International Migration and U.S. Innovation

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1. Introduction

"Innovation" is very hot word these days—in business, in policy circles, and in academics. For individual companies, innovation is described as central for competitive success. At the level of society, innovation is an important input to prosperity and the key long-run driver of economic growth. In the United States, immigrants are often linked to innovation and its related outcomes (e.g., patenting, entrepreneurship). It is thus not surprising that many central proponents of migration focus on the potential innovation benefits that U.S. firms and the country as a whole could derive by attracting more talent—it appears to be the ultimate free lunch. Yet, there are others who advocate against immigration, even among high-skilled workers, believing that it drives down wage rates of Americans and does not contribute to aggregate innovation.

This presentation reviews the link between migration and innovation in the United States context, pulling in part from a handbook chapter in preparation. We first describe the data used to measure these phenomena and the trends evident. This work shows the overall importance of migration for U.S. technological development and commercialization. We then review key studies that assess whether a more causal link exists—that is, can increased migration boost more innovation? Here the evidence is mixed, although as whole it favors an affirmative answer. We describe limits in what we know and promising avenues for future research with respect to firms in particular and their role in the immigration of high-skilled workers.

Space and time constraints require this review be very selective, citing only a modest number of papers and topics. Kerr (2013) provides a more comprehensive review of the empirics of high-skilled immigration and innovation. This lengthier piece provides pointers to work done on countries other than the United States, discusses global connections that skilled migrants maintain with their home countries, and more generally expands the U.S. description.

2. Descriptive Traits

The U.S. workforce for innovation depends strongly on migrants. This section begins by recalling some facts about the Science, Technology, Engineering and Mathematics (STEM) workforce in particular. STEM fields are often those most closely associated with innovation, although this definition is certainly narrower than the full workforce engaged in innovative efforts. STEM fields and their innovative outputs are the easiest to measure in the data, leading to the predominate focus on them.

Immigrants to the United States represent a substantial share of the overall population and its growth rate. In the 2008 Current Population Survey, immigrants accounted for about 16% of the working population with a college education and they constituted about 29% of the net growth in this group since 1995. For STEM, however, the levels of contributions of migrants are substantially higher at almost 25% among college-educated workers. At the doctoral level this share nears 50%, which does not reflect second- and later-generation migrant contributions. Moreover, Kerr and Lincoln (2010) estimate that immigrants account for a majority of the net increase in the U.S. STEM workforce since 1995.

The contributions are also reflected in metrics related to innovation. Patents are the most studied example. Using data from the World Intellectual Property Organization (WIPO) database, Wadhwa et al. (2007) find that non-U.S. citizens account for at least one inventor on 24% of international patent applications from the United States. Beyond these levels, the WIPO data have some selection issues that limit their usefulness for longer-time-duration analyses. Using the United States Patent and Trademark Office (USPTO) database, Kerr (2007) and Kerr and Lincoln (2010) develop estimates of ethnic inventor contributions (i.e., those of Chinese or Indian ethnic heritage) using ethnic name matching procedures. These papers emphasize the high degree of patenting contributions by ethnic inventors, especially the growth since 1975. The share of domestic patents filed by U.S. inventors of Chinese and Indian ethnicities increase from under 2% in 1975 to 9% and 6%, respectively, in 2005.

With respect to entrepreneurship and the commercialization of innovation, several pieces argue for similarly large roles for immigrants (e.g., Saxenian 1999, Wadhwa et al. 2007). These studies have often been done for advocacy purposes and with biased samples, but at the same time they are thought to be correct in direction and general magnitude. They too generally find immigrants constituting roughly a quarter of innovative founders and that this share appears to be growing.

These various metrics—workforce composition, patents, firms starts—provide guidance to quantities of activity and are generally speaking in one accord. When one turns to the relative quality of immigrants engaged in innovation—in popular press terms, the claims that immigrants are the "best and brightest"—there is substantially more heterogeneity and nuance across metrics.

The most comprehensive assessments come through Hunt and Gauthier-Loiselle (2010) and Hunt (2011, 2013), who examine representative data sources like the National Survey of College Graduates and the American Community Surveys. Hunt argues that immigrants who come to the United States for employment or study purposes, versus family reunification, have a large raw advantage over natives for patenting and starting new companies. She demonstrates however that most of this advantage comes through choices the migrants make with respect to their education attainment in terms of fields of study and higher education pursuit. Thus, as an example, immigrant and natives who have obtained a master's degree in electrical engineering appear to have similar abilities towards producing innovations; the perceived advantage of immigrants comes through them being more like to pursue a master's degree in electrical engineering in the first place. Kerr and Lincoln (2010) and Kerr et al. (2013) reach a relatively similar conclusion when examining the quality levels of patents produced.

This general comparability in terms of quality contrasts with work showing that immigrants account for a disproportionate share of innovation superstars. Stephan and Levin (2001) first identify how immigrants are over-represented among most-cited authors, among authors of the most-cited papers, among members of the National Academy of Sciences, and so on. Other work has also shown American winners of the Nobel Prize are disproportionately immigrant. Many

have also pointed to the immigrant founders of very prominent U.S. firms (e.g., Sergey Brin of Google).

Thus, migration influences U.S. innovation through its quantity dimensions—the large number of STEM workers who are immigrants—and also through its influence at the very outer tails of the distribution. There remains a substantial amount that we need to determine about these statistics. For example, we have yet to fully characterize the heterogeneity in impacts by when people move to the United States—as children, students, or adult workers. These relationships are as important for policy choices as for academic description. For example, while many advocates of greater U.S. immigration visas use Brin as an example of potential benefits, those against higher admission levels point out that he migrated at age six and thus does not really fit the description advocates are offering.

More generally, it would be good to understand better how the quantity and quality dimensions relate to each other. It could be that they are independent of each other, with spillovers and benefits from superstars being shared throughout STEM workers. On the other hand, we have ample evidence of ethnic clustering around superstars. For example, migrating graduate students are often positioned within the laboratories and departments of star researchers from their home countries. There may exist deeper connections across these two traits of the innovation workforce.

3. Impact for U.S. Employment, Wages, and Innovation

While some quibbles may exist across studies, observers on both sides of the migration debate agree in broad terms on the statistics outlined in Section 2. Their interpretations of these facts are, however, very different. Taking as an example the fact that migrants account for the majority of the U.S. workforce growth since 1995 related to innovation, proponents of immigration conclude that the United States should admit more skilled immigrants to further boost innovation. Advocates against immigration, however, argue that the seemingly positive statistics represent a loss of America jobs to foreigners. In other words, absent immigration, the United

States would achieve the same innovation outcomes with Americans taking the lead and not immigrants.

Thus, the key academic literature turns next to estimating the impact of skilled immigration on natives, often termed crowding-in or crowding-out effects, and on whether there is evidence that total innovation in the economy increases as immigration grows. Due to the occupational choice that open labor markets provide, these native responses are intimately tied up with employment and wages, which are frequently studied. Absent exceptional quality differences for immigrants, which do not appear to be the case except for at the extremes of the distribution, the increase or decrease of aggregate innovation due to immigration depends in large part on how immigrants affect the employment of natives.

The core studies that we highlight come from a labor economics tradition that focuses on causal identification. This work starts from the premise that the best evidence about the link of immigration and innovation would come from random and exogenous adjustments of immigration levels. This would be similar to medical trials, and we might learn from subsequent innovation responses the true causal link between immigration and innovation. This is not possible in the real world, of course, and so economists search for settings as close as possible to the archetype—for example, exogenous changes in immigration levels to particular cities, occupations, or fields. By comparing affected units with peers that were not affected, we can in some circumstances get close to the impossible ideal test. Papers tend to be judged on how well the conditions described are met. Kerr (2013) describes the inference from these tests in greater detail and also the theoretical models that lie behind the definition of labor markets.

A first line of work defines the unit of analysis to be a U.S. city or state. This approach follows a technique originally develop by Card (2001) for analyzing general immigration's impact on domestic wages and employment and applies it to the innovation context. One thus looks for whether increases in migration to Boston compared to Chicago are associated with stronger future innovation in Boston compared to Chicago. Hunt and Gauthier-Loiselle (2010) consider states and decades for their work, finding very large boosts to innovation from immigration.

These effects must come in part through crowding-in phenomena; that is, natives are encouraged to engage in more innovative work by greater immigration levels to the state.

Using sharper variation provided by annual changes in the U.S. H-1B visa system—a temporary immigration category that accounts for the majority of skilled worker admissions related to STEM work—Kerr and Lincoln (2010) find more modest effects, with increases in immigration yielding increases in innovation mainly through the immigrants themselves rather than crowding-in or crowding-out effects. Using a similar set-up, Peri et al. (2013) further find large city-level productivity increases following from H-1B program expansions in local areas that extensively rely on the program. Thus, while differences exist across studies, analyses of local areas consistently confirm the important link between migration and innovation.

A second approach takes specialized fields of study or expertise as the unit of analysis. This approach is more appropriate than the local area work to the extent that labor markets for skilled work are national in scope and focused around fields (e.g., electrical engineering vs. nuclear engineering, rather than Boston vs. Chicago). Two prominent studies in this line of work come to very different conclusions. Borjas and Doran (2012) evaluate an influx of Russian mathematicians following the collapse of the Soviet Union and find no increase in the United States' production of mathematics. Thus, the incoming Soviet researchers mainly displaced Americans from the jobs (especially younger graduates). On the other hand, Moser et al. (2014) find substantial growth in innovation in chemicals fields that were recipients of Jewish scientists fleeing Nazi Germany. One key reason for these differences may be limited opportunities for growth in the mathematics field studies by Borjas and Doran (2012), but in general further work should analyze these and similar historical settings to sharpen our understanding of these issues.

A related approach to this occupation or field analysis considers native choices of majors within schools, at either the undergraduate or graduate school levels. Native students could choose (or be forced) to specialize in other educational areas if immigrants are competing for the slots. Examples of this work are Borjas (2005, 2006), Lowell and Salzman (2007), Orrenius and Zavodny (2013), and Bound et al. (2013), which are quite distinct in their approaches. In general,

this line of research tends to find natives shifting away from STEM-related areas of studies or occupations when many immigrants are competing for these positions.

While this literature remains relatively small compared to the importance of the question, we are starting to converge (slowly) on an understanding of how the approaches compare with each other. Kerr (2013) provides a more extensive discussion about which approach might be more relevant that we do not repeat here. Instead, we make the core note that the presence of growth opportunities vs. constraints appears to be critical. In settings where growth opportunities abound, immigration can unlock innovation. In settings where resources are fixed, immigration can't move the overall needle and instead takes the form of competition for the limited supply. Tracing out this conjecture empirically would help to bring these various studies together and sharpen our policy advice surrounding the likely consequences of adjustments in immigration levels. Other important questions include whether the boundaries used in the approach are porous and which one has the greatest hope of reflecting national validity.

4. Ongoing Efforts for Firms

As describe more deeply in Kerr et al. (2014), on which this section pulls, firms play a central role in the immigration process for STEM workers. There are many parts of this process that do not fit well within the traditional approaches taken to understand the impacts of immigration. Recent efforts seek to build firm-level data that help disentangle the role of firms in determining admissions and the effect of the admissions on the businesses themselves. A firm-level analysis also allows us to account for other kinds of heterogeneity that are not captured with other approaches. This is especially important since firms hold specific assets that are often instrumental in determining employment outcomes and their organizational structures more generally. When there are complementary inputs (as might be the case with, for example, skilled and low-skilled labor), firms will be able to internalize these complementarities and capture opportunities for enhanced productivity, learning, and the development of entirely new capabilities. This better grounding can also evaluate employee-biased claims (e.g., Matloff 2003) that high-tech firms use migration to keep their workforces younger and cheaper, and yet the

standard frameworks cannot evaluate this claim until they take into account firm optimization more systematically.

The U.S. visa system for skilled immigrants also possesses certain non-market features that make a firm-level analysis more interesting and appropriate. Examples are the non-priced nature of the visas, the allocation on a first-come-first-served basis, and the regulated cap. Second, immigrant workers sponsored on an H-1B visa are effectively tied to the firm that employs them. The outcome of these and other features of the visa system is to place firms in the center of the skilled immigration process. At many points, the economics of firms can dramatically shape the structure of U.S. immigration (and indeed the system is partly designed to have this characteristic). As an example, the bullets below provide some assembled data on the share of new H-1B visa issuances going to workers from India or computer related occupations (India accounts for the lion's share of this type of worker):

- 1995: India ~20%, Computer 25%
- 1998: India ~45%, Computer 57%
- 2002: India 28%, Computer 28%
- 2008: India 57%, Computer 53%
- 2012: India 64%, Computer 70+%

There is an exceptional set of fluctuations in terms of the H-1B program's composition. These shares for computer-related occupations increased during the information technology boom of the 1990s, only to retract during the tech recession in 2002. The shares then expanded back in 2008 and have further strengthened in recent years. This flexibility has its advantages and potential drawbacks that are highlighted in Kerr et al. (2014) but the key point to make here is its dependency on firm demand. Temporal shifts in firm and industry demands affected over 25%-30% of the visa allocation in terms of countries of origin and occupation. A system of allocating visas on a first-come-first-served basis without restrictions regarding the composition of visas to be distributed will always possess these characteristics.

Findings to date are unfortunately small relative to their importance. First, growth in the employment of skilled immigrants is connected with greater overall firm employment. This growth, however, differs across worker groups in important ways (e.g., favoring younger natives over older natives, favoring complementary occupations). Technological development increases as the firms employ more workers undertaking invention. Subsequently, these migrants influence the global operations of their employers (e.g., shifting foreign direct investment towards their home countries). Not surprisingly, firms seek to influence these admissions through lobbying efforts, however, entry costs into lobbying mean that the lobbying firms only imperfectly represent the full preferences of firms. Academic references regarding these pieces are available in Kerr et al. (2014).

5. Conclusions

Immigrants are of deep importance to U.S. innovation. This is most evident in terms of their sheer quantity for STEM work in the United States, and the disproportionate number of superstars who are immigrants speak to this. The academic literature is examining the impact of immigration on natives in innovation fields, and drawing closer to answering the question of whether migration boosts innovation. Work to date shows that these effects can be heterogeneous, leaning as a whole towards positive and especially so in cases where growth is possible. Researchers are refining their approaches and data to pay better attention to the specific institutional and policy features of high-skilled immigration. Much remains to be done, and the phenomenon is growing in importance, making this an exciting domain for some time to come.

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