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IMMIGRATION AND THE RISE OF AMERICAN INGENUITY

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ABSTRACT

This paper builds on the analysis in Akcigit et al. (2017) by using US patent and Census data to examine macro and micro-level aspects of the relationship between immigration and innovation. We construct a measure of foreign born expertise and show that technology areas where immigrant inventors were prevalent between 1880 and 1940 experienced more patenting and citations between 1940 and 2000. We also show that immigrant inventors were more productive during their life cycle than native born inventors, although they received significantly lower levels of labor income than their native born counterparts. Overall, the contribution of foreign born inventors to US innovation was substantial, but we also find evidence of an immigrant inventor wage-gap that cannot be explained by differentials in productivity.

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"That part of America which has encouraged them (the foreigners) most, has advanced most rapidly in population, agriculture and the arts."

– James Madison, Constitutional Convention, 1787

1 Introduction

From the founding of the US nation up to the recent Presidential election, the impact of immigrants has been a focal point of debate. The relationship between immigration and innovation is especially contentious. High-skilled immigrant flows can improve human capital and the stock of ideas in the host country (Kerr and Lincoln (2010); Hunt and Gauthier-Loiselle (2010)), but these flows can also lead to the displacement of domestic knowledge producers (Borjas and Doran, 2012). While the recent literature on this topic is growing, Abramitzky and Boustan (2016) note there is very little evidence connecting immigrants to US innovation over longer horizons. Moser et al. (2014) find a large boost from immigrants from the 1930s to the 1960s, but their evidence comes from a sub-group of particulary high-skilled inventors—German-Jewish émigré chemists who fled from the Nazi regime—for whom we might expect the effect to be large.

Using patent records and Federal Census data we provide broad evidence of the impact of immigrants on US innovation and document labor market outcomes for migrant inventors. We construct a measure of *foreign born expertise* and show that technology areas where immigrant inventors were more prevalent between 1880 and 1940 experienced faster growth between 1940 and 2000. We also show that immigrant inventors were more productive during their life cycle than native born inventors, although they received significantly lower wage levels than their native born counterparts. Overall, our results suggest the contribution of foreign born inventors to US innovation was substantial, but we also find evidence of assimilation frictions in the labor market.

Our analysis is part of a much larger project where we examine the golden age of US innovation by linking US patents to state and county-level data and to information in Federal Censuses between 1880 and 1940 (Akcigit et al., 2017). We aim to complement modern studies such as Aghion et al. (2015) and Bell et al. (2015) to provide a more complete picture of inventor profiles over time and space. In our main paper we document a fundamental relationship between innovation and long run economic growth and then develop a number of facts about the environment in which inventors functioned, their life cycle and the further link between innovation, inequality and social mobility. One of our findings relates to immigration. We show that in the top 10 most inventive states in terms of the average number of patents per capita between 1880 and 1940, 20.6% of the population were international migrants, compared to just 1.7% of the population of the least inventive states. In the remainder of this paper we explore the underlying relationship between immigrant inventors and innovation.

2 Historical Background

In 1947 the lobby group, the National Committee on Immigration Policy in the US published a volume on *Economic Aspects of Immigration*. It contains numerous anecdotes to support their argument that economic growth benefitted from invention by foreigners. The Scottish-born Alexander Graham Bell was pivotal in the development of the telephone; David Lindquist, the Swedish inventor who became chief engineer at Otis, developed the electric elevator; the pioneering German-born chemist, Herman Frasch, worked in Philadelphia and Cleveland on refining processes analogous to modern-day fracking. If this volume were to be re-written today, it would be replete with examples of high-skilled immigrants in Silicon Valley.

Beyond their own knowledge, high-skilled inventors can create spillovers. Effective collaboration revolves around access to the very best minds (Iaria and Waldinger, 2016). The French engineer Octave Chanute, who settled in Chicago in 1889, acted as an information hub providing Wilbur and Orville Wright with crucial technical information in their search for manned flight. There is also evidence that immigrants worked in teams, which can increase creativity through the combination of specialized insights (Jones, 2009). James Hillier, a Canadian immigrant developed the first commercially viable electron microscope at Radio Corporation of America (e.g., patent 2,354,263, 1944). There he worked with other foreign-born scientists including Ladislaus Marton, a Belgian inventor and Vladimir Zworykin, a Russian immigrant and leading television technology innovator, as well as native-born engineers.

These individuals were superstar inventors creating what Mokyr (2005) describes as "upper tail" knowledge. Yet, it is also important to go beyond such notable examples to examine the overall distribution of foreign-born inventors. During the Age of Mass Migration (1850-1913) almost 30 million European immigrants arrived in the United States. Although the national-origins quota system limited entry between the 1920s and the mid-1960s, high-skilled inventors periodically entered the country, such as those who fled Nazi Europe (Moser et al., 2014). Our extensive time period coverage is useful for studying the effect of immigration on innovation. In keeping with the focus in Akcigit et al. (2017) on the relationship between innovation and long run growth, it allows us to explore the potential benefits created by knowledge production and externalities long after these immigrants arrived.

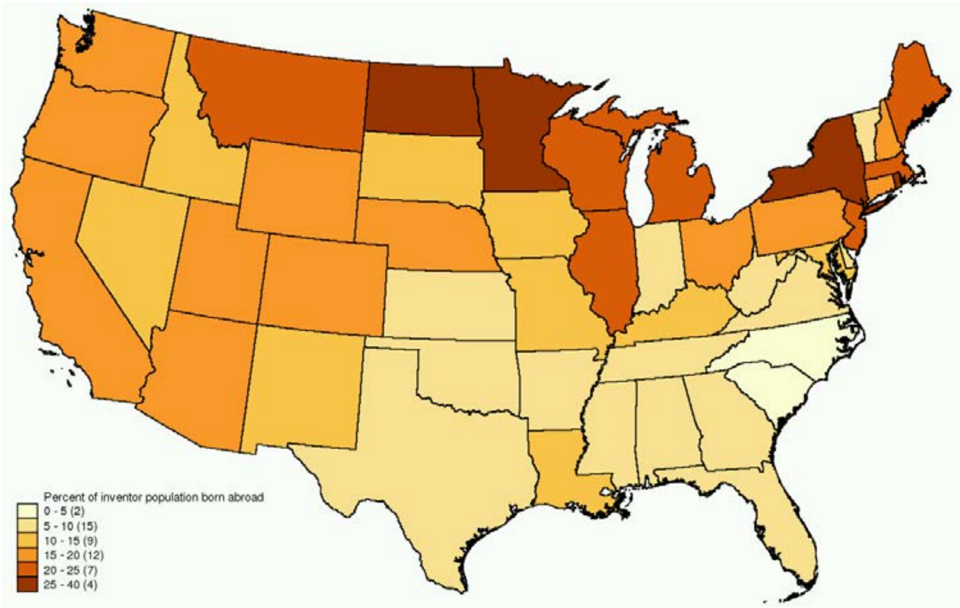
3 The Data

The data for our analysis are described fully in Akcigit et al. (2017). Here we briefly sketch out the main components. First, we use nearly the universe of patents granted by the USPTO covering the geographic location of inventors, their technology area (i.e., patent class) and patent citations. Second, we use the name and location of inventors on patent documents to match them to Federal Censuses between 1880 and 1940. We can therefore generate a profile of inventors from a rich vector of variables, including labor income, first reported in the 1940 Census as the "amount of money, wages, or salary received (including commissions)".

4 Empirical Results

We begin with descriptive evidence on immigrant inventors. Figure 1 shows that immigrant inventors tended to cluster regionally within the US. The areas in which we find heavy concentrations, such as New York, were also those where immigrants tended to locate more generally (Abramitzky and Boustan, 2016). Immigrant inventors are noticeably absent from southern states, perhaps because such places were less likely to be open to disruptive ideas and more intolerant of social change.

Figure 1: The Location of Foreign Inventors

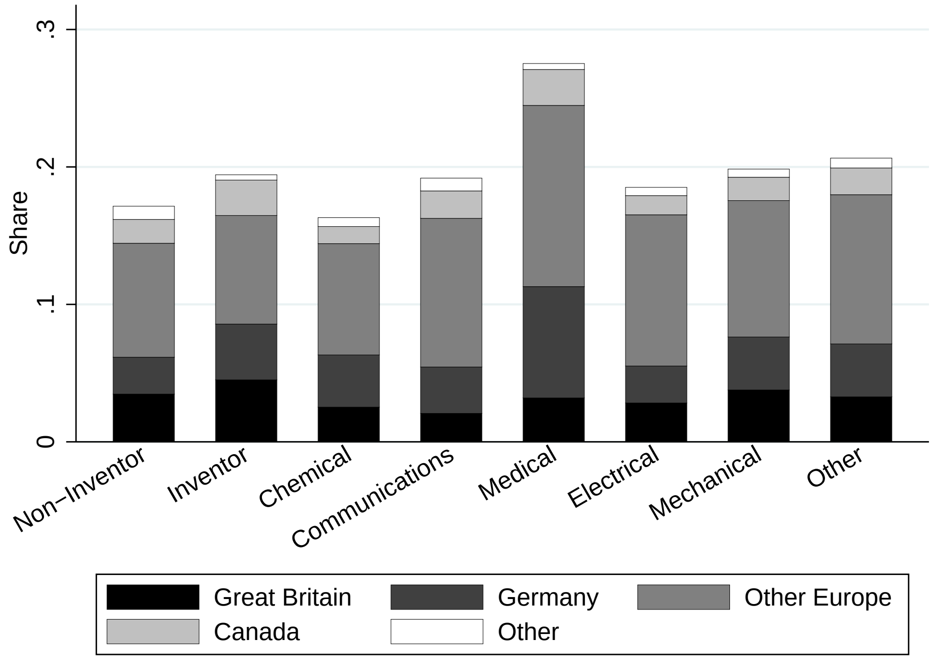


Notes. Map shows the share of each states inventors who were born abroad in our six decennial census years (1880, 1900-1940). Darker colors indicate a higher migrant share.

Figure 2 shows that the foreign-born were more prevalent among inventors active in the US than in the non-inventor population. This is consistent with entry into invention being relatively open compared to occupations such as doctors and lawyers that required some degree of cultural assimilation or formal qualification. Europeans dominated in terms of origin country, compared to Chinese and Indian ethnic heritages today. In our time period immigrants accounted for 19.6% of inventors. Today the share is about 30%.

While the contribution of immigrants to US technological progress in chemicals and

Figure 2: Foreign Inventor Share



Notes. Figure shows the share of non-inventors and inventors who were born abroad in our six decennial census years (1880, 1900-1940). The inventor share is also broken down by NBER patent category.

to a lesser extent electricity during the late nineteenth and early twentieth centuries has been well-documented, these sectors actually accounted for the smallest shares. Medical technology stands out. However, in aggregate this sector accounted for 1.0% of US patents between 1880 and 1940 compared to 13.9% for chemicals and 12.6% for electricity.

Table 1 provides estimates of the impact of immigrant inventors on the technology area in which they were active. We construct a measure of *foreign born expertise* by multiplying the share of country c's patents granted in class k between 1880 and 1940 by the number of immigrant inventors from c in the 1940 Census, and then summing across all c:

$$\text{Expertise}_k = \sum_c \frac{\#\ \text{Pat}(k,c)}{\#\ \text{Pat}(c)} \times \#\ \text{Mig\_Inv}(c)$$

The intuition behind this measure is that the US technology area in which country c patents captures its frontier innovation advantage, while the physical movement of an inventor from that country to the US magnifies the impact in that area through the transmission of codified or tacit knowledge. In endogenous growth models, innovation leads to economic growth as inventors build on prior generations of frontier ideas (e.g., Romer (1990), Aghion and Howitt (1992)).

We use this measure of *foreign born expertise* between 1880 and 1940 in a regression framework at the USPTO patent class level to predict the change in patenting between

Table 1: The relationship between patent class growth and expertise of foreign migrants

Innovation Definition:	Patents		Citations	
	(1)	(2)	(3)	(4)
Foreign Expertise	0.461***	0.408***	0.396***	0.160***
	(0.044)	(0.055)	(0.043)	(0.040)
Log Innovation 1880-1940		0.094		0.417***
		(0.067)		(0.083)
Observations	399	399	399	399

Notes. Table reports estimates from regressing log patents (columns 1 and 2) or log(1+citations) (columns 3 and 4) granted in a patent technology class k between 1940 and 2000 on foreign expertise in class k. Foreign expertise is defined as follows: multiply the share of country c's patents granted inclass k between 1880 and 1940 by the number of migrant inventors from c in the 1940 Census, then sum across all c. All variables are standardized to have 0 mean and unit standard deviation. White heteroskedasticity robust standard errors reported in parentheses. *, **, and *** indicate coefficient statistically different from 0 at the 10%, 5%, and 1% levels, respectively.

1940 and 2000. Table 1 shows that foreign expertise in a technology area is strongly related to both the level of patents and citations over the following six decades. For example, column 1 shows that a one standard deviation increase in *foreign born expertise* is associated with an increase in patents that is 46.1% of its standard deviation (in column 3 for citations the effect is 39.6% of its standard deviation). These results are robust to controlling for the long-run effects of initial patents and citations in columns 2 and 4. Our results suggest immigrants had a broad long-run macroeconomic impact on US invention.

Next we turn to the micro-level. Given the richness of our data we can observe inventors longitudinally, and so measure their career patents and citations to determine productivity. We also observe wage income in the 1940 Census (subject to the caveat that enumerators top-coded high incomes at $5,000 and income derived from, say patent sales, would not be included in reported income). Hence, we can approximate the financial returns to invention by immigrants relative to other groups, conditioning on productivity. Column 1 of Table 2 show that the career patents of immigrant inventors were ($e^{0.088} - 1 \times 100$)=9% higher than native born inventors. We also find that black inventors were about 67% more productive, and male inventors 111% more productive, than their non-black and female counterparts respectively. In column 2, although the coefficient on international migrants loses statistical significance, the magnitude of these differences holds when we consider career citations.

Now turn to the wage results in columns 3 and 4.[1] We see that despite their higher productivity, labor income for immigrant inventors was about 5% lower than for native born inventors. Although the mechanism is hard to disentangle, we find a large wage gap for black inventors relative to non-black inventors and for males relative to females

[1]We have fewer observations in the wage income regression in columns 3 and 4 compared to the productivity regressions in columns 1 and 2 due to missing information on this variable in the 1940 Census. As a robustness check, we restricted the regressions in columns 1 and 2 to only those individuals for whom we observe wage income. The results remained substantively the same.

Table 2: Career Productivity, Log Wages, and Migrant Status

Dependent Variable:	Log(Productivity)		Log(Wage Income)	
Productivity Measure:	Patents	1+Citations	Patents	1+Citations
	(1)	(2)	(3)	(4)
International Migrant	0.088**	0.066	-0.055**	-0.049**
	(0.040)	(0.050)	(0.024)	(0.024)
Black	0.514***	0.518***	-0.384***	-0.348***
	(0.152)	(0.184)	(0.101)	(0.102)
Male	0.746***	0.891***	0.415***	0.447***
	(0.138)	(0.176)	(0.111)	(0.109)
Log Productivity			0.084***	0.008
			(0.009)	(0.008)
Observations	8209	8209	5831	5831
Mean Dep. Var.	1.581	3.746	7.629	7.629
S.D. Dep. Var.	1.363	1.683	0.840	0.840

Notes. Table reports estimates from a regression of log wages (columns 1 and 2) or log career inventor productivity (columns 3 and 4) for the set of inventors matched to the 1940 census. Columns 1 and 3 define career productivity to be the total number of patents granted to an inventor, while columns 2 and 4 define productivity to be one plus the number of citations received. All regressions include controls for education, age, and state and occupation fixed effects. White heteroskedasticity robust standard errors reported in parentheses. Regression sample is set of inventors matched to the 1940 Decennial Census. We do not include prior inventors due to a lack of suitable controls (e.g. education) and the unavailability of wage data. *, **, and *** indicate coefficient statistically different from 0 at the 10%, 5%, and 1% levels, respectively.

when controlling for productivity, both of which are consistent with labor market discrimination. While the limits of our data mean we can not observe lifetime earnings, our evidence implies immigrant inventors who relocated to the United States earned lower labor income than comparable native born inventors.

5 Conclusion

The contribution of immigration to US economic growth is an important policy question. For example, Akcigit et al. (2016) show that the top income tax rates affect the international migration of superstar inventors. We have shown that immigrant inventors were especially productive and that the technology areas in which they were active exhibited higher levels of growth over the long run. Our evidence is consistent with the view that immigrant inventors had a substantial positive macroeconomic impact through their influence on US inventiveness. At the same time the micro-level labor market wage-gap we observe implies frictions associated with assimilation, which can have a large effect on economic outcomes. Hsieh et al. (2013) show that labor market barriers in the in the US from 1960 to 2010 severely dampened growth due to the misallocation of talent. The immigrant inventor wage-gap we find cannot be explained by variation in productivity.

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