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Lessons for U.S. Metro Areas: Characteristics and Clustering of High-Tech Immigrant Entrepreneurs [1]

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EXECUTIVE SUMMARY

Immigrant-owned enterprises are an increasingly important part of the U.S. economy. According to the most recent data, 18 percent of small business owners in the United States are immigrants. In addition to growth in the broader economy, immigrant entrepreneurship in the high-tech sector has grown rapidly. Evidence from this study suggests that immigrants now comprise 20 percent of the high-tech workforce and 17.3 percent of high-tech entrepreneurs. This is an increase from 13.7 percent and 13.5 percent, respectively, in 2000. Immigrant entrepreneurs in the high-tech sector are more concentrated in particular industries and in a smaller number of metropolitan areas than are other high-tech entrepreneurs. This study finds that the foreign-born labor force in high-tech industries is most concentrated in sectors such as semiconductor, other electronic component, magnetic, and optical media, communications, audio/video equipment, and computer science-related sectors. This study also finds that 80 percent of immigrant high-tech entrepreneurs are concentrated in the largest twenty-five metropolitan areas, in contrast to 57 percent of the U.S.-born population.

In addition to documenting the growth of high-tech entrepreneurship among immigrants and documenting the spatial and industry concentration of these entrepreneurs, this study also tests which factors are associated with high-tech entrepreneurs' choices to locate in particular metropolitan areas and their choices of where to locate within a metropolitan area. This study finds that both immigrant and U.S.-born high-tech businesses are more likely to locate within regional labor markets that have an overall higher percentage of high-tech industries. Immigrant high-tech businesses are less likely to be in places with higher unemployment rates, but the presence of other industries is not predictive of their residential location. Unlike the U.S.-born, higher ethnic diversity and a larger share of the foreign-born population are important factors in attracting or fostering immigrant high-tech entrepreneurship on the metropolitan level. Finally, this study finds that the occupation of residents within a metropolitan area is more predictive of the residential location of immigrant high-tech entrepreneurs than is the immigrant status of the community residents.

INTRODUCTION

Immigrant-owned enterprises are a vibrant component of the U.S. economy (Fairlie, 2012; FPI, 2012; Saxenian, 1999; Wadhwa et al., 2007). According to the most recent data, 18 percent of small business owners in the United States are immigrants. Furthermore, immigrants are more likely to be small business owners than are U.S.-born individuals (Fairlie, 2012). These businesses employed an estimated 4.7 million people, generating an estimated $776 billion in receipts in 2007 (FPI, 2012). In knowledge-based industries in particular, immigrants also are playing a vital role. Hart et al. (2011) found that about 16 percent of their national sample of "high-impact" companies in high-tech industries has at least one immigrant entrepreneur among the funding teams. In San Francisco's Silicon Valley, 24 percent of all high-technology firms in 1998 were run by Chinese or Indian immigrants (Saxenian, 1999), and that share rose to 43.9 percent between 2006 and 2012. Nationwide, 25.3 percent of the

engineering and technology companies established between 1995 and 2005 had at least one immigrant key founder. In 2005, these immigrant-founded companies collectively generated roughly $52 billion in sales and employed 450,000 workers (Wadhwa et al., 2007).[2] Kerr (2008) notes the substantive increase of U.S. patents by ethnic inventors between 1975 and 2004, especially in high-tech industries like computers and pharmaceuticals.

The spatial pattern of immigrant entrepreneurs and businesses is not even across the United States. Urban economics has highlighted the effect of agglomeration among firms, suggesting that agglomeration benefits could be especially evident among the high-skilled, small businesses, and high-tech industries given knowledge spillovers and scientific exchanges (Combes, Duranton, and Gobillon, 2010). While there are some studies in recent years on the clustering of manufacturing firms (Glaeser, Kerr, and Ponzetto, 2010) and on the intensity of agglomeration among female entrepreneurs (Rosenthal and Strange, 2012), no study has specifically examined the agglomeration patterns of immigrant entrepreneurship. Given the residential concentration of immigrants among metropolitan areas in both traditional and emerging destinations (Singer, 2004), we would expect a high degree of clustering among immigrant entrepreneurs, especially those in high-tech industries. It is hard to predict, however, whether residential clustering or industrial clustering would play a larger role in the generation of agglomeration economies.

This study will address the following questions:

- What are the characteristics of immigrant business owners in high-tech industries?
- How are immigrant business owners spatially distributed in the regional economy?
- What are the potential factors that shape the residential patterns of immigrant entrepreneurs across metropolitan areas?

LITERATURE REVIEW

Immigrant High-Tech Entrepreneurship and Agglomeration

Industrial agglomeration is a well-studied phenomenon in urban economics, beginning with the seminal theoretical developments of Marshall (1920), Arrow (1962), and Romer (1986). Firms within the same industry locate close to each other in order to benefit from knowledge transfer, intellectual spillovers, labor market pooling, and resource sharing, as well as other network effects of scale economy. Such geographic proximity and industrial concentration foster economic growth and higher productivity. Subsequent empirical studies have tried to identify the causes, scale, and benefits of industrial clustering, and have found that labor pooling has the most robust effect on agglomeration economies on both the metropolitan and sub-metropolitan levels, while knowledge spillovers positively affect agglomeration economies only at the zip-code level (Rosenthal and Strange, 2003). Entrepreneurship, measured as new firm entry,

[2] More recent data show that immigrant high-tech entrepreneurship stagnated after 2005 (Wadhwa et al., 2012).

also shows spatial clustering: higher in cities with overall smaller business size and more small suppliers, lower entry costs, and more entrepreneurial people and relevant workers (Glaeser, Kerr, and Ponzetto, 2009; Glaeser and Kerr, 2009). Despite the fact that much of the empirical work on agglomeration uses manufacturing firms in its analysis, agglomeration benefits are arguably higher among the high-skilled and high-tech industries given their reliance on knowledge spillover and scientific exchanges (Combes, Duranton, and Gobillon, 2010).

High-technology industries are highly concentrated in a number of metropolitan areas in the United States, identified as "tech poles" by Milken Institute's reports on the geography of nineteen knowledge-based industries (DeVol and Wong, 1999; DeVol et al., 2009). Combining employment concentration with patent activity and venture capital flows, Cortright and Mayer's (2001) detailed analysis of fourteen U.S. technology centers shows each metropolitan area tends to specialize in relatively few products or technologies. Cities and communities act as incubators of creativity and innovation as the economic, social, and policy context can shape the entrepreneurial environment and facilitate or inhibit entrepreneurial entry (Lee, Florida, and Acs, 2004). Industrial intensity, unemployment rate, and market access, among others factors, have been identified as important determinants of regional variations in firm formation (Armington and Acs, 2002), and a booming service economy also is associated with growth in self-employment (Hipple, 2004). The growth rate of incorporated self-employment is three times higher for persons with college degrees and higher, as compared to those with less than high school degrees (Hipple, 2004). Thus, a creative and diverse social environment, one that is open, tolerant, and creative, attracts human capital and produces high levels of innovation and entrepreneurship on state (Qian and Stough, 2011) and metro levels (Hackler and Mayer, 2008).

Evidence suggests that immigrants have higher self-employment rates than comparable native-born populations do (e.g., Borjas, 1986; Yuengert, 1995), though variations exist across racial and ethnic groups and national origins (Fairlie and Meyer, 1996; Lofstrom and Wang, 2007). Immigrant entrepreneurs' contributions are particularly pronounced in the high-technology sector, a sector that is strategically important for the long-term growth of the national economy. Of all the high-impact, high-tech firms surveyed by Hart and Acs (2011), 16 percent report having at least one immigrant entrepreneur among their owners. This is in accordance with the over-representation of foreign-born workers in the U.S. science and engineering fields in general (Stephan and Levin, 2001). These immigrant high-tech enterprises are likely to be spatially concentrated, as well, given the overall agglomeration of the high-tech industry and the fact that many entrepreneurs spin off from existing firms. Saxenian's detailed descriptions of the emergence of Chinese and Indian immigrant entrepreneurs in Silicon Valley, which together accounted for 24 percent of high-tech startups in 1998, testified to the importance of spatial clustering and network effect in this industry (Saxenian, 1999). Such concentrations also are identified in other parts of the country, including Boston's Route 128 (Saxenian, 1994) and North Carolina's Research Triangle Park (Wadhwa et al., 2007). Patent data also demonstrate that innovations filed by U.S. ethnic inventors agglomerate at a much higher level than their non-ethnic counterparts do, with the top

five Metropolitan Statistical Areas (MSAs) hosting 45 percent of such patents in the 2000s (Kerr, 2008).

Even though these firm-level analyses hint at the spatial agglomeration of immigrant high-tech entrepreneurs, no study, to our knowledge, has systematically examined their spatial patterns across metropolitan areas on the national level and through the lens of their residential location choices. Immigrant high-tech entrepreneurs' residential location choices might be shaped by the same types of factors affecting other immigrants, but also may be embedded in some different sets of socio-economic and politico-institutional environments in the host communities unique to entrepreneurs (Kloosterman, van der Leun, and Rath, 1999).

Immigrant Location Choice

Though immigrants historically have concentrated in a few gateway coastal cities, an emerging body of research has documented their changing settlement patterns from established gateway metropolitan areas to new and emerging gateways (Singer, Hardwick, and Brettell, 2008; Lichter and Johnson, 2009; Painter and Yu, 2010). Singer (2004) classified metropolitan areas into six major types of U.S. immigrant "gateways" by their historical and current immigrant trends—former gateways, continuous gateways, post-World War II gateways, emerging gateways, re-emerging gateways and pre-emerging gateways—and found that the newly emerging gateways experienced rapid foreign-born population growth, while the more established gateways saw slower percentage growth. While many factors underlie such location choices, Baird et al.'s (2008) inter-metropolitan-level analysis demonstrates that economic and quality of life factors play a more critical role than ethnic networks factors do in immigrants' inter-metropolitan settlement patterns.

Ethnically concentrated communities provide immigrant entrepreneurs with stable consumer bases for ethnic goods, recruitment channels for ethnic suppliers and workers, easy access to credit and capital, and role models in business startup (Aldrich and Waldinger, 1990; Zhou, 2004). All these are essential for nascent entrepreneurs to mobilize resources and establish businesses. However, some caution that, rather than enhancing business opportunities, a high degree of residential segregation may create an unfavorable entrepreneurial environment due to the location of job growth in other parts of the metropolitan area (Painter, Liu, and Zhuang, 2007), especially when combined with poverty concentration (Fischer and Massey, 2000). Economic structures, especially factors noted in the earlier section regarding industrial composition, economic scale, human capital, and innovation capacity also are deemed important. Wang (2010) found that metropolitan labor market characteristics, especially macroeconomic conditions and overall business structure, significantly influence self-employment patterns. It is uncertain whether immigrant networks or industrial networks will play a more dominant role in the agglomeration of immigrant high-tech entrepreneurs.

One of the very few direct empirical tests of this question is by Dahl and Sorenson (2009). They found that, in choosing where to locate their new ventures, entrepreneurs

in Denmark place a greater emphasis on being close to family and friends than on regional characteristics. Their analysis did not single out immigrants, so we do not know whether the same preference between social and economic factors applies to immigrant entrepreneurs. Kerr's (2008) analysis using patent data in the United States suggests that the ethnic inventors weigh the benefits of being close to other inventors of one's ethnicity over that of being in ethnic concentrations.

It is worth noting that, while much of this discussion concerns choice across metropolitan areas, the spatial distribution of immigrant entrepreneurs may not be even within metropolitan areas, as both industrial agglomeration and residential concentration occur on smaller geographic scales (Stuart and Rosenthal, 2003; Logan, Stults, and Farley, 2004). Recent years witnessed the emergence of ethnic communities of various socioeconomic status in both central city and suburban areas (Logan, Alba, and Zhang, 2002; Liu and Painter, 2012b). These communities would feature different levels of resource provision for aspirant ethnic entrepreneurs, especially when interacted with the larger metropolitan spatial and economic structures.

While ethnic communities could act as natural incubators for prospective entrepreneurs (Green and Butler, 1996), few studies to date have incorporated spatial, economic, and social contexts on the intra-metropolitan level in analyzing the incidence of self-employment among the immigrant populations. In their analysis of the spatial distribution of ethnic businesses in multi-ethnic Toronto, Fong et al. (2007) argued that the spatial distribution of ethnic businesses across central city and suburban communities are dependent on four local conditions: the proportion of recent immigrants, the number of small businesses, the proportion of manufacturing and retail businesses, and the presence of ethnic malls. In an intra-metropolitan analysis of Atlanta, Liu (2012) found that communities with both higher concentrations of trade industries and higher ethnic populations increase the likelihood of self-employment for Asian and Latino immigrants. Our analysis will extend these limited case studies by providing a systematic view of intra-urban dynamics within all metropolitan areas in the United States.

DATA AND METHODOLOGY

Data

The primary data in this research are derived from the Decennial Census 2000 and American Community Survey 2007–2011 combined sample (referred to as the 2011 sample). Drawing from these two time periods enables the assessment of immigrant high-tech entrepreneurship growth trends over the last decade. Entrepreneurs are defined as those who are self-employed by the "class of worker" question. While it is true that not all self-employed workers are entrepreneurs, Aldrich and Waldinger (1990) argue that it is not clear how to distinguish "entrepreneurs" from the "self-employed." Thus, immigrant entrepreneurs frequently are operationalized as self-employed immigrants in empirical analysis, especially those utilizing census household survey data (e.g., Fischer and Massey, 2000, Wang and Li, 2007). Even though there is debate

about how well self-employment captures entrepreneurial activities, this study provides the first contribution to the literature on immigrant entrepreneurs in high-tech sectors with a nationally representative sample.

We will conduct analyses on both the inter- and intra-metropolitan levels in order to determine the factors that correlate with the residential choice of one metropolitan area or another and the particular choice of location within the metropolitan area. Both tests are important because we desire to determine how neighborhood characteristics influence location choice. We use the Census-defined Metropolitan Statistical Areas (MSAs) as the unit of analysis when investigating how various characteristics influence the choice of residential location. When studying intra-metropolitan moves, we use Public Use Microdata Areas (PUMAs) as the unit of analysis. PUMAs have been used frequently as the geographic unit for intra-metropolitan analysis in employment research in general. Though PUMAs are relatively large, statistically designated places with more than 100,000 people, each PUMA usually encompasses one or multiple nuclei cities or identifiable communities, and thus serve as good proxies for local labor and housing markets.

Definition of High-Tech Industries

There exist different ways of defining high-tech immigrant entrepreneurship. It can be defined by industry (Saxenian, 1999; Cortright and Mayer, 2001; Wadhwa et al., 2007; DeVol et al., 2009), by occupation (Saxenian, 1999) and by education and skill level. In our study, we will adopt the definition developed by Milken's high-technology economy report (DeVol et al., 2009), which classifies high-tech firms by the new North American Industry Classification System (NAICS) codes instead of old Standard Industrial Classification (SIC) codes. This characterization makes the distinction between high-tech manufacturing industries and high-tech service industries. A detailed list is provided in Appendix A.

Model Specification and Variables

In addition to descriptive statistics that show the general trends, demographic, industrial, and geographic distribution of immigrant high-tech entrepreneurship, we conduct a series of regression analyses. First, we test the association between the number of high-tech entrepreneurs in 2011 and a set of metropolitan characteristics from 2000 to determine the correlates of metropolitan location choice, separately for the foreign-born and the U.S.-born. Immigrant high-tech entrepreneurs are assessed across two broad industrial groupings: (1) pharmaceutical and medicine manufacturing and services ("medical"—NAICS codes 3254, 3391, 6215, and 5417) and (2) high-tech manufacturing industries in computer equipment, communication, and electronic engineering, and high-tech services in telecommunication, computer system design, Internet services, and other related industries ("information technology, or IT"—NAICS codes 3341, 3346, 52212-5121, 517, 518, 5191, 5415, and 5417). The selection of industries is based on earlier studies that have identified different industrial location choices among the high-tech industries. For example, Cortright and Mayer (2001) found

that high-tech employment is concentrated in only a few industry segments. Metropolitan areas that show high concentrations of high-tech employment in one technology might show very low concentrations in another technology. Finally, we test the association between the growth of high-tech entrepreneurs between 2000 and 2011 and the same metropolitan area-level characteristics in 2000 to capture the change over time. The growth is measured by both the change of absolute number and of the normalized rate (per 10,000 labor force).

In this research, we are particularly interested in two sets of contextual factors measured at the metropolitan area level: demographic composition and the high-tech industrial mix. To gauge the impacts of demographic dynamics, we use the share of the foreign-born population in the total population, as well as ethnic diversity. Due to a high correlation between the share of the foreign-born population and the total number of immigrant high-tech entrepreneurs in each MSA, we use the share of the foreign-born population in 1970 to address such contemporaneous endogeneity. This approach has been adopted by previous studies that use past immigration patterns to predict current settlement locations (e.g., Card and DiNardo, 2000; Patridge et al., 2009). There also exist different ways to measure ethnic diversity. Following earlier literature (Alesina, Spolaore, and Wacziarg, 2000; Rupasingha, Goetz, and Freshwater, 2002), we use the ethnic fractionalization index to measure ethnic diversity at the metropolitan area level.[3] This index indicates the probability that two randomly drawn individuals from a metropolitan area belong to different ethnic groups.

To capture the regional base of high-tech industries and innovation capacity, we include the percentage of high-tech industries, producer service industries, labor force with at least a bachelor's degree, and total number of patents. Due to the high correlation among them, we conduct principal component factor analyses to create a comprehensive index.[4] A higher value of this index indicates higher values in all of the four aforementioned aspects, and thus a more conducive environment for high-tech industries and a higher capacity of innovation. In addition, we include other metropolitan area-level variables that measure economic, social, and demographic characteristics and innovation capacity: (1) the unemployment rate to capture the overall economic conditions, (2) the incorporation rate (defined as the number of incorporated self-employment divided by the total number of the self-employed) to measure regional economic dynamics and an overall entrepreneurial environment, and (3) the industrial structure that includes share of manufacturing, construction, trade, and social services. The identification of these variables are based on previous studies which find that industrial intensity, unemployment rate, population diversity, human capital, and market access, among others factors, are important determinants of regional variations in firm formation (Armington and Acs, 2002; Lee, Florida, and Acs, 2004). A detailed listing of variables is provided in Appendix B.

[3] The calculation is given by $\text{Index}=1-\sum(\text{Race}_i)^2$ where Race_i denotes the share of population as of race $i \in I=\{\text{non-Hispanic white, black, Asian, and Hispanics}\}$. A higher value of the index is associated with higher diversity of the ethnic composition of the population.

[4] Factor analysis statistics are available upon request.

Next, we conduct PUMA-level regressions, which test the effect of a series of demographic, economic, and cost-of-living variables on intra-metropolitan immigrant high-tech entrepreneur location choice. The dependent variable in these models is the share of MSA immigrant high-tech entrepreneurs in a particular PUMA. Following Liu and Painter (2012a), each independent variable is calculated either as the PUMA share of MSA (immigrants, manufacturing, construction, high-tech, trade, and producer services workers) or as an index value by dividing the PUMA's value by the average value among PUMAs of the same MSA (unemployment rate, college graduate rate, and median housing value). This approach is intended to capture the intra-metropolitan variation in locational amenities that underlie locational distributions, but not the variation across MSAs.

RESULTS

1. Overview: National Origin and Industrial Distribution of Immigrant High-Tech Entrepreneurs

According to the 2007–2011American Community Survey (ACS), immigrant workers constitute about 19.9 percent of the total high-tech workforce, higher than their share in the total labor force across all industries, 17.1 percent. In 2000, immigrants' share in high-tech industries was 16.7 percent, and their overall labor force share was 15.1 percent. Though sampling schemes have changed between 2000 census and subsequent ACS, results indicate a steady increase of immigrants' participation in high-tech industries commensurate with their increasing share in the U.S. population. Among the immigrant labor force in the high-tech industries, about 6.2 percent are self-employed in years 2007–2011 and 5.5 percent for year 2000.

Table 1 presents the total number of immigrants in the labor force, the number in self-employed labor force in high-tech industries for all the foreign-born, U.S.-born, and top ten countries of origin in high-tech industries, from 2000 to 2011 (five-year average). The immigrant labor force in high-tech industries grew much faster than the U.S.-born labor force did—37.2 percent versus 10.7 percent. The self-employed in high-tech industries for the foreign-born grew even faster, with a rate of 64 percent, compared to 22.6 percent for the U.S.-born. For both time periods, half of the self-employed immigrants in high-tech industries are incorporated, a higher rate than that of the native-born labor force.

Among the top ten countries that have the largest immigrant labor force in the high-tech industries, there is a significant variation in the rate of self-employment and its growth over time. From 2007–2011, the national rate of self-employment in high-tech industries is 6.2 percent. The rate is around 2 percent to 3 percent for immigrants from Vietnam, Mexico, and Philippines, and 9 percent to 10 percent for immigrants from England, Iran, and Canada. Since the beginning of the new century, the total number of the self-employed labor force in high-tech industries experienced significant growth in immigrants from Columbia, China, India, Korea, and Vietnam, but stagnant growth for countries like Iran, England, Mexico, Germany, and Cuba.

Table 1. High-Tech Labor Force and Entrepreneurs by Nativity Status and National Origin, 2000–2011

	All High-Tech Workforce			All High-Tech Entrepreneurs			Incorporate Rate	
	2000	2011	(% change)	2000	2011	(% change)	2000 (%)	2011(%)
All	9005136	10363424	15.1	499654	640425	28.2	44.8	46.7
U.S.-born	7.504.414	8.304.939	10.7	432196	529792	22.6	43.9	45.8
Foreign-born	1500.722	2.058.485	37.2	67458	110633	64.0	50.5	50.9
Share	16.7%	19.9%		13.5%	17.3%			
Mexico	136437	169330	24.1	3794	4736	24.8	37.2	32.9
Vietnam	106164	115024	8.3	1458	2893	98.4	52.7	50.0
China	89542	136006	51.9	2814	4491	59.6	51.5	50.3
India	168896	339518	101.0	5249	12018	129.0	72.4	71.6
Philippines	99188	136112	37.2	2586	4195	62.2	45.6	33.9
Germany	56481	63616	12.6	4057	5334	31.5	49.3	44.4
Canada	51509	58905	14.4	3805	5453	43.3	45.4	52.4
Korea	32731	55713	70.2	2150	4137	92.4	53.1	54.7
Taiwan	44379	48723	9.8	1683	2792	65.9	68.1	62.9
Cuba	27088	33544	23.8	2331	3043	30.5	69.7	44.1
Japan	28575	32860	15.0	1352	2212	63.6	34.2	51.2
England	36112	30467	-15.6	2507	3132	24.9	48.9	49.0
Jamaica	20968	28565	36.2	934	1720	84.2	33.3	38.0
Iran	25233	28043	11.1	2507	2824	12.6	50.3	59.0
Colombia	19806	28055	41.6	698	2422	247.0	52.3	54.6

Source: Authors' calculation of Census 2000 and ACS 2007–11 combined PUMS samples.

Compared to their U.S.-born counterparts, who are more evenly distributed across all the high-tech sectors, immigrant owned high-tech businesses are more concentrated in a limited number of industries. We use the Location Quotient (LQ) to calculate the relative concentration of immigrant versus U.S.-born across the detailed high-tech industrial sectors. The LQ is given by (Ei/Et)/(Ti/Tt) where the numerator is the share of the target group E (e.g., the immigrant high-tech labor force or business owners) in specific industrial sector i. The denominator represents the percentage of all the high-tech or high-tech business owners T (in our case, the total high-tech labor force or total self-employed) in industry i. If LQ >1, it suggests the group of interest is more concentrated in sector i when compared to the share of this sector nationally. The overall foreign-born labor force in high-tech industries is more concentrated in sectors such as semiconductor, other electronic component, magnetic, and optical media (LQ=1.6), communications, audio/video equipment (LQ=1.4), and computer science-related sectors (LQ=1.3).

Table 2. Industrial Distribution (Location Quotient) of High-Tech Workforce and Entrepreneurs, 2011

Industry	All Workers		Entrepreneurs	
	U.S.-born	Foreign-born	U.S.-born	Foreign-born
Pharmaceutical and medicine	1.0	1.2	0.9	1.4
Commercial and service industry machinery	1.0	0.9	1.0	1.2
Computer and peripheral equipment	0.9	1.3	0.9	1.4
Communications, audio and video equipment	0.9	1.4	1.0	1.1
Semiconductor, other electronic component, magnetic, and optical media	0.9	1.6	0.9	1.4
Navigational/measuring/medical/control instruments	1.0	0.9	1.0	0.9
Aerospace products and parts	1.1	0.8	1.0	1.1
Medical equipment and supplies	1.0	1.2	0.9	1.5
Software publishers	0.9	1.2	1.0	1.2
Motion pictures and video	1.1	0.6	1.0	0.8
Telecommunications	1.1	0.7	0.0	0.0
Internet service providers, web search portals, and data processing services	1.1	0.7	1.1	0.6
Other information services	1.0	0.8	0.9	1.3
Architectural, engineering, and related	1.1	0.7	1.0	0.8
Computer systems design and related	0.9	1.3	1.0	1.1
Scientific R&D	1.0	1.1	1.0	0.9
Medical and diagnostic laboratories	1.0	0.8	0.9	1.3

Source: Authors' calculation of Census 2000 and ACS 2007–11 combined PUMS samples.

2. Spatial Distribution of Immigrant High-Tech Entrepreneurship

Immigrant-owned high-tech businesses are not evenly distributed across the metropolitan labor markets. We use two metrics to summarize their relative spatial concentration as compared to the U.S.-born population at the MSA level. We first use the Herfindahl-Hirschman Index, defined as $HHI_t=\sum_{m=1}^{M} Share_{mt}^{2}$, where M indexes 283 MSAs and $share_{mt}$ is MSA m's share of all metro workers/entrepreneurs in period t. A larger HHI denotes a higher spatial concentration. The second metric is the share in the top twenty-five MSAs (during the 2007–2011 period) of all metro workers/entrepreneurs. Though crude, this measure shows the relative dominance of twenty-five MSAs for different population segments. Resulting statistics are presented in Table 3.

Table 3. Concentration Measures across MSAs, 2011

	Herfindahl-Hirschman index (HHI)			Share of Top Twenty-five MSAs		
	Immigrant	U.S.-born	All	Immigrant	U.S.-born	All
			All Workers			
2000	0.057	0.014	0.018	73.2%	45.2%	49.7%
2011	0.046	0.014	0.018	70.5%	45.1%	50.2%
			All High-Tech Workers			
2000	0.054	0.020	0.024	57.1%	79.9%	61.3%
2011	0.046	0.018	0.022	77.7%	54.5%	59.6%
			All High-Tech Entrepreneurs			
2000	0.070	0.024	0.029	80.2%	57.8%	61.2%
2011	0.058	0.023	0.028	78.3%	57.5%	61.4%

Source: Authors' calculation of Census 2000 and ACS 2007–11 combined PUMS samples.

Based on HHI indices, immigrants have a greater spatial concentration than their U.S.-born counterparts do in all time-group combinations. Across different groups, immigrant high-tech entrepreneurs demonstrate the highest concentration, surpassing all high-tech workers and all workers. Interestingly, all indices are lower in 2011 than in 2000, suggesting a deconcentrating trend among the immigrant population. This is consistent with growing literature that documents immigrants' dispersing settlement patterns. As for the share measures, the top twenty-five MSAs host up to 80 percent of all immigrant high-tech entrepreneurs as compared to about 58 percent of U.S.-born high-tech entrepreneurs in both 2000 and 2011. These numbers also are larger than the comparable shares for all workers, as well as for all high-tech workers. These results all point to the overall greater agglomeration among immigrant high-tech entrepreneurs across metropolitan areas.

Table 4 lists the top twenty-five MSAs by their share of all metro high-tech entrepreneurs in 2011 and displays their total and normalized number and change over the last decade. As is evidenced in the Table 4, the three metros of New York, Los Angeles, and San Francisco alone account for about a third of all immigrant high-tech entrepreneurs in the country in 2011. This may not be surprising, given their historical ties as the largest immigrant gateway metros. Worthy of note is the fact that several other metros, besides Los Angeles and New York, registered substantial growth over the last decade. These include Atlanta; Chicago; Fort Lauderdale, Fla.; Houston, Texas; Miami, Riverside, Calif.; and Washington, D.C. Interestingly, the metros of Silicon Valley—San Francisco and San Jose—didn't experience substantial growth. We also map out these patterns for the top fifty MSAs.

Table 4. High-Tech Entrepreneurs for Top Twenty-five MSAs

	2011						2000–2011 Change			
	Immigrants			U.S.-born			Immigrants		U.S.-born	
MSA name	Number	Share	Per 10,000	Number	Share	Per 10,000	Number	Per 10,000	Number	Per 10,000
Atlanta, GA	2502	2.4%	9.6	10631	2.4%	40.9	1543	5.1	2301	2.0
Austin, TX	859	0.8%	9.8	5667	1.3%	64.6	546	5.0	2301	12.7
Baltimore, MD	1128	1.1%	7.9	5162	1.2%	36.0	688	4.5	1221	5.5
Boston, MA-NH	2184	2.1%	9.6	10911	2.4%	48.2	432	1.3	988	0.9
Chicago, IL	4162	4.0%	8.7	15268	3.4%	31.7	1643	2.9	2482	2.7
Dallas-Fort Worth, TX	2191	2.1%	6.8	12235	2.7%	37.8	932	2.0	2221	-0.3
Denver-Boulder, CO	988	0.9%	7.0	8772	2.0%	62.0	469	2.7	1538	2.5
Detroit, MI	1001	1.0%	4.7	5405	1.2%	25.3	574	2.7	389	2.2
Fort Lauderdale, FL	2450	2.3%	25.8	3167	0.7%	33.4	1298	11.5	760	3.5
Houston-Brazoria, TX	2687	2.6%	9.6	8142	1.8%	29.0	1331	3.2	1164	-3.7
Los Angeles-Long Beach, CA	15903	15.2%	24.2	37966	8.5%	57.8	4967	5.1	6355	2.6
Miami-Hialeah, FL	4630	4.4%	37.4	2923	0.7%	23.6	1900	10.0	1028	4.6
Minneapolis-St. Paul, MN	739	0.7%	4.1	7198	1.6%	40.3	157	0.5	104	-3.6
New York, NY	14487	13.9%	15.8	34207	7.7%	37.3	4538	3.7	5786	2.8
Orlando, FL	1093	1.0%	9.7	4910	1.1%	43.7	639	4.3	2026	9.3
Philadelphia, PA	1581	1.5%	5.7	9602	2.2%	34.7	579	1.7	647	-0.9
Phoenix, AZ	1392	1.3%	7.3	7191	1.6%	37.9	742	3.0	610	-5.7
Portland, OR	764	0.7%	6.9	6184	1.4%	55.7	41	-0.6	1419	6.2
Riverside, CA	1853	1.8%	9.5	4888	1.1%	25.1	1221	4.9	2086	4.9
San Diego, CA	2492	2.4%	15.6	8486	1.9%	53.1	912	4.4	2121	8.0
San Francisco, CA	5627	5.4%	21.5	16005	3.6%	61.3	862	1.8	2243	4.3
San Jose, CA	3133	3.0%	33.7	4714	1.1%	50.7	615	5.1	325	0.9
Seattle-Everett, WA	1796	1.7%	12.2	9100	2.0%	61.8	632	3.2	2803	13.1
Tampa-St. Petersburg, FL	1197	1.1%	8.6	5671	1.3%	40.9	637	3.7	1341	2.8
Washington, D.C.	4943	4.7%	15.8	11915	2.7%	38.0	2597	6.8	1814	-0.6

Source: Authors' calculation of Census 2000 and ACS 207-11 combined PUMS samples.

Figure 1 maps out the distribution of all immigrant high-tech entrepreneurs among the top fifty MSAs in 2011, and Figure 2 demonstrates their change between 2000 and 2011. In addition, we also include maps (Figure 3 and Figure 4) that show the geographical clustering of immigrant entrepreneurship in two industrial groups—medical-related and computer/IT-related—and their differing spatial distributions.

Figure 1. Immigrant High-Tech Entrepreneurs by MSA, 2011

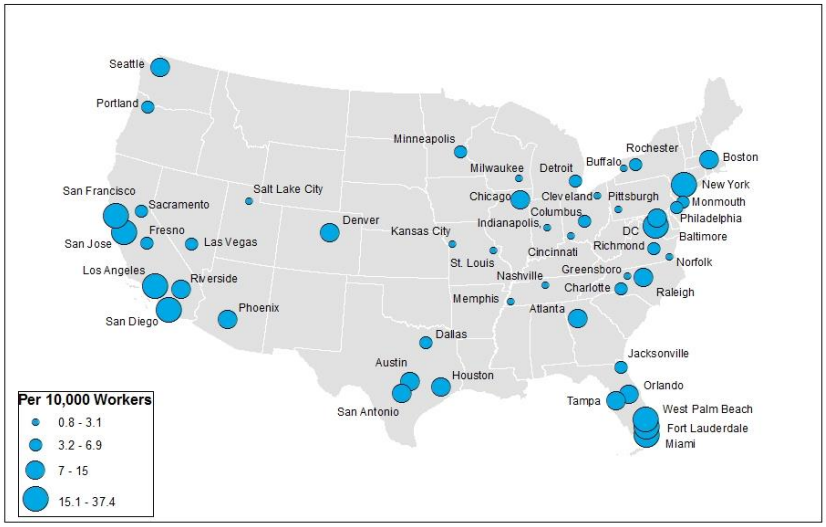


Figure 2. Immigrant High-Tech Entrepreneur Growth by MSA, 2000–2011

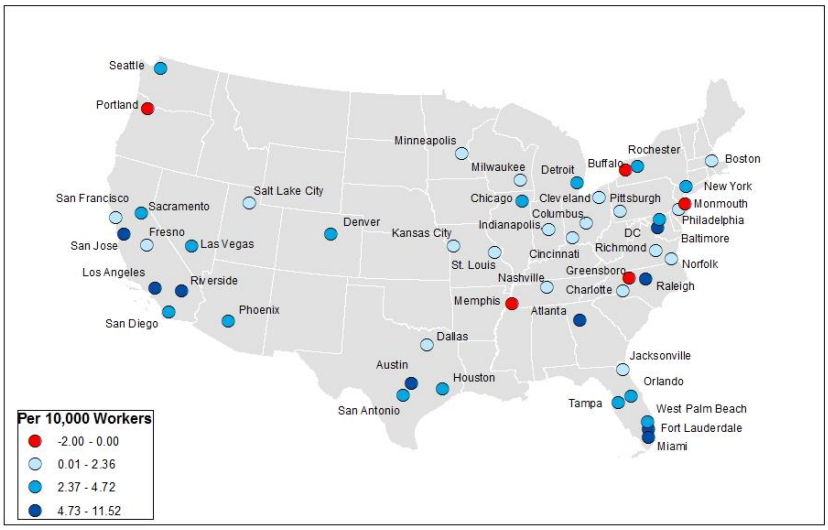


Figure 3. Immigrant Entrepreneurs in Medical Industries by MSA, 2011

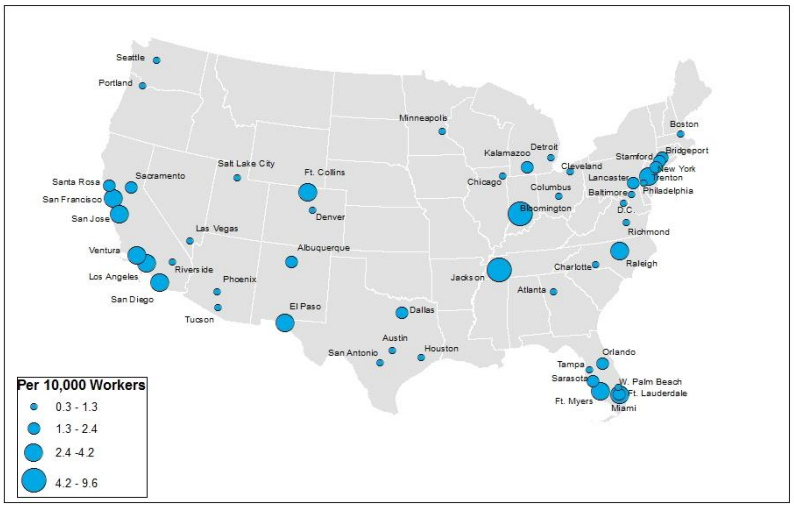
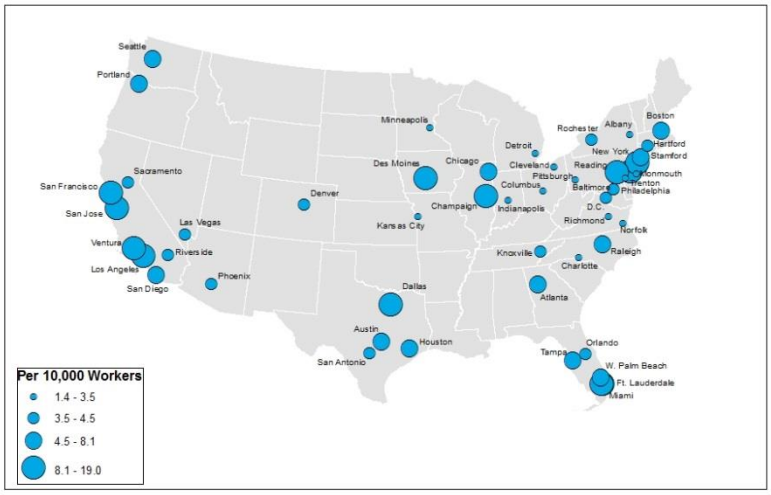


Figure 4. Immigrant Entrepreneurs in Computer Industries by MSA, 2011



3. Results: Inter-metropolitan residential choice

Table 5 presents the model results that display the impact of MSA-level characteristics associated with the number of high-tech entrepreneurs per 10,000 labor force for the foreign-born and the U.S.-born, as well as for different industries. The first two columns show the comparison between the immigrant and U.S.-born high-tech entrepreneurs. Results suggest that a metropolitan area with a historically high foreign-born population, a higher ethnic diversity, a stronger base of high-tech industries, and higher innovation capacity is more likely to have a higher level of immigrant high-tech entrepreneurship. Holding all other conditions constant, a 10 percent increase in percentage of the foreign-born in a metropolitan area in 1970 implies an increase of 5.58 self-employed immigrants in high-tech industries per 10,000 labor force in 2007–2011. An increase of 0.37 unit of diversity index (0.37 is the average value of diversity index, which ranges from 0.06 to 0.68 in the sample) will increase the total number of immigrant entrepreneurs in high-tech industries by 2.5 per 10,000 labor force. This suggests that the context for immigration matters. Similarly, the high-tech index variable, which includes the percentage of high-tech industries and producer services, the number of college graduates, and the total number of patents in 2000, is a significant positive predictor of the metropolitan area of choice for immigrants in high-tech businesses.

Similar to immigrants, the total number of high-tech businesses for the U.S.-born entrepreneurs is higher in metropolitan areas with a stronger base of high-tech industries and higher innovation capacity. However, a historical immigrant presence and ethnic diversity of the regional labor market are not significant for U.S.-born entrepreneurs. Metropolitan areas with higher percentages of construction and social services tend to have higher numbers of native-born-owned businesses in high-tech industries. In addition, a higher incorporation rate in a metropolitan area, as a proxy for lack of small businesses and a more monopolized business environment, has a significantly negative association with the number of businesses in high-tech industries for the U.S.-born in year 2011.

Table 5. Regression Results on MSA-Level High-Tech Entrepreneurs in 2011 (Per 10,000 labor force)

Variable	Immigrant	U.S.-Born	Immigrant	
			Medical	Computer
Foreign-born Share	0.558***	-0.057	0.066**	0.347***
Ethnic Diversity	6.912***	3.002	1.313**	6.013***
Unemployment Rate	-0.218	0.643	-0.026	-0.276*
Incorporation Rate	-0.041	-0.391**	-0.016	-0.014
Manufacturing Share	-0.033	-0.06	0.018	0.022
Construction Share	0.283*	3.546***	0.095*	-0.079
Trade Share	0.134	-0.056	0.017	0.153
Social Services Share	-0.045	0.314*	0.035	0.0479
High-Tech Index	1.005**	11.562***	0.312***	1.264***
Intercept	-1.381	2.114	-1.835	-2.965
R2	0.4972	0.5388	0.1786	0.5125
N	283	283	283	283

* p<0.05; ** p<0.01; *** p<0.001

Notes: Foreign-born share is from year 1970; all other variables are from year 2000.
High-Tech Index is a composite variable of four factors: percent high-tech, percent producer service, percent bachelor's degree, and (ln)number of patents in 2000.

Medical is medical and pharmaceutical industry, including manufacturing, services, and R&D.

Computer is computer sciences, electronic engineering industries in manufacturing, services, and R&D.

The next two columns show immigrant entrepreneur results for two industrial groups: medical and computer/IT. Similar to the overall model for the entire immigrant group, a historical immigrant concentration in the metropolitan area and a strong base for high-tech industries are significant predictors for both of these models. In addition, a metropolitan area with a higher unemployment rate is less likely to have a large immigrant high-tech presence in computer and IT-related industries.

These patterns suggest that the number of immigrant owned high-tech businesses are contingent on both the regional industrial structure and immigrant/minority population. A high presence of similar industries or agglomeration of high-tech industries at the regional level signals a favorable environment critical to creative activities. By locating in these regional labor markets, immigrant high-tech businesses could have better access to markets, financial resources, critical capabilities and skills, and institutional support that constitute an "entrepreneurship environment" (Malecki, 1997, p. 164). "Embeddedness" in a regional milieu that is conducive to innovation is important for both immigrant- and U.S.-born owned high-tech businesses.

At the same time, immigrant high-tech businesses are more likely to be located in metropolitan areas that have higher historical share of the foreign-born population and higher ethnic/racial diversity. The positive association among these variables could be derived from several sources. First, a large immigrant population directly increases the base of both potential immigrant business owners and co-ethnic labor demanded by

immigrant businesses. Previous studies have found that immigrant entrepreneurs begin by working for co-ethnic firms and then move to self-employment in an ethnic enclave before they expand to wider non-ethnic markets (Iyer and Shapiro, 1999). Destinations with a historically high level of immigration also imply more acceptable social and business norms toward immigrant-owned businesses. Over the past several decades, large-scale immigration waves in the United States have expanded consumers' demand and purchasing power for ethnic products, therefore encouraging the development of ethnic businesses overall—and, potentially, ethnic businesses in high-tech sectors, particularly—in diverse areas. In addition, a regional labor market with a higher ethnic diversity and foreign-born population is more likely to be open, tolerant, and creative in producing high levels of entrepreneurship. This finding is consistent with previous studies on immigrant-owned businesses or ethnic self-employment in general (Hart et al., 2011; Wang 2010, 2012). The overall pattern suggests that immigrant entrepreneurs in high-tech industries strategically take advantage of both classic resources favorable to high-tech industries in general and ethnic—or immigrant-bounded—resources provided by a large immigrant population.

Table 6. Regression Results on MSA-Level High-Tech Entrepreneur Growth 2000–2011

	Immigrants		Native-born	
	1. Absolute	2. Per 10,000	1. Absolute	2. Per 10,000
Foreign-born Share	52.258**	0.187**	43.249	-0.157
Ethnic Diversity	1189.248***	3.853**	1672.930***	-0.029
Unemployment Rate	-32.325*	-0.154	-43.225	-0.733
Incorporation Rate	3.859	0.03	-3.16	-0.077
Manufacturing Share	10.596	0.066	11.143	-0.226
Construction Share	-13.258	-0.199	21.923	-0.131
Trade Share	25.991	0.095	47.105*	0.606
Social Services Share	1.907	0.122*	0.992	0.051
High-Tech Index	101.494**	0.860***	190.728**	-2.023
Intercept	-918.179*	-5.823	-1179.784*	2.866
R2	0.3251	0.1912	0.2587	0.0485
N	283	283	283	283

* p<0.05; ** p<0.01; *** p<0.001

Notes: Foreign-born share is from year 1970; all others are from year 2000.
High-Tech Index is composite variable of four factors: percent high-tech, percent producer service, percent bachelor's degree, and (ln)number of patents in 2000.

Table 6 examines how growth in the number of high-tech entrepreneurs between 2000 and 2011 is associated with MSA-level characteristics for immigrants as compared to the U.S.-born population. Model 1 tests the changes in absolute number of self-employment in high-tech industries, and Model 2 tests the changes in the participating rate of high-tech self-employment per 10,000 labor force. Consistent with what we found earlier, a higher percentage of the foreign-born population, higher ethnic diversity, and a stronger base of high-tech industries and higher innovation capacity (higher percentage

of high-tech industries, producer services, highly educated, and patents) are significantly associated with faster growth of immigrant businesses in high-tech industries, measured by the absolute change or the rate per 10,000 labor force. For example, for a 0.37 unit increase in the values of regional ethnic diversity index in year 2000, the number of self-employed immigrants in high-tech industries will increase by 440, and the normalized rate will increase by 1.4 per 10,000 labor force, between 2000 to 2007–2011. In addition, a lower unemployment rate is positively associated with a larger growth of the total number of immigrant businesses in the high-tech industries; and a larger share of social services is significantly related with a larger growth measured by the normalized rate.

For the U.S.-born population, the change in the total number of self-employment in high-tech industries is significantly related to the overall base of high-tech industries and innovation capacity (the high-tech and education factor). This result is consistent with the model presented in Table 5. Unlike previous results, the growth between 2000 and 2011 for the U.S.-born population also is significantly related to the overall ethnic diversity in a metropolitan area, although the foreign-born share is not significant. These results imply that an open and culturally diverse environment is positively associated with creative and innovative activities for both immigrants and the U.S.-born.

4. Results: Intra-metropolitan residential choice

Table 7 presents regression results that display the associations between PUMA-level characteristics and the location choice of high-tech immigrant entrepreneurs. In total, 1,488 PUMAs form the 283 MSAs. Model 1 includes several variables commonly found in the residential location choice literature. These variables include the PUMA's share of MSA immigrant population, PUMA unemployment rate, college graduates rate in the labor force, and median housing price relative to its MSA. Model 2 further adds the PUMA share of local residents out of MSA total in several broad industrial groupings: high-technology, construction, manufacturing, trade, and producer services. It is worth noting that, as these calculations are based on place of residence, not place of work, they capture the industrial composition of the local residents instead of jobs. We use 2000 values for the independent variables to predict the concentration of immigrant high-tech entrepreneurs in 2011.

Table 7. Regression Results of PUMA Share of MSA Immigrant High-Tech Entrepreneurs 2011

	Model 1	Model 2
Foreign-born Share	0.938***	-0.065
Unemployment Rate	-0.032***	-0.015
College Graduate Index	0.046**	0.013
Housing Price Index	0.028	0.008
High-Tech Share		0.427**
Construction Share		-0.757***
Manufacturing Share		1.026***
Trade Share		-1.216***
Producer Service Share		1.587***
Intercept	-0.032	-0.006
R2	0.6357	0.7044
N	1488	1488

* p<0.05; ** p<0.01; *** p<0.001

Note: All variables taken from 2000.

Model 1 demonstrates that immigrant high-tech entrepreneurs have a higher concentration in areas with a high level of immigrant population and college graduates, as well as low unemployment rate, all relative to the MSA level. However, variables showing the industrial mix of the local residents override the significant effects of these previous variables in Model 2. High-tech immigrant entrepreneurs tend to converge toward areas with high shares of MSA manufacturing workers, high-tech workers (excluding entrepreneurs), and producer services workers, as well as low shares of MSA construction and trade workers in 2000. These results illustrate the importance of an existing network of high-skilled workers in a local area in further attracting immigrant high-tech entrepreneurs.

CONCLUSION AND DISCUSSION

While previous studies on immigrant entrepreneurship have focused largely on small businesses in low-skilled industries, this study examines the characteristics and spatial patterns of immigrant entrepreneurship in high-tech industries in the United States on the metropolitan level. Commensurate with their increasing share in the U.S. population, immigrants' participation in high-tech industries as both workers and business owners has increased steadily since 2000, at a faster rate than for their U.S.-born counterparts. Also different from the U.S.-born, who are more evenly distributed across all the high-tech sectors, immigrant owned high-tech businesses are more concentrated in a limited number of industries, such as computer sciences and medical- and pharmaceutical-related fields.

Immigrant owned high-tech businesses have different spatial concentration patterns than the U.S.-born across metropolitan areas. In particular, immigrant high-tech

entrepreneurs are more likely to be concentrated in select metropolitan areas, although there has been slight deconcentration across the first decade of this century. While the largest immigrant gateways account for a dominant share of all immigrant high-tech entrepreneurs in the country in 2011, new immigrant destinations in the South and West have seen significant increases of immigrants in high-tech industries.

In understanding the spatial patterns across metropolitan labor markets, this study finds that, for both immigrants and the U.S.-born, a higher number of high-tech businesses is positively associated with regional labor markets that have an overall higher percentage of high-tech industries. At the same time, higher ethnic diversity and a larger share of the foreign-born population are crucial factors in attracting or fostering immigrant high-tech entrepreneurship on the metropolitan level. Findings from this study suggest that a historic base of high-tech industries and innovation capacity in terms of college graduates and patents is conducive to innovation and high-tech entrepreneurship. Finally, this study finds that the occupation of residents within a metropolitan area is more predictive of the residential location of immigrant high-tech entrepreneurs than is the immigrant status of the community residents.

It is worth noting that residential location choice on any geographic level is an endogenous process that is contingent on area characteristics but also helps shape area characteristics. Though we try to control such simultaneity through lagged models to account for the time any effect will take place, we cannot make a strong claim that these are causal relationships. Another limitation of this study is that we have to approximate high-tech entrepreneurship with self-employment due to lack of public data at the firm level with owners' information and their geographic identification. Future research also will investigate the benefits of agglomeration for both residential clustering and firm location. Urban economic theory is not definitive as to the location of knowledge spillovers. Most models assume that firm location and residential location are the same. However, it might be the case that knowledge spillovers could happen near one's residence rather than near one's firm location.

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APPENDIX

Appendix A. List of NAICS codes for High-Tech Industries

	High-tech manufacturing industries
3254	Pharmaceutical and medicine manufacturing
3333	Commercial and service industry machinery manufacturing
3341	Computer and peripheral equipment manufacturing
3342	Communications equipment manufacturing
3343	Audio and video equipment manufacturing
3344	Semiconductor and other electronic component manufacturing
3345	Navigational/measuring/medical/control instruments manufacturing
3346	Manufacturing and reproducing magnetic and optical media
3364	Aerospace products and parts manufacturing
3391	Medical equipment and supplies manufacturing
	High-tech services industries
5112	Software publishers
5121	Motion picture and video industries
517	Telecommunications
518	Internet service providers, web search portals, and data processing services
5191	Other information services
5413	Architectural, engineering, and related services
5415	Computer systems design and related services
5417	Scientific R&D services
6215	Medical and diagnostic laboratories

Appendix B. Independent Variables and Definitions

Name of Variable	Coding Strategy
Immigrant Share	Share of the immigrant population in 1970
Ethnic Diversity	ethnic diversity = 1-sum(Racei)2
Unemployment Rate	unemployment rate
Incorporation Rate	rate of incorporation among all the self-employed labor force
Manufacturing Share	percentage of labor force in manufacturing
Construction Share	percentage of labor force in construction
Trade Share	percentage of labor force in wholesale and retail trade
Social Service Share	percentage of labor force in education, social service, art and recreation, personal service
High-Tech Index	composite index composed of four variables: high-tech industry share, producer service share, share college degree or higher in the labor force and number of patents