Volume Title: The Roles of Immigrants and Foreign Students in US Science, Innovation, and Entrepreneurship

Volume Authors/Editors: Ina Ganguli, Shulamit Kahn, Megan MacGarvie, editors

Volume Publisher: University of Chicago Press

Volume ISBNs: 978-0-226-69562-4 (cloth); 978-0-226-69576-1 (electronic)

Volume URL: https://www.nber.org/books-and-chapters/roles-immigrants-and-foreign-students-us-science-innovation-and-entrepreneurship

Conference Date: April 27, 2018

Publication Date: February 2020

Chapter Title: Immigrant Entrepreneurs and Innovation in the US High-Tech Sector

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Chapter URL: https://www.nber.org/books-and-chapters/roles-immigrants-and-foreign-students-us-science-innovation-and-entrepreneurship/immigrant-entrepreneurs-and-innovation-us-high-tech-sector

Chapter pages in book: (p. 149 – 171)

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Immigrant Entrepreneurs and Innovation in the US High-Tech Sector

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6.1 Introduction

How much do immigrants contribute to innovation? Popular accounts of US science, engineering, and high-tech business creation tend to cast immigrants in a starring role, and anecdotes on exceptional immigrants are easy to find, but systematic evidence is rare. A number of studies have examined immigrants as individual inventors, as employees of high-tech firms, and as scientists, engineers, and self-employed (e.g., Wadhwa et al. 2007a and 2007b; Kerr and Lincoln 2010; Hunt 2011).[1]

However, there have been few studies of immigrant entrepreneurs, and

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We benefited from the comments of Tom Astebro, Ina Ganguli, David Hart, Bill Kerr, Sari Pekkala Kerr, Shulamit Kahn, Megan MacGarvie, Joe Staudt, and participants in two conferences at the NBER. We thank the National Science Foundation (NSF) for support (Grants 1262269 and 1719201 to George Mason University). Any opinions and conclusions expressed herein are ours only and do not necessarily reflect the views of the NSF or the US Census Bureau. All results have been reviewed to ensure that no confidential information is disclosed. The Disclosure Review Board bypass numbers are CBDRB-2018-CDAR-087, DRB-B0017-CED-20181126, and DRB-B0025-CED-20181219. For acknowledgments, sources of research support, and disclosure of the authors' material financial relationships, if any, please see https://www.nber.org/chapters/c14103.ack.

1. Other contributions to these topics include Stephan and Levin (2001), Peri (2007), Hunt and Gauthier-Loiselle (2010), and Kerr (2013).

most of those focus on firm size and growth.[2] Only Hart and Acs (2010) examine innovation measures—research and development (R&D) and patenting—at the firm level using a survey of 1,300 "high-impact" high-tech companies.[3] They report little difference between firms with and without immigrant founders, but they consider a sample of firms already at the right tail of the firm performance distribution. Such data do not permit research to draw any inferences on the relative innovativeness of typical high-tech businesses owned by immigrants and natives, which is the question we address in this chapter.

This chapter aims to contribute to an understanding of the innovation impact of immigrant entrepreneurship in the US high-tech sector using a much larger and richer data set than those heretofore available. We analyze the Annual Survey of Entrepreneurs (ASE), a new database from the US Census Bureau covering about 11,000 owners of 7,400 high-tech employer businesses based on a random sample of all nonfarm businesses. Like the well-known Survey of Business Owners (SBO), the ASE questionnaire contains detailed information on the four largest owners and some characteristics of the businesses, which provide us with control variables for measuring immigrant-native differences conditional on other characteristics, including demographics, human capital, and ownership teams. Unlike the SBO, however, and crucially for this chapter, the ASE includes many innovation measures that form the outcome variables in our study, including reported innovation activities in both products and processes, R&D, trademarks, and patents.[4]

The ASE also contains a number of variables that permit more disaggregated analysis. Data on race/ethnicity permit some examination of immigrants' countries of origin. Data on educational attainment allow us to estimate separately by education group. We are also able to examine immigrant-native differences in the roles played by a number of factors that may be jointly determined with innovation outcomes, including ownership motivations, start-up capital, and choice of industry. For all of these variables, we are interested in both characterizing immigrants relative to native

2. As far as we can determine, the only studies of job creation by immigrant entrepreneurs using broad, representative samples are Fairlie and Lofstrom (2014) and Kerr and Kerr (2017, 2018). Brown et al. (2018) analyze immigrant status among other founder characteristics in a study of high-growth entrepreneurship. Our focus on innovation outcomes is different, but we build on this work and provide some comparisons with our approach in what follows. A few other studies focus on particular industries, regions, or immigrant ethnicities.

3. Saxenian (2002) and Wadhwa et al. (2007a) examine immigrants as owners but do not measure innovation at their firms.

4. The random sampling for the ASE contrasts with the usual approach in "innovation surveys," including the Business Research and Development and Innovation Survey (BRDIS) in the US, where the sample is principally based on firms known or expected to be carrying out R&D.

entrepreneurs and measuring how they influence or mediate immigrant-native entrepreneur differences in innovation performance.

The subject of our study lies at the intersection of several large areas of research. To start with, there is a voluminous literature on the economic effects of immigrants. Most of this research focuses on the consequences of immigration for native worker wages and treats immigrants as a qualitatively similar factor of production so that immigration represents a labor supply shock to a particular region or education-experience group (e.g., Card 1990, 2001; Borjas and Doran 2015; Borjas and Monras 2017; Ottaviano and Peri 2012; Peri 2012, 2015). Other immigration research focuses on the disadvantage faced by immigrants in US labor markets and the extent and pace of immigrant-native convergence in wages, or "assimilation" (Borjas 1985, 2015; Chiswick, Lee, and Miller 2005; Chiswick 2009). Some studies of immigrants consider the possibility that immigrants have certain advantages and document higher rates of science, technology, engineering, and mathematics (STEM) workforce participation, patents, publication citations, and Nobel Prize winners among immigrants (Kerr and Lincoln 2010; Stephan and Levin 2001; Hunt and Gauthier-Loiselle 2010).

Yet much innovation takes place within firms, and our study relates to research on firm-level R&D, patenting, and other aspects of innovation. As is widely recognized, however, R&D and patents both have limitations as measures of innovation, much of which takes place without formal R&D or patenting. Some surveys, including the Community Innovation Surveys (CIS) in Europe and the Business Research and Development and Innovation Survey (BRDIS) in the US, attempt to fill this gap with qualitative questions on product and process innovations (Mairesse and Mohnen 2010). These surveys have documented the incidence of such activities and demonstrated their correlation with productivity (e.g., Griffith et al. 2006; Parisi, Schiantarelli, and Sembenelli 2006; Hall 2011). But the data in these studies are usually based on small samples (e.g., only 5,000 receive the full questionnaire for the BRDIS) that are nonrandomly selected to focus on firms with known R&D activity. Still more important for our purposes, they contain no information on the firm's founders or owners.

Such characteristics have been extensively analyzed in the literature on self-employment determinants, including immigration status (e.g., Fairlie and Lofstrom 2014). But they are seldom measured for owners of firms as distinguished from own-account (employee-less self-employed) workers. And a rich set of owner-founder characteristics has never before been linked to the kind of innovation measures that have become common in firm-level studies.

We find uniformly higher rates of innovation in immigrant-owned firms for 15 of 16 different measures. In most but not all cases, the differences are statistically significant, and in most cases, they survive detailed controls

for other demographic and human capital characteristics of the entrepreneurs, as well as the size and family composition of teams. In many cases, they also remain significant in specifications controlling for start-up finance, motivations, and industry. The immigrant-native difference holds for both recent start-ups and older firms and at all levels of the entrepreneur's education. The main exception is owning a copyright or trademark, the most marketing-related activities measured here. Otherwise, the data imply a robust immigrant advantage in innovation.

The rest of the chapter is organized as follows. Section 6.2 describes the data and section 6.3 the methods. Section 6.4 contains results, and section 6.5 concludes.

6.2 Data

We exploit new confidential microdata from the Census Bureau's 2014 ASE. The ASE is an annual survey that supplements the SBO, conducted every five years, providing detailed demographic characteristics on business owners and their motivations to start a business, as well as economic characteristics of their firms. Of particular importance for this chapter, it includes a rich set of innovation measures, which are the main outcome variables in our study.

The ASE sample contains nonfarm businesses with at least one paid employee and receipts of $1,000 or more. Using the Census Business Register (BR) as the sampling frame, the ASE sample is stratified by the 50 most populous Metropolitan Statistical Areas (MSAs), state, and the firm's number of years in business.[5] The ASE sample is randomly selected, except for large companies in each stratum, which are selected with certainty based on volume of sales, payroll, or number of paid employees. The initial 2014 ASE sample was about 290,000 employer firms, and the response rate was 74 percent.

For this chapter, we restrict the full ASE sample to firms in the high-tech sector as defined by the share of STEM employment in the industry.[6] This represents about 5.31 percent of firm-owner observations in the ASE. We also exclude businesses in which no individual owns at least 10 percent of the equity, because detailed owner information is not provided for such businesses. We drop owners who choose the same answers for every motivation question (all very important, all somewhat important, or all not important), because those answering patterns may not reflect the true intensity for each question, as well as firm-owner observations that have missing values for

5. See Foster and Norman (2016) for further details about the ASE.

6. We define *high-tech sector* based on the share of STEM employment in the industry using Bureau of Labor Statistics data; for the exact definition, see Goldschlag and Miranda (2016, 58).

any of the variables used in the regressions. Our final sample consists of about 11,000 owners of 7,400 firms. We weight each owner by their ownership equity share, adjusting them to sum up to one within each firm, and we weight each firm by ASE survey weights to make the sample representative for the US economy.

Our main variable of interest is an indicator for whether the owner is an immigrant, defined in the ASE as a noncitizen at birth.[7] As we examine the differences in the propensity to innovate between immigrant and native owners, we control for various other owner and firm characteristics. The owner demographic characteristics consist of gender, age, race and ethnicity, type of education, prior business experience, and veteran status. We also include the relationships among business owners in firms with multiple owners, whether they are couple-owned, noncouple family-owned, or multigenerational. Variable construction is similar to the procedures in Brown et al. (2018).

The ASE asks about nine different motivations for owning the business, including (1) "Best avenue for my ideas/goods/services" (*Ideas*); (2) "Opportunity for greater income/wanted to build wealth" (*Income*); (3) "Couldn't find a job/unable to find employment" (*No Job*); (4) "Wanted to be my own boss" (*Own Boss*); (5) "Working for someone else didn't appeal to me" (*Work for Self*); (6) "Always wanted to start my own business" (*Always Wanted*); (7) "An entrepreneurial friend or family member was a role model" (*Role Model*); (8) "Flexible hours" (*Flexible Hours*); and (9) "Balance work and family" (*Balance Family*). These questions ask how important the reason is: not important, somewhat important, or very important. In the descriptive statistics, we collapse the variables for a particular motivation into a single variable equaling 0 if not important, 1 if somewhat important, and 2 if very important, while in the regressions we include separate dummies for somewhat important and very important for each motivation.

In some specifications, we also use the amount of start-up capital and four-digit North American Industry Classification System (NAICS) industries as controls. The amount of finances used to start or initially acquire the business includes all sources: savings, other assets, and borrowed funds. Finance is expressed as ten categorical variables from less than $5,000 to $3 million or more, as well as "none needed" and "don't know."

Descriptive statistics for owner and firm characteristics are provided in table 6.1. Almost 20 percent of owners of high-tech firms are immigrants, which is higher than the shares of immigrants (defined as born noncitizen) in the general population, at about 13.0 percent; in the adult population, about 15.7 percent; and in self-employment, about 17.9 percent, based

7. This definition reflects a change in practice relative to previous surveys such as the SBO, which asked about birthplace (whether in the US). The difference is in people who were born outside the US but as citizens (i.e., because at least one parent was a citizen at the time). We nonetheless retain the conventional labels "immigrant" and "native" in our analysis.

Table 6.1 Descriptive statistics: demographic characteristics

Variables	All	Immigrant	Native
Immigrant	19.79	100.00	0.00
Race/ethnicity			
Hispanic	3.59	6.81	2.79
White (non-Hispanic)	80.55	33.58	92.14
Asian Indian (non-Hispanic)	7.93	36.46	0.89
Chinese (non-Hispanic)	2.72	10.38	0.83
Other Asian (non-Hispanic)	2.80	9.52	1.14
Other minority (non-Hispanic)*	2.41	3.25	2.20
Education			
Less than bachelor's degree	23.71	9.55	27.21
Bachelor's degree	43.55	37.20	45.11
Graduate degree	32.74	53.24	27.68
Observations	11,000	2,000	9,000

Note: These are percentages of owners by characteristics from the ASE high-tech sample. Non-Hispanic African Americans are included with "Other minority (non-Hispanic)" because the number of immigrants in this category is too small to disclose.

on our calculations from the 2014 Current Population Survey. The 20 percent of owners within high-tech firms is also higher than the 16 percent of immigrant owners in the full ASE sample that includes all industries and higher than Hart and Acs's (2010) estimate for their "high-impact" sample of high-tech firms, again 16 percent. But it is lower than that reported by Saxenian (2002) for immigrant ownership of high-tech firms in Silicon Valley at 24 percent, Wadhwa et al.'s (2007a, 2007b) estimate of 25 percent, and Kerr and Kerr's (2017) estimate of 24 percent. Each of these sources draws on different types of samples and definitions.

Table 6.1 shows the fraction of the owners in the sample having each characteristic and the fraction for immigrants and the native-born separately. We distinguish Hispanics and among non-Hispanics, whites, Asian Indians, Chinese, other Asians, and others. Among high-tech entrepreneurs, immigrants have a higher share than natives in the Hispanic, Asian Indian, Chinese, and other Asian populations. The largest difference is for Asian Indians, who account for 36 percent of all immigrant owners and only 1 percent of native owners.

Table 6.1 also shows differences in educational attainment. Immigrants are less likely to have only a bachelor's degree, and they are much less likely to have less than a bachelor's degree—only about one-third as likely as natives. But more than half of immigrant owners hold an advanced degree, and they are much more likely than natives—nearly twice as likely—to have graduate education.

Do immigrants differ from natives in their reported motivations for entrepreneurship? Table 6.2 contains the means of the motivation variables on a 0-1-2 scale, as discussed above, for the full sample and for immigrants and

Table 6.2 Descriptive statistics: motivations for owning the business

Variables	All	Immigrant	Native
Idea	1.49	1.51	1.48
Income	1.49	1.46	1.50
No job	0.10	0.14	0.09
Own boss	1.47	1.35	1.50
Work for self	0.90	0.79	0.92
Always wanted to own business	1.18	1.32	1.14
Role model	0.62	0.63	0.62
Flexible hours	1.26	1.21	1.27
Balance work/family	1.28	1.28	1.28
Observations	11,000	2,000	9,000

Note: These are means-of-motivation variables measured on a scale where 0 is not important, 1 is somewhat important, and 2 is very important.

Table 6.3 Descriptive statistics: start-up capital and firm age

Variables	All	Immigrant	Native
Finance			
No capital needed	10.73	9.27	11.09
Capital under 5k	26.35	31.05	25.19
5k to 10k	11.54	12.80	11.22
10k to 25k	14.06	14.98	13.83
25k to 50k	7.77	7.70	7.79
50k to 100k	6.75	5.73	7.00
100k to 250k	5.80	5.14	5.96
250k to 1m	3.50	3.85	3.42
1m to 3m	1.17	1.54	1.08
3m and more	0.50	0.72	0.45
Don't know start-up capital	11.84	7.21	12.98
Firm age			
Young (age <= 5)	39.66	50.50	36.99
Old (age > 5)	60.34	49.50	63.01
Observations	11,000	2,000	9,000

Note: These are the percentages of owners by characteristics from the ASE high-tech sample.

natives separately. Immigrant owners report a higher propensity to cite an inability to find a job as their motivation (although this motivation is uncommon for both groups in this high-tech sample), and a higher share of them say they have always wanted to own the business as a lifelong dream compared to natives. More relevant to innovation, immigrants have a slightly higher propensity to own the business because it is "the best avenue for their ideas, goods, or services." Overall, however, the differences in patterns of motivation appear slight.

Concerning the amount of start-up capital, table 6.3 shows that the

Table 6.4 High-tech industries: definition and composition

High-tech industry	Share of sample	Share of immigrants	Share of natives
Oil & Gas Extraction (2111)	2.29	D	D
Pharmaceutical & Medicine Manufacturing (3254)	0.54	17.63	82.37
Computer & Peripheral Equipment Manufacturing (3341)	0.39	D	D
Communications Equipment Manufacturing (3342)	0.44	D	D
Semiconductor and Other Electronic Component Manufacturing (3344)	1.01	18.41	81.59
Navigational, Measuring, Electromedical, & Control Instruments Manufacturing (3345)	1.38	16.94	83.06
Aerospace Product & Parts Manufacturing (3364)	0.32	D	D
Software Publishers (5112)	1.44	23.25	76.75
Wired Telecommunications Carriers (5171)	0.71	21.00	79.00
Other Telecommunications (5179)	0.94	D	D
Data Processing, Hosting, & Related Services (5182)	2.46	17.67	82.33
Other Information Services (5191)	2.17	17.27	82.73
Architectural, Engineering, & Related Services (5413)	39.07	12.19	87.81
Computer Systems Design & Related Services (5415)	43.67	28.55	71.45
Scientific Research & Development Services (5417)	3.18	23.18	76.82

Note: "D" means suppressed to ensure that no confidential information is disclosed.

immigrant-native differences exhibit a J-shaped relationship such that immigrants are slightly more likely to be in the lowest category of start-up capital and substantially more likely to be in the highest categories. Immigrants are 43 percent more likely than natives to have finances in the range $1–3 million, and for more than $3 million, they are 60 percent more likely.

We also consider firm age as a possible correlate of innovation behavior. Table 6.3 shows that immigrants typically own younger firms (here defined as five years or fewer since first hiring) than do natives. Just over half of the immigrant-owned high-tech firms started up within the previous five years, while 63 percent of the native-owned firms are older than five years.

Nearly three-quarters of the firms in this high-tech sample are in two four-digit NAICS industries: Architectural, Engineering, and Related Services (5413) and Computer Systems Design and Related Services (5415). As shown in table 6.4, immigrant-owned firms are disproportionately located in the latter and underrepresented in the former. No other industry accounts for as much as 3 percent of the sample, and the immigrant-native differences in all these other industries are small and statistically insignificant.[8]

Our outcome variables include detailed innovation, R&D, and intellectual property measures. The ASE asks whether the business conducted 12 different product or process innovation activities in the last three years (2012–14). We create a binary variable for innovation to indicate whether

8. While there are 15 four-digit high-tech industries, some sectors have too few observations for the results to be disclosed.

Table 6.5 Descriptive statistics: innovation measures

Variables	All	Immigrant	Native
Innovation activities			
Innovation dummy	69.39	72.01	68.74
Innovation count	3.58	3.89	3.50
Production innovation dummy	56.90	60.55	56.00
Process innovation dummy	60.30	61.61	59.98
R&D activities			
R&D activity (any type)	23.11	28.02	21.90
Work toward patent	13.40	16.98	12.52
Developed prototypes	13.29	17.18	12.34
Applied scientific/technical knowledge	11.16	15.26	10.14
Produced publishable findings	9.68	12.55	8.97
Created generalizable research	11.34	15.73	10.26
Work to discover scientific facts	6.02	9.27	5.22
Work to extend understanding of scientific fact	10.51	14.37	9.56
Intellectual property			
Copyright or trademark	20.03	16.79	20.83
Patent granted or pending	6.60	8.50	6.13
Observations	11,000	2,000	9,000

Note: These are the percentages of owners by innovation measures (except for innovation count) from the ASE high-tech sample.

a firm conducted any product or process innovation in the last three years. We also calculate an innovation count by summing the number of product and process innovation activities. We make binary indicator variables for each type of product and process innovation activities. Product innovations include (1) sold a new good or service that no other business has ever offered before; (2) sold a new good or service that this business has never offered before; (3) improved a good or service's performance by making changes in materials, equipment, software, or other components; (4) developed a new use for a good or service; (5) added a new feature to a good or service; and (6) made it easier for customers to use a good or service. Process innovations include (1) applied a new way of purchasing, accounting, computing, maintenance, inventory control, or other support activity; (2) reduced costs by changing the way a good or service was distributed; (3) upgraded a technique, equipment, or software to significantly improve a good or service; (4) made a significant improvement in a technique or process by increasing automation, decreasing energy consumption, or using better software; (5) decreased production costs by improving the materials, software, or other components; and (6) changed a delivery method to be faster or more reliable.

Table 6.5 shows means of these innovation activities. About 69 percent of firms report they conducted at least one innovation, and the average number of innovation types is 3.6 in our high-tech sample. Although not shown in the table, the most common product innovation is improving a good or service's performance (44.3 percent) and making it easier for customers to

use a good or service (41.7 percent); upgrading a technique, equipment, or software to significantly improve a good or service (50.9 percent) is the most frequent process improvement.

The ASE asks business owners whether their business carried out seven different R&D activities in 2014. We create an indicator for whether the business conducted any of these types of R&D. We also construct binary variables for each of the activities separately. We classify the following activities as "Applied R&D": (1) conducted work that might lead to a patent, (2) developed and tested prototypes that were derived from scientific research or technical findings, and (3) applied scientific or technical knowledge in a way that has never been done before. We classify "Basic R&D" as activities that (1) produced findings that could be published in academic journals or presented at scientific conferences; (2) created new scientific research or technical solutions that can be generalized to other situations; (3) conducted work to discover previously unknown scientific facts, structures, or relationships; and (4) conducted work to extend the understanding of scientific facts, relationships, or principles in a way that could be useful to others. In table 6.5, 23.1 percent of firms conducted at least one of these R&D activities in 2014, and the most frequent R&D activity is work that might lead to a patent. In general, the average rate of conducting R&D activities is lower than the innovation activities above.[9]

The last set of outcome variables concerns intellectual property. The ASE asks whether the business owns one or more of each of the following in 2014: copyright, trademark, patent (granted), and patent (pending). We use a dummy variable for owning either a copyright or a trademark and another for ownership of a patent granted or pending. Looking at table 6.5, about 20 percent of firms within the high-tech sector own a copyright or trademark, while less than 5 percent of firms own patents either pending or granted.

A striking result from table 6.5 is the consistently stronger innovation performance of immigrant-owned compared to native-owned firms. Immigrants are more likely to carry out 15 of the 16 measures of innovation. The exceptions are copyrights and trademarks, where native-owned firms have the advantage. Examining the statistical significance of these differences and how they change when other variables are taken into account are the subjects of the next sections.

6.3 Methods

We use the sample of owners and firms to estimate a series of regression models for each firm-level innovation outcome conditional on the owner's immigrant status. To take into account firms with multiple owners, we weight firm-owner observations by ownership shares. Given that the

9. The lower R&D propensity could be partly due to the fact that the R&D questions are about activity in just one year, while the innovation activities are over three years.

ASE is a random sample of employer businesses drawn from the BR, this implies our results are representative of the firm population. We use a linear probability model for binary innovation outcomes and a Poisson regression model for innovation count. Standard errors are clustered at the firm level. Our base specification is

$$Y_{ij} = \beta M_{ij} + f(Age_j) + u_{ij}, \quad (1)$$

where M_{ij} is an immigrant owner indicator for owner i of firm j. The dependent variables are each type of product innovation, process innovation, R&D activity, and intellectual property. Since businesses are of different ages and innovation may be correlated with firm age, in every specification (including the base), we control for a quadratic function of firm age, $f(Age_j)$. The coefficient on the immigrant owner indicator (β) captures the differences in innovation outcomes, essentially the raw gaps controlling only for firm age, between immigrant and native owners.

The purpose here is simply to describe differences in innovation behavior between immigrant and native owners. Just as in an analysis of gender differences in wages, for example, there is no issue of causality: we do not interpret the results as the impact of turning a random native into an immigrant (just as the interpretation placed on a female coefficient is not the impact of changing a male into a female). But it is also of interest to know whether there are observable differences that might account for the raw gap estimated by equation (1). For this purpose, we estimate another specification with owner characteristic controls as

$$Y_{ij} = \beta M_{ij} + f(Age_j) + X_{ij}\gamma + u_{ij}, \quad (2)$$

where X_{ij} is a vector of characteristics of owner i of firm j. The vector includes demographic variables (gender, age, and race/ethnicity), proxies for human capital (education, veteran, and prior business), and ownership team variables (size and family relationships). Arguably, these variables are predetermined with respect to innovation behavior. The β estimated from equation (2) is a measure of the innovation gap between native and immigrant owners adjusted for personal characteristics.

In addition, immigrants may differ from natives in ways that are less clearly exogenous and indeed may be jointly determined with innovation: motivations, start-up capital, and industries as shown in the following specification:

$$Y_{ij} = \beta M_{ij} + f(Age_j) + X_{ij}\gamma + Q_{ij}\alpha_Q + K_j\alpha_K + S_j\alpha_S + u_{ij}, \quad (3)$$

where Q_{ij} is the set of motivation variables, K_j is the set of vectors of the amount of start-up finance categories, and S_j is the set of vectors of four-digit NAICS industry dummies. Most small business owners start their businesses due to nonpecuniary motives with no intention to grow or innovate (Hurst and Pugsley 2011). Given the selection process to come to the US, immigrant owners may have different motivations to own their businesses, which may influence their innovation outcomes. The importance of access to finances

for business start-ups is well documented in the literature (e.g., Evans and Jovanovic 1989; Evans and Leighton 1989), and immigrant-owned businesses also tend to have higher start-up capital amounts than those owned by natives (Fairlie 2012). Higher start-up finances among immigrant owners may account for the differences in innovation outcomes between immigrant and native owners. Finally, immigrants may select into specific industries. Immigrants may be more or less likely to own businesses in industries with more innovation activities (e.g., certain parts of the high-tech sector), and this specification controls for this choice, comparing immigrants and natives within industries.

We also examine the heterogeneity of relative innovation performance of immigrant owners along three dimensions: education categories, race/ethnicity, and firm age. The literature on high-skilled immigrants (those with a bachelor's degree or higher) provides evidence that they are more likely to hold patents (e.g., Hunt and Gauthier-Loiselle 2010; Kerr and Lincoln 2010). However, the role of education in immigrant entrepreneurship has been less studied. We therefore examine heterogeneous innovation outcomes by owner education, distinguishing three groups: those with less than a bachelor's degree, those with a bachelor's degree, and those with advanced degrees.

Previous research has also examined immigrants by country of origin. Saxenian (2002) and Wadhwa et al. (2007a, 2007b) report higher shares of Indian and Chinese immigrants (Asian) in high-tech sectors, for example, showing an especially high share for Indians. Although the ASE does not ask for country of origin, we use race/ethnicity to reflect the region of origin. We distinguish Hispanics, and among non-Hispanics, whites, Asian Indians, Chinese, other Asians, and others.

Finally, we investigate whether the relative innovation performance of immigrant owners varies with the age of the firm. Although all specifications control for firm age, it is interesting to ask whether any immigrant advantage in innovation holds only during the early, entrepreneurial phase of a firm's development or also during more mature phases. For this purpose, we permit the immigrant owner coefficient to vary based on whether the firm is five or fewer years old or not.

The specification for heterogeneous immigrant contributions is

$$Y_{ij} = Z_{ij} M_{ij} \delta + f(Age_j) + X_{ij} \gamma + \varepsilon_{ij}, \tag{4}$$

where $Z_{ij} M_{ij}$ are the interaction terms between owner characteristics Z_{ij} (education categories, race/ethnicity, or firm age) and the immigrant indicator M_{ij} for owner i of firm j.

6.4 Results

Tables 6.6 and 6.7 display regression results for each measure of innovation using the three specifications described above: (1) base (no controls

Table 6.6 **Product and process innovation by immigrants**

Variables	Base	+ Demographics	+ Motivations, finance & industry
Innovation activities			
Innovation dummy	2.883	4.669	2.539
	(1.469)	(1.788)	(1.748)
Innovation count	0.090	0.146	0.081
	(0.031)	(0.036)	(0.036)
Product Innovation	3.488	6.438	3.055
	(1.588)	(1.921)	(1.870)
Process innovation	1.632	4.606	2.887
	(1.582)	(1.964)	(1.950)
Observations	11,000	11,000	11,000

Note: Results from LPM estimation of equation (1) at firm age 1. Coefficients and standard errors are multiplied by 100 for ease of reading. All regressions include firm age and age squared. The second column ("+ Demographics") includes demographic variables (gender, age, and race/ethnicity), proxies for human capital (education, veteran, and prior business), and ownership team variables (size and family relationships). The last column includes motivations from table 6.2, start-up finance from table 6.3, and four-digit NAICS industry dummies from table 6.4. Standard errors clustered by firm are in parentheses.

other than firm age), (2) adding demographic controls, and (3) adding motivations, finance, and industry controls. The different types of product and process innovation activities, including the dummy for any activity and the count of the number of activities are in table 6.6. Table 6.7 contains the different types of R&D as well as the intellectual property measures (copyright or trademark and patent granted or pending).

The results show that immigrant-owned firms have higher propensities to conduct product and process innovation as well as R&D activities. The inclusion of demographic controls generally raises the immigrant association with innovation activities, suggesting that immigrant owners tend on average to have other characteristics that are negatively associated with product and process innovation. Demographic controls attenuate the immigrant associations with R&D activities, however.

Differing motivations, levels of start-up capital, and/or choices of industry explain much of the immigrant association with innovation activities but not R&D activities, as evidenced by the significant attenuation of the immigrant coefficients when including those controls in the innovation activity regressions and more modest attenuation or even intensification when adding them to the R&D regressions.[10]

The immigrant effect is positive across all R&D activities, though after

10. In results not shown here, the effect varies considerably across innovation measures. It is especially strong for developing a new use for a good or service. Immigrants have a higher propensity to develop goods or services that no other firm offers but not goods or services that are new only to this firm. The former is a more radical form of innovation. Among process innovations, the immigrant association is insignificant for applying a new way to support

Table 6.7 R&D, copyright, trademark, and patents by immigrants

Variables	Base	+ Demographics	+ Motivations, finance & industry
R&D activity			
R&D activity (any type)	5.580	4.653	3.720
	(1.426)	(1.828)	(1.767)
Work toward patent	3.714	2.886	2.297
	(1.175)	(1.514)	(1.450)
Developed prototypes	4.729	3.885	3.169
	(1.180)	(1.565)	(1.492)
Applied scientific/technical knowledge	4.528	3.698	3.358
	(1.114)	(1.453)	(1.407)
Produced publishable findings	3.342	1.667	1.877
	(1.019)	(1.334)	(1.267)
Created generalizable research	4.772	4.102	3.654
	(1.122)	(1.451)	(1.399)
Work to discover scientific facts	3.749	2.754	3.009
	(0.895)	(1.150)	(1.103)
Work to extend understanding of scientific facts	4.574	3.062	3.346
	(1.084)	(1.405)	(1.341)
Intellectual property			
Copyright or trademark	–3.343	–0.150	–2.201
	(1.199)	(1.592)	(1.555)
Patent granted or pending	2.362	0.035	–0.330
	(0.858)	(1.051)	(1.009)
Observations	11,000	11,000	11,000

Note: Results from LPM estimation of equation (1) at firm age 1. Coefficients and standard errors are multiplied by 100 for ease of reading. All regressions include firm age and age squared. The second column ("+ Demographics") includes demographic variables (gender, age, and race/ethnicity), proxies for human capital (education, veteran, and prior business), and ownership team variables (size and family relationships). The last column includes motivations from table 6.2, start-up finance from table 6.3, and four-digit NAICS industry dummies from table 6.4. Standard errors clustered by firm are in parentheses.

adding controls, it becomes insignificant for producing publishable findings. Immigrant ownership is generally not associated with owning intellectual property, and the association is actually negative and significant in two of the three trademark specifications. The only positive and significant association is with patent pending in the specification without controls.

To investigate whether the immigrant advantage varies with firm age, we permit the immigrant indicator to vary with firm age in two categories: up to five years old and more than five years old. Regression estimates are shown in table 6.8. The propensity to engage in innovation activities is similar for both young and older firms owned by immigrants. The point estimates are

activity and upgrading a technique/equipment/software, while it is quite strong for increasing automation/using better software.

Table 6.8 Innovation by immigrants: firm age heterogeneity

Variables	Base	+ Demographics	+ Motivations, finance & industry
Innovation dummy			
Old × Immigrant	4.086	4.630	2.700
	(2.022)	(2.230)	(2.147)
Young × Native	3.982	1.099	1.298
	(1.308)	(1.379)	(1.342)
Young × Immigrant	5.385	4.518	3.530
	(2.032)	(2.393)	(2.341)
Innovation count			
Old × Immigrant	0.127	0.157	0.084
	(0.042)	(0.046)	(0.044)
Young × Native	0.105	0.004	–0.004
	(0.028)	(0.029)	(0.027)
Young × Immigrant	0.164	0.122	0.069
	(0.043)	(0.050)	(0.048)
R&D activity (any type)			
Old × Immigrant	8.592	7.051	5.337
	(1.968)	(2.211)	(2.117)
Young × Native	3.665	3.021	1.924
	(1.195)	(1.250)	(1.207)
Young × Immigrant	6.383	4.899	3.862
	(1.947)	(2.362)	(2.274)
Copyright or trademark			
Old × Immigrant	–2.572	–0.127	–2.165
	(1.719)	(1.965)	(1.938)
Young × Native	–2.186	–3.296	–3.780
	(1.142)	(1.187)	(1.147)
Young × Immigrant	–7.064	–4.577	–6.434
	(1.581)	(1.985)	(1.900)
Patents (granted or pending)			
Old × Immigrant	3.756	1.582	0.490
	(1.252)	(1.302)	(1.246)
Young × Native	0.464	0.848	0.284
	(0.684)	(0.709)	(0.675)
Young × Immigrant	1.336	–0.069	–0.951
	(1.099)	(1.331)	(1.235)
Observations	11,000	11,000	11,000

Note: Results from LPM estimation of equation (1) at firm age 1. Coefficients and standard errors are multiplied by 100 for ease of reading. All regressions include firm age and age squared. The second column ("+ Demographics") includes demographic variables (gender, age, and race/ethnicity), proxies for human capital (education, veteran, and prior business), and ownership team variables (size and family relationships). The last column includes motivations from table 6.2, start-up finance from table 6.3, and four-digit NAICS industry dummies from table 6.4. Standard errors clustered by firm are in parentheses.

Table 6.9a Innovation by immigrants: education heterogeneity

Variables	Base	+ Demographics	+ Motivations, finance & industry
Innovation dummy			
Below BA × Immigrant	6.834	6.655	3.921
	(4.056)	(4.003)	(3.809)
BA × Native	3.273	1.887	0.878
	(1.487)	(1.493)	(1.439)
BA × Immigrant	4.472	6.105	3.225
	(2.456)	(2.664)	(2.556)
Graduate × Native	4.681	4.089	2.181
	(1.664)	(1.684)	(1.639)
Graduate × Immigrant	6.288	7.503	4.405
	(2.155)	(2.468)	(2.428)
Innovation count			
Below BA × Immigrant	0.180	0.186	0.119
	(0.081)	(0.081)	(0.077)
BA × Native	0.119	0.087	0.068
	(0.033)	(0.033)	(0.030)
BA × Immigrant	0.081	0.150	0.070
	(0.053)	(0.058)	(0.056)
Graduate × Native	0.117	0.114	0.087
	(0.036)	(0.036)	(0.034)
Graduate × Immigrant	0.241	0.302	0.218
	(0.045)	(0.051)	(0.049)
Observations	11,000	11,000	11,000

Note: Results from LPM estimation of equation (1) at firm age 1. Coefficients and standard errors are multiplied by 100 for ease of reading. All regressions include firm age and age squared. The second column ("+ Demographics") includes demographic variables (gender, age, and race/ethnicity), proxies for human capital (education, veteran, and prior business), and ownership team variables (size and family relationships). The last column includes motivations from table 6.2, start-up finance from table 6.3, and four-digit NAICS industry dummies from table 6.4. Standard errors clustered by firm are in parentheses.

higher for immigrant-owned older firms for R&D activities and ownership of intellectual property. Among native-owned firms, the propensity to conduct R&D activities is higher for young firms, but for innovation activities, a positive young firm effect disappears once adding controls, and differences are insignificant for intellectual property ownership. Both immigrant-owned firm age categories exhibit higher propensities to engage in innovation and R&D than either native-owned firm age categories across most specifications, while differences are generally insignificant for intellectual property ownership. These results suggest the immigrant advantage is maintained or even increases with firm age.

Regarding variation in the immigrant effect with educational attainment, we specify the equation so that the reference category is natives with less than a bachelor's degree. As shown in table 6.9, the propensity to carry

Table 6.9b **R&D, copyright, trademark, and patents by immigrants: education heterogeneity**

Variables	Base	+ Demographics	+ Motivations, finance & industry
R&D activity (any type)			
Below BA × Immigrant	6.141	5.916	5.498
	(3.662)	(3.762)	(3.747)
BA × Native	4.738	4.037	2.988
	(1.164)	(1.178)	(1.145)
BA × Immigrant	3.350	6.395	4.245
	(2.011)	(2.376)	(2.261)
Graduate × Native	16.89	15.62	11.94
	(1.473)	(1.485)	(1.429)
Graduate × Immigrant	19.86	21.76	17.27
	(2.099)	(2.432)	(2.328)
Copyright or trademark			
Below BA × Immigrant	2.493	3.522	1.435
	(3.337)	(3.398)	(3.241)
BA × Native	5.151	4.248	3.049
	(1.190)	(1.192)	(1.142)
BA × Immigrant	–2.528	2.411	–0.421
	(1.725)	(2.043)	(1.998)
Graduate × Native	10.46	9.201	7.876
	(1.423)	(1.425)	(1.375)
Graduate × Immigrant	4.867	8.811	5.640
	(1.803)	(2.151)	(2.091)
Observations	11,000	11,000	11,000

Note: Results from LPM estimation of equation (1) at firm age 1. Coefficients and standard errors are multiplied by 100 for ease of reading. All regressions include firm age and age squared. The second column ("+ Demographics") includes demographic variables (gender, age, and race/ethnicity), proxies for human capital (education, veteran, and prior business), and ownership team variables (size and family relationships). The last column includes motivations from table 6.2, start-up finance from table 6.3, and four-digit NAICS industry dummies from table 6.4. Standard errors clustered by firm are in parentheses.

out any product or process innovation activity is increasing in education for native-owned firms, but not immigrant-owned firms. For innovation count, there is a higher association with innovation for native-owned firms where the owner has at least a bachelor's degree, but there is little difference between bachelor's and advanced degrees. The coefficients exhibit a U-shape with educational attainment for immigrant-owned businesses. Firms with advanced-degree immigrants have the highest innovation count propensities and those with less-than-bachelor's-degree natives have the lowest. Having a graduate degree is strongly associated with R&D activity for both native- and immigrant-owned firms, and the immigrant effects within the graduate degree category are larger. For copyrights and patents, it is firms with native owners with graduate degrees that distinguish themselves. Across all innova-

Table 6.10a Innovation by immigrants: race heterogeneity

Variables	Base	+ Demographics	+ Motivations, finance & industry
Innovation dummy			
Hispanic × Immigrant	–1.417	–1.955	–1.735
	(5.235)	(5.119)	(4.932)
White × Immigrant	6.816	6.111	4.101
	(2.135)	(2.162)	(2.088)
Asian Indian × Immigrant	0.474	–0.320	–4.872
	(2.394)	(2.478)	(2.488)
Chinese × Immigrant	5.087	4.170	0.628
	(4.126)	(4.053)	(4.047)
Other Asian × Immigrant	–0.819	–1.831	–3.927
	(4.428)	(4.437)	(4.222)
Other Minority × Immigrant	1.046	0.249	–4.786
	(7.565)	(7.353)	(7.141)
Innovation count			
Hispanic × Immigrant	0.031	0.017	0.014
	(0.113)	(0.106)	(0.100)
White × Immigrant	0.217	0.204	0.132
	(0.042)	(0.042)	(0.041)
Asian Indian × Immigrant	0.008	–0.025	–0.172
	(0.052)	(0.053)	(0.051)
Chinese × Immigrant	0.143	0.133	0.024
	(0.088)	(0.084)	(0.081)
Other Asian × Immigrant	–0.079	–0.108	–0.156
	(0.092)	(0.090)	(0.089)
Other Minority × Immigrant	–0.056	–0.072	–0.238
	(0.174)	(0.165)	(0.170)
Observations	11,000	11,000	11,000

Note: Results from LPM estimation of equation (1) at firm age 1. Coefficients and standard errors are multiplied by 100 for ease of reading. All regressions include firm age and age squared. The second column ("+ Demographics") includes demographic variables (gender, age, and race/ethnicity), proxies for human capital (education, veteran, and prior business), and ownership team variables (size and family relationships). The last column includes motivations from table 6.2, start-up finance from table 6.3, and four-digit NAICS industry dummies from table 6.4. Standard errors clustered by firm are in parentheses.

tion measures, the immigrant advantage is generally largest for owners with less than a bachelor's degree.

Finally, we use race and ethnicity to examine differences in the immigrant innovation advantage across the region of origin. Results with white natives as the reference group are shown in table 6.10. Sample sizes get thin, so results are less precisely estimated. One striking result is that firms owned by Asian Indians, despite their high prevalence in the sample, tend to produce less of all types of innovation when full controls are included.

Table 6.10b **R&D, copyright, trademark, and patents by immigrants: race heterogeneity**

Variables	Base	+ Demographics	+ Motivations, finance & industry
R&D activity (any type)			
Hispanic × Immigrant	1.493	–0.645	1.376
	(4.612)	(4.575)	(4.290)
White × Immigrant	12.99	9.360	8.009
	(2.329)	(2.291)	(2.184)
Asian Indian × Immigrant	–0.457	–4.143	–5.077
	(2.175)	(2.185)	(2.160)
Chinese × Immigrant	13.54	7.047	3.559
	(4.441)	(4.287)	(3.892)
Other Asian × Immigrant	–2.030	–3.537	–5.770
	(3.636)	(3.521)	(3.112)
Other Minority × Immigrant	–0.107	–3.195	–6.906
	(6.737)	(6.292)	(6.233)
Copyright or trademark			
Hispanic × Immigrant	–4.912	–6.061	–5.087
	(3.841)	(3.797)	(3.843)
White × Immigrant	4.280	2.592	–0.095
	(2.097)	(2.064)	(1.975)
Asian Indian × Immigrant	–9.049	–10.02	–11.94
	(1.625)	(1.685)	(1.784)
Chinese × Immigrant	0.486	–2.116	–4.284
	(3.749)	(3.672)	(3.578)
Other Asian × Immigrant	–8.466	–9.400	–9.797
	(2.863)	(2.766)	(2.636)
Other Minority × Immigrant	D	D	D
Observations	11,000	11,000	11,000

Note: Results from LPM estimation of equation (1) at firm age 1. Coefficients and standard errors are multiplied by 100 for ease of reading. All regressions include firm age and age squared. The second column ("+ Demographics") includes demographic variables (gender, age, and race/ethnicity), proxies for human capital (education, veteran, and prior business), and ownership team variables (size and family relationships). The last column includes motivations from table 6.2, start-up finance from table 6.3, and four-digit NAICS industry dummies from table 6.4. Standard errors clustered by firm are in parentheses. "D" means suppressed to ensure that no confidential information is disclosed.

6.5 Conclusion

Much of the research on immigration assumes that natives and immigrants are similar factors in production, in various cases conditional on geographical region, education, and experience. An influx of immigrants is analyzed as a labor supply shock to the region or the skill group. Another large and long-standing body of research focuses on the difficulties immigrants face in adjusting to their new environments, measuring rates of

"assimilation," usually defined as the degree of convergence to otherwise similar native workers.

A much smaller literature takes a different approach, treating immigrants as potentially advantaged rather than either similar or disadvantaged relative to natives. Much of this research has focused on individual immigrants in science, the STEM workforce, and entrepreneurship. With some variation, the results suggest disproportionate contributions to some measures of innovation, with immigrants more likely to hold patents, work in STEM fields, achieve high citation indices, and receive Nobel Prizes (Hunt 2011; Kerr 2013; Kahn and MacGarvie 2016). One interpretation of these results is that immigrants self-select from the right tail of the ability distribution and perhaps that the distribution has a fatter right tail than that of natives (Kahn et al. 2017).

Our premise is similar to this literature, asking whether immigrants tend to be more innovative than natives. But our focus is on firms founded and operated by immigrants in comparison to those owned by natives. There has been a lot of "hype" about immigrant entrepreneurs in the US high-tech sector but relatively little evidence on the extent to which they contribute disproportionately to innovation. This chapter provides such evidence, drawing on a large representative sample of high-tech businesses and using detailed information on owner characteristics, motivations, and start-up capital, as well as an extensive set of innovation measures. We focus on the high-tech sector because of its prominence in US growth.

The results suggest higher innovation activities by immigrants for nearly all the innovation measures we are able to analyze. The measures range from detailed product and process innovation, to several forms of R&D, to intellectual property rights associated with innovation, including patents. The only measures where immigrants have notably lower performance compared with natives are for copyrights and trademarks.

Immigrant entrepreneurs tend to be much better educated than their native counterparts in the high-tech sector on average, but the immigrant advantage persists when we control for education and other owner characteristics, and we find an immigrant advantage at all levels of education, again with the exception of copyright or trademark. Immigrant entrepreneurs also tend to operate younger firms, and while we find firm age is negatively correlated with innovation, again the immigrant advantage exists when we control for firm age (as we do in all specifications). Moreover, we find an immigrant advantage in innovation for both younger and older firms.

Future research could expand on these findings by broadening both the population under consideration and the set of outcome variables to be analyzed. A sample including other industries could shed light on the relative innovativeness of immigrant entrepreneurs outside of the high-tech sector. Rather than confining attention to the nativity of individual owners, the

analysis could be extended to the possible effects of combining immigrant and native human capital within entrepreneurial teams. Finally, the roles of immigrant entrepreneurs in job creation and productivity growth could be examined in a broader assessment of the contributions of immigrants to innovative entrepreneurship in the US. We hope to report our findings on these issues in the near future.

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