

Kerr, William

**Article**

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## High-Skilled Immigration, Domestic Innovation, and Global Exchanges

William Kerr\*

High-skilled immigrants account for about 25 percent of the workers in the most innovative and entrepreneurial U.S. industries, and they are responsible for a roughly similar share of output measures like patents or firm starts. Immigrants have also accounted for the majority of the growth in the U.S. scientific workforce since the 1990s. The magnitudes of these contributions make understanding the economic consequences of immigration an important research priority.

In this piece, I summarize the major themes that have emerged from my work on high-skilled immigration. I start by describing the construction of the ethnic patenting records that I use in most of my studies. I then outline projects that have considered the economic consequences of high-skilled immigrants for the United States. The last part of this research summary focuses on the outbound economic

consequences of high-skilled emigration for the home countries of those who move to the United States.

### Developing Data

While the substantial role of immigrants in U.S. technological development has long been recognized, data constraints have posed a significant challenge for research. Some datasets, like the decennial Censuses, provide rich cross-sectional accounts but limited longitudinal variation. Others, such as the Current Population Survey, provide better longitudinal detail but less cross-sectional heterogeneity. Moreover, it has been especially difficult to collect data on the role of high-skilled immigrants in research-oriented firms and universities.

Most of my work on high-skilled immigrants builds off the assignment of probable ethnicities to individuals who appear in U.S. patent records. The United States Patent and Trademark Office (USPTO) publishes all the patents it grants, which have exceeded 200,000 grants in recent years. Every patent must list at least one inventor, and patents are allowed multiple inventors.

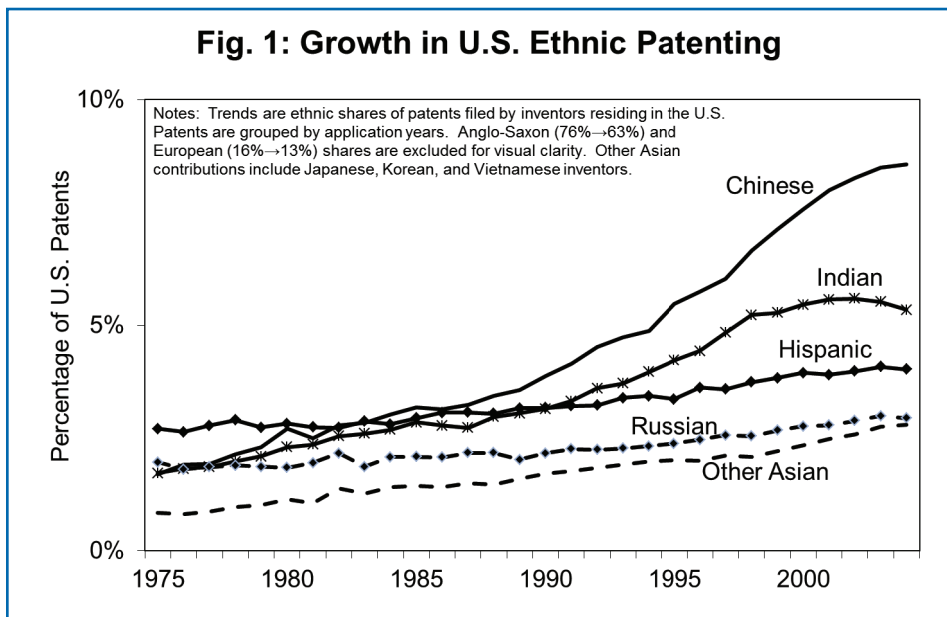
Several features of patent litigation make it advisable to correctly list the identities of those truly doing the innovative work when filing for a patent, and through the assignment of patents, this inventor role can be separated from ownership of the property rights to the patent.

I use the names of inventors to assign their probable ethnicities. This procedure exploits the fact that individuals with surnames of Gupta or Desai are likely to be Indian, Wang or Ming are likely to be Chinese, and Martinez or Rodriguez are likely to be Hispanic. Name matching procedures have been developed to provide probabilistic ethnicities for virtually all inventors in the USPTO system. The name approach is comparatively stronger at separating among Asian ethnic groups than among European or Hispanic names. This approach does not isolate immigration status directly for multiple reasons, but it does provide an indirect measure that proves useful in research.

The appeal of this approach is that it permits assignment of ethnicities to individual patent records. With this granularity, the USPTO records can be aggregated in many ways, for example by

\*Kerr is a Faculty Research Fellow in the NBER's Program on Productivity, Innovation, and Entrepreneurship. He is an Associate Professor at Harvard Business School. His profile appears later in this issue.

**Fig. 1: Growth in U.S. Ethnic Patenting**



year, by city, by very detailed technology codes, and by institution. Moreover, the patent data include a wealth of information, so one can, for example, study citations that patents make to other patents for evidence of ethnic networks in knowledge flow. One can also use measures developed in the technological change literature (such as patent originality scores) to compare inventor contributions across ethnicities.

Figure 1 shows the tremendous increase in the ethnic contribution of U.S. inventors over the last 30 years, focusing only on inventors residing in the United States at the time of their work. The contribution of Chinese and Indian ethnic inventors displays exceptional growth, increasing from under 2 percent each to 9 percent and 6 percent respectively. Ethnic contributions are disproportionately concentrated in high-tech fields, and Figure 2 shows the Chinese and Indian inventor shares for several noteworthy companies. The data underlying Figures 1 and 2 are the basis for most of my research on high-skilled immigration in the U.S. economy.

### Domestic Inbound Consequences

One portion of my work uses the USPTO data to examine how high-

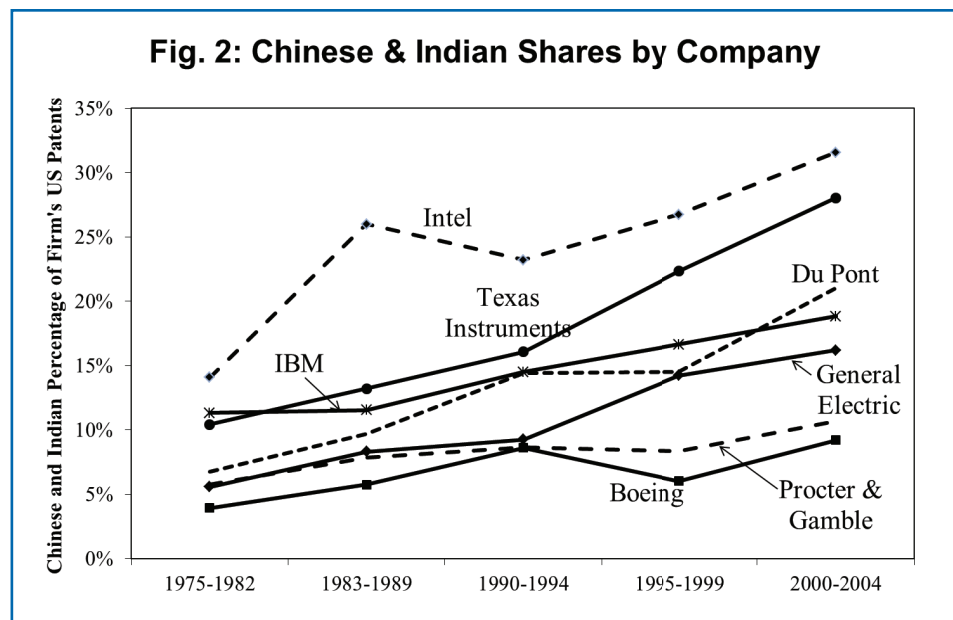
skilled immigration affects the rate of U.S. technology development and its spatial allocation. One project with William Lincoln examines how immigration policy influences the rate of U.S. innovation through changes in the supply of potential inventors to the economy.<sup>1</sup> We focus on the H-1B visa program that is the primary visa category for temporary workers entering the United States for employment in high-skilled occupations related to science and engineering. The U.S. national cap on new H-1B admissions has fluctuated substantially over the last

two decades, and the program is a point of significant controversy in the public debate over immigration. Proponents and detractors disagree about how important H-1B admissions are for U.S. technology advancement and whether native workers are displaced by immigrants.

We study how changes in H-1B admissions impact the growth and character of U.S. invention. Our central analysis exploits differences across cities in their dependence on immigrants for their science and engineering workforce. Dependent cities experience substantially stronger growth in Indian and Chinese ethnic inventions when H-1B admission rates are higher. We do not find evidence of adverse effects for inventors with Anglo-Saxon names, which are our proxy for native U.S. workers. If anything, the project suggests that native invention may grow slightly when the number of immigrant scientists and engineers is increasing in a city. Aggregating across ethnic groups, total U.S. invention increases by a small amount in the short run with higher H-1B admissions. This increase is primarily through the direct contributions of immigrant inventors.

These results are important for understanding the consequences of more flexible immigration policies for high-skilled workers. In contrast to the demand side of innovation—where entrepreneurial innovation responds

**Fig. 2: Chinese & Indian Shares by Company**



to market needs and growth in market sizes — this supply side of innovation is less understood. It can be very challenging for workers to move across occupations and industries, especially in knowledge-intensive sectors. The heavy U.S. dependence on immigrants for its scientific workforce makes immigration policy an important supply-side determinant of U.S. innovation, as it governs the entry of workers who can perform key tasks in innovation-intensive industries.

A subsequent project, also using cross-city variation, considers the degree to which immigrants aid the efficient reallocation of inventors toward areas where breakthrough inventions occur.<sup>2</sup> Urban economists have long discussed cases in which innovation shifts to be near the source of the next great mousetrap, for example, the quick shift of semiconductors from Boston to Silicon Valley and the rapid rise of Micron Technology, Inc. in Boise, Idaho. As part of a broader effort to quantify this effect, this project showed the substantial degree to which immigrant inventors lead the shifts across space to new industrial clusters. This greater mobility results partly from immigrant inventors being more mobile than native workers, but it is particularly connected to the fact that initial location decisions upon moving to the United States can be easily shaped.

More recent work has turned to uniting the ethnic patenting data with administrative data on the employment structures of U.S. firms. From a conceptual perspective, this integration is very important since most forms of high-skilled immigration are 1) done through firms that sponsor visas, and 2) have many non-market aspects to their allocation. Examples of the latter are the regulated supply of new high-skilled immigrants by the government, their allocation to firms without a pricing mechanism, and the tied employer-employee relationships that follow. Given that firms effectively conduct much of the selection of U.S. high-skilled immigrants, it is imperative to understand better how they utilize the visas.<sup>3</sup>

In projects with Lincoln and Sari

Pekkala Kerr, we link the ethnic patenting dataset to the U.S. Census Bureau's Longitudinal Employer Household Database.<sup>4</sup> This is a very exciting research platform because the employer-employee data allow us to follow individuals and firms over time. Moreover, the data directly identify the immigrant status of employees, which is particularly powerful in combination with the ethnic patenting data.

Our key paper analyzes how fluctuations in the H-1B program impact the hiring of different groups of workers. We explore the idea that high-skilled immigration allows dependent firms to keep their workforces younger. Advocates against the H-1B program voice this concern, arguing anecdotally that the program is used in high-tech firms for labor cost minimization by displacing older and more expensive workers. While the vast majority of H-1B workers are under the age of 40, this proposed relationship has not been rigorously examined.

We find evidence that increased employment of high-skilled immigrants in the firm links to younger workforces. Whereas younger native groups expand their employment in step with immigrants, there are very limited adjustments regarding the employment of older natives. As a consequence, the share of older workers in the firm declines, both in total and among native workers only. On the other hand, it is important to note that absolute declines in older worker employment are not observed. We consider some differences in effects by occupation, and we discuss how our results reflect a blend of cost minimization and access to scarce skills. These findings describe a pattern of substitution and complementarity between immigrants and natives that could not have been discerned with prior techniques and data.

Overall, the development of new employer-employee data offers great promise for expanding our understanding of the immigration process from both empirical and theoretical perspectives. The literature on international trade, for example, has benefited signifi-

cantly in recent years from greater consideration of the role of the firm, and I believe a similar outgrowth will occur for high-skilled immigration research in coming years.

## Home-Country Consequences of High-Skilled Emigration

The studies described above analyze how immigrants influence U.S. innovation. My research also considers the relationships that high-skilled immigrants in the United States maintain with their home countries. Case studies of Silicon Valley depict powerful ethnic business networks that transfer knowledge and technology across countries, but the broader strength and generality of these networks have been rarely tested.

My initial research on this question establishes some key macroeconomic relationships using country-industry data in combination with the ethnic patenting series.<sup>5</sup> This work quantifies how a larger ethnic scientific community in the United States aids the transfer of new technologies to the home country. This transfer is strong enough to show up in manufacturing output and productivity data for the home country, and it is also evident in trade patterns.<sup>6</sup> At several points, my work has used the Immigration Reform Act of 1990, which differentially affected high-skilled immigration from countries based upon how general quota changes interacted with country size, to tease out causal relationships.

Understanding the channels behind this technology transfer has been the subject of subsequent work. One channel is clearly inventor-to-inventor communication. Ethnic networks are evident in global patent citations, where overseas inventors display a 50 percent higher citation rate for members of their own ethnicity working in the United States, conditional on technology area and similar controls. This ethnic transfer is particularly powerful in the first five years after a new discovery is made, and it is no longer present after technologies have been around for ten years as a result of wide-



spread diffusion.

My work with C. Fritz Foley also establishes that foreign direct investment (FDI) is an important mechanism and introduces again the theme of understanding the role of firms in these global linkages.<sup>7</sup> We match the ethnic patenting data to confidential data on the foreign activities of U.S. multinationals collected by the Bureau of Economic Analysis. This platform allows us to see how growth in a firm's ethnic scientific workforce in the United States relates to FDI placement, both in total and also in activities specifically related to R&D and patenting. We find that within-firm growth in the number of U.S.-based inventors of a particular ethnicity translates into higher FDI placement by that firm in countries associated with that ethnic group. This effect is particularly strong for location decisions related to innovation. Our results suggest that employing innovators of a certain ethnicity increases some aspects of the competitiveness of U.S. multinational firms in countries associated with that ethnicity.

Another project with Ejaz Ghani and Christopher Stanton examines the outsourcing channel using contract-level data from oDesk, the world's largest online platform for outsourcing.<sup>8</sup> oDesk links firms and workers from many countries; India is the largest destination country on oDesk in terms of outsourcing. We study the role of the ethnic Indian diaspora worldwide in sending contracts to India and in influencing the traits of these contracts. An important finding from this work is that while tools like oDesk minimize many of the frictions that dias-

pora connections have historically overcome (such as information asymmetries and reputation-based contracts), the diaspora makes effective use of these tools and their role even strengthens with familiarity with the platform. This suggests that the importance of ethnic networks for international exchanges is unlikely to decline, and may even increase, with the advent of online platforms and related reductions in transportation and communication costs.

Overall, these studies find that larger high-skilled immigrant populations in the United States from a given country provide partial access to U.S. resources and opportunities for those who live in that country. This resource assembly through ethnic and professional networks complements resource assembly through spatial proximity in industrial clusters. It contrasts with traditional economic models where, for example, technology diffusion occurs instantaneously or declines uniformly with geographic distance.

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<sup>2</sup> W.R. Kerr, "Breakthrough Inventions and Migrating Clusters of Innovation," NBER Working Paper No. 15443, October 2009, and *Journal of Urban Economics*, 67(1) (January 2010), pp. 46–60.

<sup>3</sup> These issues are further elaborated upon in W.R. Kerr, "U.S. High-

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<sup>4</sup> S.P. Kerr, W.R. Kerr, and W.F. Lincoln, "Skilled Immigration and the Employment Structures of U.S. Firms," NBER Working Paper No. 19658, November 2013; S.P. Kerr and W.R. Kerr, "Immigration and Employer Transitions for STEM Workers," *American Economic Review*, 103(3) (May 2013), pp. 193–7.

<sup>5</sup> W.R. Kerr, "Ethnic Scientific Communities and International Technology Diffusion," *Review of Economics and Statistics*, 90(3) (August 2008), pp. 518–37.

<sup>6</sup> W.R. Kerr, "Heterogeneous Technology Diffusion and Ricardian Trade Patterns," NBER Working Paper No. 19657, November 2013.

<sup>7</sup> C.F. Foley and W.R. Kerr, "Ethnic Innovation and U.S. Multinational Firm Activity," NBER Working Paper No. 17336, August 2011, and *Management Science* (2013).

<sup>8</sup> E. Ghani, W.R. Kerr, and C.T. Stanton, "Diasporas and Outsourcing: Evidence from oDesk and India," NBER Working Paper No. 18474, October 2012, and forthcoming in *Management Science*.