune Magazine. Mr. Wadhwa holds a B.A. in Computing Studies from Canberra University in Australia and an MBA from New York University.

Appendix A: High Technology Industry Definition

U.S. Government defined Standard Industrial Classification (SIC) codes

Industry	SIC
Semiconductors	
Special industry machinery	3559
Semiconductors and related devices	3674
Instruments for measuring and testing electricity and electrical signals	3825
Computers/Communications	
Electronic computers	3571
Computer storage devices	3572
Computer peripheral equipment, n.e.c.	3577
Printed circuit boards	3672
Electronic components, n.e.c.	3679
Magnetic and optical recording media	3695
Telephone and telegraph apparatus	3661
Radio and television broadcasting and communications equipment	3663
Communications equipment, n.e.c.	3669
Bioscience	
Drugs	283
Surgical medical and dental instruments and supplies	384
Medical laboratories	8071
Laboratory apparatus and analytical, optical, measuring, and controlling instruments	382 (except 3822, 3825 and 3826)
Defense/Aerospace	
Small arms ammunition	348
Electron tubes	3671
Aircraft and parts	372
Guided missiles and space vehicles	376
Tanks and tank components	3795
Search, detection, navigation, guidance, aeronautical and nautical systems Instruments and equipment	381
Environmental	
Industrial and commercial fans and blowers and air purification equipment	3564
Service industry machinery, n.e.c.	3589
Sanitary services	495
Scrap and waste materials	5093

Software

Computer programming services	7371
Prepackaged software	7372
Computer integrated systems design	7373
Computer processing and data preparation and processing services	7374
Information retrieval services	7375

Innovation/Manufacturing-Related Services

Computers and computer peripheral equipment and software (wholesale trade)	5045
Electronics parts and equipment, n.e.c. (wholesale trade)	5065
Computer facilities management services	7376
Computer rental and leasing	7377
Computer maintenance and repair	7378
Computer-related services, n.e.c.	7379
Engineering services	8711
Research and testing services	873

Note: Our SIC listings differ slightly from those employed by AnnaLee Saxenian in her 1999 report "Silicon Valley's New Immigrant Entrepreneurs". Our present research focuses strictly on engineering and technology companies. As a result we did not analyze Professional Services companies (SIC 275, 276, 279, 731,732, 733, 736, 81, 8721, 8713, 872 and 874) which were included in Saxenian's 1999 study, but were outside the purview of the engineering and technology disciplines.

Appendix B: WIPO Search Strings

Our search of the WIPO PCT application database was conducted using Neopatents Spore® Search software. Though the search strings we used could be replicated on the WIPO website, Spore® allowed us increased flexibility. Spore® permitted our team to combine WIPO PCT search results into "SmartSets" that eliminated overlapping data and records that were multiple-counted. Spore® Search also allowed full datasets to be output into Excel for greater flexibility in analysis and processing. After completing our searches through Spore® we exported our data to Excel where we were able to classify it by inventor nationality and technology area of invention. A differentiation based on technology area was made possible by utilizing the International Patent Classification (IPC) Codes published by WIPO.

WIPO PCT Search Strings

an/US* AND (ana/xx NEAR are/US).

    where xx is the "country code" for a specific applicant/inventor nationality.

The components of the search string are explained as follows:

    an/US* - This phrase identifies all patent applications filed through WIPO's US receiving office.

    ana/xx - The "*ana*" phrase stands for "*applicant nationality*". "*xx*" represents the country code we're searching for. For example, India would be "*IN*", and France would be "*FR*." Please note that in all countries except for the US, the applicant may be a company. However, for PCT applications that designate the US (only or in addition to other countries), which includes almost all PCT applications, the applicant field should also list the inventors due to requirements of the US patent laws.

    are/US - The "*are*" phrase stands for "*applicant residence*". The generic form of the phrase is are/xx where "xx" can stand for any country. In this case, we're looking for applicants residing in the U.S., and hence we replace "xx" with "U.S."

    NEAR – "*NEAR*" is a proximity connector that looks for records having terms within 20 characters of each other. During the course of our search we observed that using "AND" between the "ana" and "are" phrases resulted in records that had inventors resident in countries other than the US. For example, usage of AND to search for records that would come under JP/US (a Japanese national residing in the US) also fetched records that qualified with two or more inventors but not within our target; e.g. one document with two inventors, one inventor listed as JP/JP (Japanese national residing in Japan) and another as US/US (US national residing in the US). Usage of the "NEAR" phrase helped eliminate this, and fetched primarily records that qualified with inventors under the xx/US category (xx national residing in the US).

WIPO Data Special Considerations

While auditing our data we found that search strings for Germany (an/US* and (ana/DE NEAR are/US) were not acquiring accurate records from the WIPO German database. After several consultations with Neopatents CTO, we determined that this search error was due to the manner in which German PCT information is populated. To compensate for this, we adopted a special search string for Germany (*an/US* and "DE US"*). To validate data pulled from this unique string we audited search results by randomly checking the full patent records associated with our search results. We ultimately found this string to be a reliable means of querying data for German foreign nationals. A note regarding the specialized German search string has been included in all of our graphs in the Data Analysis – WIPO Patent Records section of this report.

For a portion of our patent-data analysis, we compared the number of patents granted to US immigrants under PCT as a percentage of total patents granted across a number of different technology fields. This analysis required our group to index all WIPO U.S.-resident filings (342,101 documents). Due to limitations in bandwidth and the time associated with large data downloads, our group was unable to download two months of total WIPO data, and we received partial records for 17 additional months (together this represents missing records from 6.153% of the WIPO database). A weighted average method was used to estimate data for the missing or incomplete months of data.

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