U.S. Immigration Policies and the STEM Entrepreneurial Workforce

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Abstract

Large technology firms and startups are often credited with driving innovation and job growth, and there are heated debates about whether policy reforms are needed to attract and retain high-skilled foreign workers in U.S. companies. Using a longitudinal survey that follows 2,203 science and engineering PhDs from graduate school to first-time employment, we examine the sorting of foreign and U.S. workers into employment in startups or established firms. Although foreign students are 45% more likely to be interested in working in a startup prior to graduation, after graduation they are 50% less likely to do so. Controlling for ability and other characteristics, ex ante career interests are a strong predictor of startup employment among U.S. workers but not among foreign workers, suggesting that foreign workers may face constraints in choosing their preferred jobs. We find no difference between foreign and native workers in the likelihood of receiving a job offer from a startup or in wages. Finally, among established firm employees we find that foreign workers are more likely than native workers to report that their most preferred job is in a startup, suggesting a potential pool of entrepreneurial labor that might move to startups if provided the opportunity to do so. These findings have implications for debates on U.S. immigration policies and the human capital of entrepreneurial ventures.

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1 Introduction

Large technology firms and startups are often credited with driving innovation and job growth, and there are heated debates about whether policy reforms are needed to attract and retain high-skilled foreign workers. While considerable attention has been directed to immigrant entrepreneurs and the potential role of "startup visas" that enable immigrants to start high-growth companies in the U.S., overlooked in the debate has been the impact of U.S. immigration policies on the high-skilled entrepreneurial workforce. These policies impact not only immigrant entrepreneurs, but also U.S. entrepreneurs who rely upon high-skilled foreign workers to grow. However, the extent to which startups and established firms might differ in their ability to hire highly-skilled foreign workers has not been explored. In this study we examine the factors that predict differences between foreign and U.S. PhDs in their first-time industry employment in startups or established firms.[1]

Startups face important challenges in recruiting human capital (Baron et al., 1996, Baron et al., 2001, Hsu, 2009, Wasserman, 2012). For one, startups face a range of competing demands and typically lack dedicated human resource functions, leaving little time for deep searches of the labor market. Similarly, many entrepreneurial firms – especially early-stage ventures – have limited resources to compete with established firms with respect to pay, job security, and nonpecuniary workplace benefits (Oi and Idson, 1999). As such, startups must often rely on individuals who actively search for positions in startups and who value the particular characteristics startups have to offer (e.g., freedom and dynamism), while being less concerned

[1] In this study, we define *foreign workers* as survey respondents who were not U.S. citizens during graduate school at a U.S. research university and on a temporary study visa (i.e. F-1) prior to transitioning to full-time industry employment. *U.S. workers* are defined as survey respondents who reported that they were either U.S. citizens or who possessed a green card during graduate school, and thus do not require a visa to work in the U.S. after graduation.

about startups' disadvantages with respect to other factors such as job security or income (Roach and Sauermann, 2015).

For technology startups that rely upon highly-skilled scientists and engineers, foreign workers are a particularly important segment of the workforce. First, prior research has shown that foreign PhDs are more likely to start companies (Kahn et al., 2017) and are more likely to be interested in entrepreneurship prior to graduation (Roach, 2017, Roach and Sauermann, 2015). Second, high-skilled foreign workers – and PhDs in particular – contribute more to firm innovation than native workers (Hunt, 2011, Kerr and Lincoln, 2010), making them a critical segment of the high-technology entrepreneurial workforce. Third, foreign workers comprise a considerable share of the high-skilled PhD workforce, ranging from over 50% in engineering and computer science to 37% in the physical sciences and 26% in the life sciences (National Science Foundation, 2015).

Despite the importance of foreign STEM PhDs to U.S. innovation and economic growth, concerns have been raised that the costs and complexities of obtaining a U.S. work visa may constrain high-skilled foreign workers in their job search, thereby limiting both workers' ability to match to their preferred type of employment and the labor supply available to startups. As such, high-skilled foreign workers who are interested in working in a startup may be less likely to do so because the visa process imposes considerable costs and risk upon both startups and potential employees.

On the demand side, recruiting may be particularly challenging for startups when seeking highly-specialized workers such as PhDs, as the number of potential employees with the needed expertise may be small and difficult to locate. In addition, firms seeking to sponsor a work visa face costs of $5,000-$10,000 per employee for filing fees plus attorney fees, and the process can

take several years. Moreover, while prior studies have shown that startups typically pay lower wages than established firms (Burton et al., 2018, Haltiwanger et al., 2013), startups are required to pay foreign workers at least the prevailing wage for a given occupation and region, which is often comparable to established firm wages.[2] Thus, hiring foreign workers can be more costly for startups than hiring native workers. When combined with the time and effort required to sponsor a worker, these costs can place a considerable burden on small young firms. While established firms face similar financial costs to sponsor workers, they often have greater experience and specialized HR functions that mitigate the downsides of hiring foreign workers. Moreover, the costs are easier for established firms to bear given their larger size and resources. Taken together, startups may be less willing than established firms to hire foreign workers.

On the employee side, foreign workers – even those attracted to startup employment – may choose to work for established firms to increase their chances of getting a U.S. work visa. In addition, foreign workers entering first-time employment may be reluctant to take a startup jobs as firm failure would terminate their work authorization and require them to restart the visa process at a new employer.[3] Together these challenges may make it difficult for technology startups to hire the high-skilled workers they need to rapidly grow, especially in STEM fields like computer science where the share of the workforce comprised of foreign worker is greater.

We investigate whether and how first-time labor market outcomes differ between foreign and U.S. PhDs using a novel longitudinal survey that follows a cohort of U.S. graduate students from 2010-2016 and that is matched to online career profile data (e.g., LinkedIn). Specifically, we show that although during graduate school foreign PhDs are more likely than their U.S.

[2] Using the U.S. Department of Labor foreign labor certification permanent resident disclosure data (PERM), the authors estimate that foreign PhDs from U.S. universities who entered the workforce between 2014 and 2016 are offered an average wage of $113,100 in established firms and $116,400 in a startup firm.

[3] Foreign workers who have already received an H-1B from a firm may port their visa to a new employer without going through the lottery, making it easier for foreign workers to move from an established firm to a startup in subsequent employment.

counterparts to be interested in working in a startup, after graduation only 6% of foreign PhDs work in a startup compared to 14% of U.S. PhDs. This difference persists even when controlling for ability, individual career preferences and labor market conditions. We also find that U.S. PhDs sort into jobs that are consistent with their ex ante interest in working in a startup, while foreign PhDs do not. Moreover, among established firm employees, we find that 25% of foreign workers reported that their most preferred career is in a startup, possibly suggesting a potential pool of entrepreneurial labor that might transition to startup employment.

Our study differs from prior research on the U.S. high-skilled foreign workforce in a number of ways. First, we focus specifically on individuals with graduate degrees from U.S. universities (Bound et al., 2015) and do not consider STEM workers who enter the U.S. on temporary work visas (Hunt, 2011, Kerr and Lincoln, 2010). As such, our study contributes to policy discussions related to retaining international students who come to the U.S. for graduate school, such as whether to offer permanent residency (i.e., a green card) upon graduation or to exempt U.S. graduates from caps on temporary visas. Second, we examine a cohort of PhD graduates in their first-time employment, a career stage when visa issues are most salient (Bound, et al., 2015, Bound and Turner, 2014). Our cohort design enables us to compare and contrast recent graduates from top research universities entering the workforce at roughly the same point in time with nearly identical levels of education and work experience. Third, rather than focus on one particular work visa category such as H-1B, our cohort design enables us to examine the full range of visas – self-sponsored or employer-sponsored and temporary or permanent – available to international students at U.S. universities. For example, although STEM doctorates are able to work in the U.S. for up to 36 months after graduation without an

employer-sponsored visa, obtaining longer-term temporary (e.g., H-1B) or permanent (e.g., green card) employer-sponsored work visas may heavily influence foreign workers' job choice.

This study also differs from prior STEM immigration research in our focus on science and engineering PhDs, the most highly-trained segment of the STEM workforce and one that contributes disproportionately to firm innovation (National Science Board, 2012). By focusing on recent doctorates from U.S. universities, our study departs from recent debates over entry-level IT workers coming to the U.S. from other countries on temporary work visas, which include concerns over foreign workers displacing U.S. workers for lower wages (Hirano and Imbens, 2002, Kerr and Lincoln, 2010). Instead, the labor market for science and engineering PhDs is characterized by lower unemployment and higher wages relative to other STEM degrees, indicating strong labor market demand for this highly-specialized workforce.[4] This can be illustrated by the dramatic increase in PhDs' average starting salaries in our sample, which from 2012 to 2016 increased 14% for established firm employees (from $106,000 to $121,000) and 26% for startup employees (from $83,000 to $105,000.). Foreign science and engineering PhDs are also of particular policy interest given that they are typically among the highest priority for permanent resident visas and whose "extraordinary" skills have greater national interest.

Our results also speak to several streams of entrepreneurship and human capital literature. Among others, we inform recent work seeking to understand entrepreneurial human capital (Burton et al., 2016, Campbell, 2013, Haltiwanger, et al., 2013, Ouimet and Zarutskie, 2014) by studying whether and why startups may be at a disadvantage in hiring high-skilled foreign PhDs. Second, our study speaks to research on labor market dynamics, and especially the role of preferences in shaping labor market outcomes (Agarwal and Ohyama, 2013, Roach and

[4] Unemployment rates for PhDs in the U.S. are around 2% or lower during the period of our study: https://www.bls.gov/spotlight/2017/educational-attainment-of-the-labor-force/pdf/educational-attainment-of-the-labor-force.pdf

Sauermann, 2015). Finally, our results have important implications for founders, as well as for policy makers seeking to foster entrepreneurial activity and considering immigration reform.

2 Data and Sample

Our empirical analysis utilizes a national longitudinal survey of 10,781 science and engineering PhDs from 39 top-tier U.S. research universities. Respondents were first surveyed in 2010 or 2013 while in graduate school (30% response rate) and then again after graduation in 2013 or 2016 during full-time employment in either a startup or an established firm (73% response rate). To ensure comprehensive data on employment outcomes, we supplemented the survey with hand-curated career profile data from LinkedIn and Google search for all respondents (including non-respondents to the second survey), which includes individuals' job title and employer characteristics. In 2016, we identified post-graduate outcomes for 86% of our respondents, of which 7.7% are still PhD students, 25.2% are postdocs, 22.1% are in a university position (either tenure or nontenure track), 5.8% are in a national lab or research institute, 33.5% are in industry, and 5.7% are in other private sector occupations.

We restrict our sample to 2,203 PhDs who graduated and entered employment in industrial R&D occupations between 2010-2016, with approximately 23% having done a postdoc before working full-time. The survey provides detailed micro data on individuals' preferences and characteristics, PhD experience, and research lab setting, as well as employer characteristics, work activities, and starting salary. We use survey data on work activities (e.g., basic research, development, etc.) and LinkedIn data on job titles (e.g., research scientist, software engineer, etc.) to identify PhDs employed full-time in R&D-related occupations in U.S. firms. We exclude from our sample individuals employed outside the U.S., as well as those employed in consulting,

finance, and non-R&D occupations. To retain our focus on PhDs choosing between comparable jobs in startups and established firms, we also exclude founders and startup executives (e.g., CTO).

We identify foreign workers as PhDs who reported in the survey that they were not a U.S. citizen during graduate school or their postdoc, and thus would require a visa to work in the U.S. after graduation.[5] In our sample, 92% of PhD students reported they were on study visa (e.g., F-1, J-1) and 7% reported that they had a green card, typically by marriage as reported in open-ended responses.[6] Since green card holders are not required to obtain a work visa and have the same freedom to choose their employment as U.S. citizens, for our analyses we combine both groups and classify them as *U.S. workers*. *Foreign workers* in our study were non-U.S. citizens who required a work visa for industry employment. Approximately 33% of our sample are foreign workers, and among these 32.5% are from China, 22.3% are from India, 5.6% are from South Korea, 3.7% are from Taiwan. The share of foreign R&D employees in our sample is highest in computer science (51%) and engineering (39%), and lowest in the life sciences (20%). The share of life science PhDs in our sample is lower than the overall population, which is likely the result of many recent life science doctorates in our sample are doing a postdoc and have yet to transition to full-time employment. We control for 18 detailed fields of study to account for variation in career paths, salary, and other factors, as well as whether an individual did a postdoc before entering private sector employment.

To identify whether PhDs were employed in a startup or an established firm, we rely upon both survey and LinkedIn data on employer age and number of employees at the time an

[5] The share of international PhD students graduating with permanent resident status is approximately 9% of all international PhD students (National Science Foundation, 2015).
[6] Authors' calculations based on the public use SESTAT Data Tool: https://ncsesdata.nsf.gov/sestat/sestat.html

individual started working at the company. We code startups (i.e., young and small) as any employer that is five years or younger and has 100 or fewer employees at the time the employee joined the company. All other employers are coded as "established" firms, including fast growing entrepreneurial ventures that had over 100 employees at the time the PhD joined the company (e.g., Uber) and corporate spinoffs that are typically young and large (e.g., Google Life Sciences spinoff Verily). Based on this classification, 6% of foreign workers are employed in startups compared to 14% of native workers, illustrating a large disparity in startup employment. Figure 1 illustrates the share of native and foreign workers employed in startups by broad degree field. Overall, 20% of startup employees and 35% of established firm employees are foreign workers. Table 1 reports summary statistics of our sample by citizenship status and employer firm type.

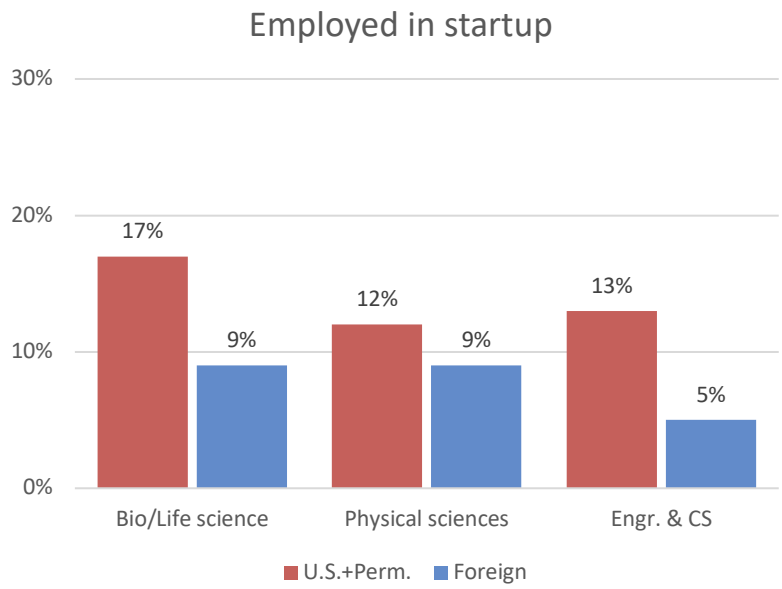

Figure 1 – Share of startup employees by PhD degree field

Table 1 – Summary statistics

	Full sample		Foreign workers		U.S. workers	
	Foreign	Native	Startup	Est. firm	Startup	Est. firm
Obs.	752	1,526	50	702	206	1,320
%Obs	0.33	0.67	0.07	0.93	0.14	0.87
Male	0.75	0.67	0.68	0.76	0.67	0.67
Married	0.45	0.42	0.52	0.44	0.45	0.41
Num. children	1.05	1.04	1.16	1.05	1.04	1.04
Prior postdoc	0.21	0.24	0.20	0.21	0.29	0.23
U.S. & perm.res.	0.670				0.091	0.580
China	0.085		0.004	0.081		
India	0.058		0.003	0.055		
Other nationality	0.188		0.015	0.173		
Life sciences	0.20	0.80	0.02	0.14	0.18	0.66
Chemistry	0.25	0.75	0.02	0.09	0.22	0.66
Physics	0.25	0.75	0.02	0.09	0.23	0.66
Engineering	0.39	0.61	0.02	0.07	0.37	0.54
Computer Science	0.51	0.49	0.03	0.07	0.48	0.42

NOTES: Demographic characteristics are reported as cell means; nationality statistics are column percentages; degree fields statistics are row percentages

3 Results

In our empirical analysis, we first examine differences between foreign and native workers in the likelihood of sorting into startup employment through a series of logistic regression analyses. More specifically, we investigate factors that might explain differences in employment sorting, including ability, career preferences, and labor market factors. We then examine whether foreign and native workers differ in whether they applied to and received offers for startup jobs. We conclude by examining differences in starting salaries in startups and established firms.

3.1 Employment sorting into startups or established firms

To examine whether foreign workers differ in their likelihood of working in a startup, we estimate a series of logistic regressions where the dependent variable is startup employment and

the predictor variables include individual demographics, ability, ex ante career preferences, and labor market factors that relate to the availability of startup jobs. Table 2 reports results from a series of logistic regressions that predict the likelihood of working in a startup. Model 1 is the baseline specification that includes demographic characteristics and includes controls for PhDs' degree field and the year they entered the workforce. We see that foreign workers exhibit a 51% lower likelihood of working in a startup compared to native workers, while gender, marital status, and number of children have no relationship with startup employment.[7]

Models 2 and 3 explore the extent to which ex ante career interests, worker ability, and labor market conditions might explain the different employment outcomes of foreign and native workers. To measure ex ante career interests, we asked respondents while in graduate school: "Putting job availability aside, how attractive or unattractive do you personally find each of the following careers?", where careers included "startup job with an emphasis on research or development" and "established firm job with an emphasis on research or development." Respondents rated each career independently using a 5-point scale ranging from "extremely unattractive" (1) to "neither attractive nor unattractive" (3) to "extremely attractive" (5). We code ex ante startup work interests as 1 for respondents who reported that a startup job was "extremely attractive" (5) or "attractive" (4), and 0 otherwise. In the aggregate, 73% of foreign PhDs interested in working in a startup, which is significantly greater than the 65% of U.S. PhDs interested in working in a startup (t-statistic = -3.84, p=0.0001). Figure 2 illustrates the share of foreign and native workers who reported while in graduate school that working in a startup was attractive for the broad fields of the life sciences, physical sciences, and engineering & computer science.

[7] Table A1 reports results where foreign workers are distinguished between Chinese, Indian, and all other nationalities.

Table 2 – Logistic regressions of startup employment

Dependent variable	Startup employee				
Sample	**Full**	**U.S. workers**	**Foreign workers**	**Ex ante interest in startup**	**Engr. & CS**
Model	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
Foreign worker	-0.67***			-0.77***	-0.81***
	(0.20)			(0.23)	(0.24)
Male	0.10	0.14	-0.43	-0.01	0.16
	(0.16)	(0.16)	(0.43)	(0.18)	(0.28)
Married	0.14	0.10	0.30	-0.05	-0.07
	(0.17)	(0.17)	(0.36)	(0.17)	(0.18)
Num. children	-0.15	-0.24	-0.10	-0.13	-0.48*
	(0.12)	(0.13)	(0.22)	(0.13)	(0.21)
Prior postdoc	0.17	0.21	-0.34	0.13	0.08
	(0.13)	(0.15)	(0.40)	(0.15)	(0.32)
Ex ante interest in startup		0.78***	0.32		0.73**
		(0.17)	(0.37)		(0.24)
Ex ante interest in est. firm		-0.61**	-0.29		-0.89**
		(0.22)	(0.54)		(0.28)
Ex ante self-perceived ability		-0.06	-0.04	0.01	-0.01
		(0.03)	(0.08)	(0.04)	(0.04)
NRC univ. dept. rank		0.14	0.53**	0.20*	0.32**
		(0.09)	(0.17)	(0.09)	(0.12)
Publications at graduation		0.09*	0.08	0.05	0.03
		(0.05)	(0.07)	(0.04)	(0.05)
Annual U.S. early-stage VC funding (log)		1.03***	1.88**	1.08***	1.18***
		(0.25)	(0.69)	(0.25)	(0.36)
Annual U.S. GDP growth rate		0.18	0.14	0.30	0.43
		(0.18)	(0.43)	(0.18)	(0.27)
Constant	-3.28***	-11.24***	-21.27***	-11.90***	-26.55***
	(0.46)	(2.36)	(6.06)	(2.34)	(3.07)
PhD degree field FE	Y	Y	Y	Y	Y
Job start year FE	Y				
Observations	2203	1475	723	1483	1115
Log pseudolikelihood	-724.56	-539.31	-145.84	-514.53	-303.54

Robust standard errors clustered on university reported in parentheses; *** p < 0.001, ** p < 0.01, * p < 0.05.

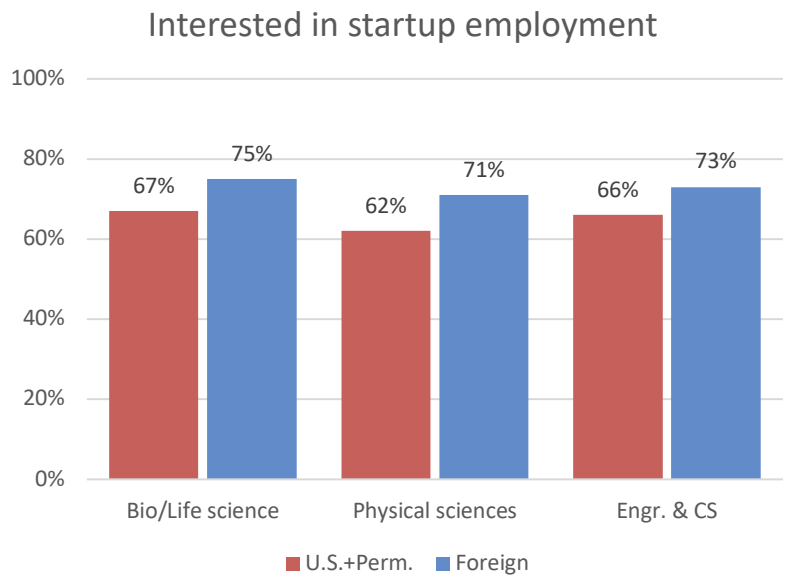

Figure 2 - Share of PhDs Interested in Working in a Startup During Graduate School

NOTES: Share of PhDs who reported while in graduate school that working in a startup is either "attractive" or "extremely attractive".

We find that ex ante career interests significantly predict employment outcomes for native workers (Model 2), but do not explain employment outcomes for foreign workers (Model 3). More specifically, native workers who report during graduate school an interest in working in a startup have a 19% greater likelihood of working in a startup after graduation, while those with an interest in working in an established firm have a 114% lower likelihood of working in a startup (i.e., greater likelihood of working in an established firm). In addition, the difference in coefficient estimates between native and foreign workers with respect to their ex ante career interests are significant.[8] Model 4 restricts the sample to PhDs who reported an ex ante interest in working in a startup, thereby excluding individuals who are unlikely to seek out and accept startup jobs. As with the full sample, foreign workers are significantly less likely than native workers to work in a startup.

[8] A seemingly unrelated test confirms that the difference in coefficients between native and foreign workers for ex ante work interests are significant (interest in a startup χ^2=19.64, p=0.0001; interest in established firm χ^2=7.85, p=0.020).

Table 3 – Logistic regressions of ex ante career interests

Dependent variable	Ex ante interest in startup	Foreign worker
Model	**(1)**	**(2)**
Foreign worker	0.37***	
	(0.11)	
Male	0.65***	-0.08
	(0.09)	(0.14)
Married	0.07	0.16
	(0.08)	(0.11)
Num. children	0.03	0.04
	(0.06)	(0.08)
Prior postdoc	-0.21	0.15
	(0.13)	(0.18)
Ex ante interest in startup		0.32**
		(0.12)
Ex ante interest in est. firm		0.30
		(0.19)
Ex ante self-perceived ability	0.10***	0.16***
	(0.03)	(0.03)
NRC univ. dept. rank	0.02	-0.37***
	(0.03)	(0.09)
Publications at graduation	-0.01	0.06*
	(0.02)	(0.03)
Constant	-0.57*	-3.73***
	(0.24)	(0.43)
PhD degree field FE	Y	Y
Job start year FE	Y	Y
Observations	2203	2201
Log pseudolikelihood	-1341.77	-1216.35

Robust standard errors clustered on university reported in parentheses; *** p < 0.001, ** p < 0.01, * p < 0.05.

The disparity between foreign PhDs' ex ante interest in working in a startup and their ex post startup employment is further explored in Table 3. Models 1 shows that during graduate school foreign PhDs have 45% greater likelihood than native workers to be interested in working in a startup while controlling for individual characteristics. Model 2 considers differences between foreign andU.S. workers with respect to ex ante preferences and characteristics. The

results illustrate that individuals who were interested in working in a startup during graduate school are more likely to be foreign, while there is no difference for individual who were interested in working in an established firm. Together these results suggest that U.S. citizens and green card holders, who are not constrained by work visas in their job choice, sort into jobs that align with their ex ante career interests, while foreign workers requiring visa sponsorship who would prefer to work in a startup are more likely to work in an established firm.

In addition to ex ante career interests, we also examine whether worker ability or labor market conditions might explain why foreign workers are less likely to work in startups. To do this, we include three measures of ability: PhDs' ex ante self-perceived ability relative to their peers, the National Research Council's ranking of their PhD department, and their number of publications at graduation.[9] Given that our sample is based on PhDs in first-time employment, more common measures of ability used in prior studies research such as education, prior wages, or work experience are not applicable. Moreover, we believe that self-perceived ability will shape individuals' expectations of their own ability to succeed at a job, as well as how they convey themselves to prospective employers. At the same time, assessing the ability of recent PhD graduates may be difficult for employers. As such, they may rely on objective measures such as PhD department rank and number of publications to infer worker ability. For native workers (Model 2), individuals with more publications are graduation are more likely to work in a startup, while self-perceived ability and NRC ranking exhibit no relationship. For foreign workers on the other hand (Model 3), we see that NRC university department ranking significantly predicts startup employment. Self-perceived ability does not predict employment sorting for either group.

[9] To address concerns over collinearity with the ability measures, we performed analysis with each ability measure separately with substantively identical results (available upon request from the authors).

We also include the annual VC funding for seed and early-stage ventures at the year a PhD entered the workforce as a proxy for changes in the availability of startup jobs. To the extent that VC funding increases (decreases) over time, we expect a greater (lesser) availability of startup jobs since funding for early-stage technology ventures is typically to hire scientists and engineers to develop the technology. Figure 1 illustrates this relationship with annual early-stage VC funding (in $M) from 2010-2016 and the shared of PhDs working in startups by early they entered the workforce.[10] We also include the annual GDP growth rate to control for macroeconomic trends that might influence overall job availability.

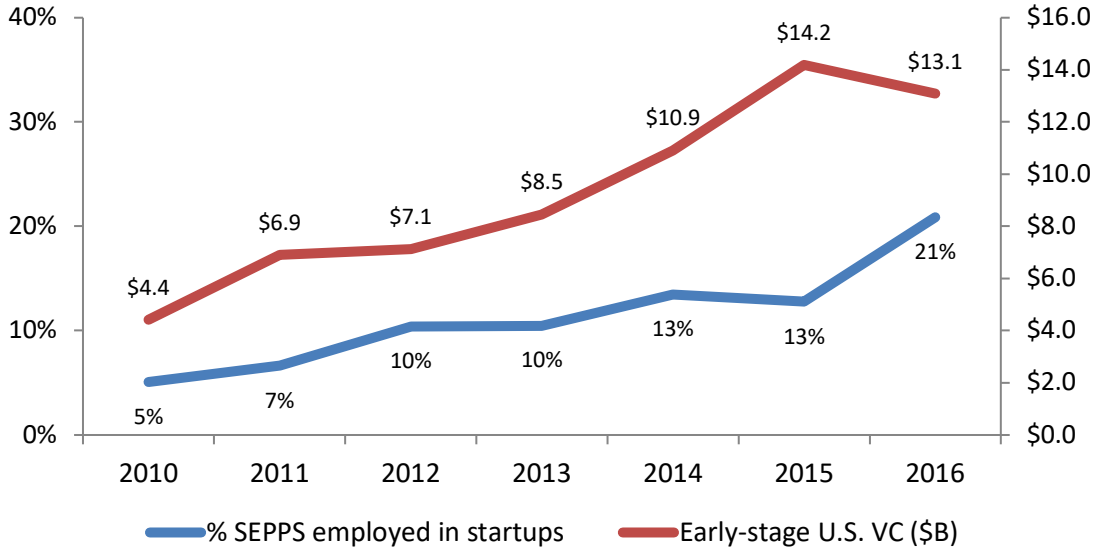

Figure 3: Annual Trends in early-stage VC funding and PhD startup employment

We see in Table 2 that for both native (Model 2) and foreign workers (Model 3) VC funding is positively associated with a greater likelihood of working in a startup, and the effect is stronger for foreign workers.[11] A one standard-deviation increase in the log of early-stage VC

[10] VC data are from PwC Moneytree/CB Insights (http://www.pwc.com/moneytree)
[11] The seemingly unrelated test statistics are χ^2=17.58, p=0.0002.

funding increases the likelihood of foreign workers sorting into startups by 3.5 times, while the same change increases the odd of U.S. workers by 1.8 times. The stronger relationship between VC funding and foreign PhDs working in startups could reflect that venture-backed startups are better able to pay the higher prevailing wages required to justify hiring foreign workers, as well as bear the filling and legal costs to sponsor foreign workers for a visa.

Given that over half of PhDs with degrees in engineering and computer science are foreign, one might be concerned that the sorting patterns observed thus far might be greater in these fields. To investigate this, Model 5 restricts the sample to PhDs with degrees in engineering or computer science, who have a 56% lower likelihood of working in a startup. Thus, foreign PhDs in engineering and computer sciences are even less likely to work in a startup than PhDs in other fields.

One interpretation of this result is that there may be more established firm jobs for PhDs in engineering and computer science, thus these sorting patterns may reflect job availability rather than visa constraints. To explore this, we conducted a search on Glassdoor, a leading online job search website, of current job postings in the San Francisco and Boston areas that mention a PhD as a qualification. At the time of our search (March 4, 2018) there were 8,142 job postings, with 17% being from companies with fewer than 200 employees, the smallest firm size filter available.[12] With respect to degree field, 63% of all postings were for PhDs in biological sciences, 26% were for PhDs in engineering, 8% for PhDs in computer science, and 3% for PhDs in chemistry. Although the majority of available jobs are in the biological sciences, the share of postings from small firms was highest for a PhD in computer science at 24%, followed by 20% for biological sciences, 19% for engineering, and 14% for chemistry. Recall

[12] Glassdoor does not provide a filter for employer age. However, a manually inspection of many of the small firms with job postings confirm that they are newly founded companies.

that the shares of PhDs in our sample with degrees in engineering and computers working in a startup are 13% for U.S. citizens and permanent residents and 5% for foreign PhDs. Together these findings suggest that startups most likely to hire engineering and computer science PhDs may be particularly disadvantaged in hiring foreign workers.

An important concern with the sorting of recent PhD graduates is the concentration of startups in entrepreneurial regions like Silicon Valley and Boston while universities are geographically dispersed across the U.S. For example, a PhD student from a university not embedded in an entrepreneurial ecosystem, such as Cornell, might face labor market constraints that make it more difficult to obtain a startup job relative to PhD students from Stanford or UCSF. These constraints might be exacerbated for foreign PhDs from more remote universities, who may not possess as much institutional knowledge about entrepreneurial regions or may face other language or cultural challenges that prevent them for finding startup jobs.

To explore this possibility, we constructed a variable that is 1 if an individual received their PhD from a university in either the San Francisco Bay Area (i.e., Berkeley, Stanford or UCSF) or the Boston Area (i.e., Harvard or MIT).[13] To the extent that doing their PhD at a university within an entrepreneurial region facilities individuals' ability to find startup jobs, then we expect this variable to significantly predict sorting into startup, and this effect will be greater for foreign PhDs. In addition to geographic proximity, universities in entrepreneurial regions may also be more likely to encourage PhD students to work in startups. However, prior research has shown that the encouragement of entrepreneurship varies across universities within region,

[13] One might be concerned that by including these particular universities our results reflect an "elite university" effect rather than an entrepreneurial region effect. In results available from the authors, we include an "elite university" variable that includes the following universities in our data: Berkeley, Caltech, Chicago, Columbia, Cornell, Duke, Harvard, MIT, Princeton, and Stanford. Our results reported in Table 4 are robust to the inclusion of this variable.

where, for example, MIT more strongly encourages working in startups while Harvard does not (Roach, 2017).

Table 4 presents a series of logistic regressions to explore this relationship. The baseline results in Model 1 illustrate that individuals who did their PhD at a university in an entrepreneurial region were significantly more likely to work in a startup. The coefficient estimate for foreign workers is slightly lower than in Table 2, but the main effect that foreign PhDs are significantly less likely than U.S. PhDs to work in startups remains. Model 2 reports the interaction between entrepreneurial region and foreign worker, which is not significant. Models 3 and 4 present results for the subsamples of PhDs in entrepreneurial and non-entrepreneurial regions, respectively. Model 3 shows that foreign who did their PhD at a university in an entrepreneurial region have a 48% lower likelihood of working in a startup compared to U.S. PhDs, while Model 4 shows that foreign who did their PhDs outside these two entrepreneurial regions have a 44% lower likelihood of working in a startup.[14] Thus, foreign PhDs, whether they are from universities in entrepreneurial regions or not, are considerably less likely to work in startups than their U.S. counterparts.

[14] Although the relative magnitude of these estimates are similar, they are significantly different: $\chi^2=15.20$, $p=0.0005$

Table 4 – Logistic regressions of entrepreneurial region effects

Dependent variable	Startup employee			
Sample	Full	Full	Univ. in entr. region	Univ. outside entr. region
Model	(1)	(2)	(3)	(4)
Univ. entr. region	0.55**	0.54**		
	(0.19)	(0.19)		
Foreign worker	-0.59**	-0.60**	-0.65**	-0.59**
	(0.18)	(0.22)	(0.24)	(0.23)
Foreign X Univ. entr. region		0.05		
		(0.34)		
Male	0.04	0.04	-0.02	0.13
	(0.15)	(0.15)	(0.23)	(0.19)
Married	0.15	0.15	0.38	0.06
	(0.16)	(0.16)	(0.22)	(0.20)
Num. children	-0.19	-0.20	-0.07	-0.28*
	(0.12)	(0.12)	(0.30)	(0.14)
Prior postdoc	0.13	0.13	0.11	0.22
	(0.13)	(0.13)	(0.10)	(0.18)
Ex ante interest in startup	0.68***	0.68***	0.45**	0.81***
	(0.17)	(0.17)	(0.17)	(0.23)
Ex ante interest in est. firm	-0.53*	-0.53*	-0.42	-0.64*
	(0.21)	(0.21)	(0.31)	(0.29)
Ex ante self-perceived ability	-0.05	-0.05	-0.08	-0.04
	(0.03)	(0.03)	(0.06)	(0.04)
NRC univ. dept. rank	0.07	0.07	-0.08	0.12
	(0.09)	(0.09)	(0.08)	(0.12)
Publications at graduation	0.08*	0.08*	0.08	0.08
	(0.04)	(0.04)	(0.06)	(0.05)
Annual U.S. early-stage VC funding (log)	1.17***	1.17***	2.13***	0.85**
	(0.29)	(0.29)	(0.23)	(0.33)
U.S. GDP growth rate	0.18	0.18	-0.17	0.32
	(0.15)	(0.15)	(0.34)	(0.19)
Constant	-13.11***	-13.11***	-21.34***	-10.21***
	(2.70)	(2.70)	(2.98)	(3.08)
PhD degree field FE	Y	Y	Y	Y
Observations	2200	2200	445	1745
Log pseudolikelihood	-699.86	-699.86	-190.36	-498.35

NOTES: University entrepreneurial region is an indicator variable that is 1 if an individual did their PhD at a university in the San Francisco (i.e., Berkeley, Stanford or UCSF) of Boston (i.e., Harvard or MIT) regions, and 0 otherwise. Robust standard errors clustered on university reported in parentheses; *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

3.2 Job applications and job offers

One possible explanation for foreign workers sorting into employment in established firms over startups could be that foreign workers are less likely to apply to startup jobs, possibly with the expectation that startups will be less likely to sponsor them for a work visa or because they believe the risks of working in a startup are too great to even pursue that career path. On the other hand, foreign workers may apply to startup positions, but startups may be less likely to make offers to foreign workers given the time and expense of sponsoring them for a work visa. To explore these two possibilities, we asked respondents in the second-wave of the survey who were employed (n=942) a range of questions about their job search and current career preferences. First, we asked respondents to report on their job search, including whether they applied for jobs in a startup (40% of foreign workers did compared to 45% of native workers) and whether they received at least one startup job offer (66% for both foreign and native workers).

Logistic regressions reported in Table 5 show that foreign workers do not differ from native workers in their likelihood of applying to startup jobs (Model 1). It is important to note that individuals with an ex ante interest in working in a startup are more likely to apply to startup jobs, further confirming that ex ante career interests are associated with individuals' job search behavior. In addition, foreign workers do not differ from native workers in their likelihood of receiving at least one job offer from a startup (Model 2). Together these results show that foreign PhDs, especially those interested in working in startups, apply to startup jobs and receive job offers, suggesting that they have the opportunity to work in a startup but are choosing instead

to work in established firms.[15] Future research is needed to understand the underlying reasons, which may include concerns about visa but also other reasons.

Table 5 – Logistic regressions of job search

Sample	Startup job		Est. firm job	
	Applied for job	Received offer	Applied for job	Received offer
Model	**(1)**	**(2)**	**(3)**	**(4)**
Foreign worker	-0.04	-0.00	0.22	0.18
	(0.18)	(0.25)	(0.22)	(0.33)
Male	0.35**	-0.28	0.15	-0.11
	(0.14)	(0.26)	(0.24)	(0.24)
Married	-0.11	0.14	-0.29	0.16
	(0.19)	(0.27)	(0.29)	(0.21)
Num. children	-0.02	0.02	-0.24	0.20
	(0.10)	(0.14)	(0.17)	(0.17)
Prior postdoc	-0.01	-0.36	0.70	1.05**
	(0.31)	(0.36)	(0.45)	(0.34)
Ex ante interest in startup	0.76***	0.23	-0.16	-0.34
	(0.16)	(0.22)	(0.22)	(0.26)
Ex ante interest in est. firm	-0.33	-0.30	1.02***	0.77**
	(0.23)	(0.29)	(0.22)	(0.27)
Ex ante self-perceived ability	-0.06	0.05	0.06	0.16*
	(0.05)	(0.08)	(0.05)	(0.07)
NRC department ranking	0.10	0.24*	-0.13	0.29*
	(0.07)	(0.10)	(0.11)	(0.13)
Publications at graduation	-0.01	0.00	-0.02	-0.07
	(0.04)	(0.06)	(0.06)	(0.04)
Annual U.S. VC funding (log)	0.69**	-0.16	0.36	-0.11
	(0.27)	(0.33)	(0.52)	(0.43)
U.S. GDP growth rate	0.24	0.40	0.44	0.29
	(0.20)	(0.27)	(0.25)	(0.30)
Constant	-7.44**	1.23	-3.51	1.61
	(2.44)	(3.06)	(4.76)	(3.65)
PhD degree field FE	Y	Y	Y	Y
Observations	744	394	608	719
Log pseudolikelihood	-474.09	-257.92	-246.72	-261.73

Robust standard errors clustered on university reported in parentheses; *** p < 0.001, ** p < 0.01, * p < 0.05.

[15] In results not reported here we replicated our main employment sorting regressions for the subsample of PhDs who received a startup job offer and find that foreign workers are still significantly less likely than native workers to work in a startup.

Second, we asked respondents to rank their most preferred career, putting aside their current employment. Note that this measure differs from the ex ante measure in that it is asked ex post and respondents chose only one of the options. Among PhDs working in established firms, 25% of foreign workers reported that their most preferred job was in a startup, compared to 18% of native workers. Logistic regressions confirm that foreign workers are significantly more likely to most prefer working in startup over other job options (0.52 odds, 0.25 clustered standard error, p=0.037) even after controlling for individual characteristics, startup labor market conditions, and degree field.

3.3 Wage comparisons

The results thus far suggest that foreign PhDs are more interested than U.S. PhDs in working in a startup, but they are significantly less likely to do so. While this might suggest that changes in visa policies that make it easier for foreign PhDs to work in startups would lead to a deeper labor pool for startups, one may be concerned that foreign workers would displace native workers in startups at lower wages despite the fact that employers are required to pay foreign workers the prevailing wage for their occupation, skill level and location. Another concern is that foreign workers might take jobs in established firms at lower wages than their native coworkers in exchange for visa sponsorship.

Table 6 – OLS regressions of starting salary

Sample	Full	Startup empl.	Est. firm empl.	Foreign worker	U.S. worker	Engr & CS
Model	(1)	(2)	(3)	(4)	(5)	(6)
Startup employee	-0.12**			-0.09	-0.12**	-0.15**
	(0.03)			(0.08)	(0.03)	(0.04)
Foreign worker	0.02	0.11	0.02			0.01
	(0.02)	(0.07)	(0.02)			(0.03)
Male	0.08**	0.05	0.08**	0.09	0.08**	0.06
	(0.02)	(0.06)	(0.02)	(0.05)	(0.03)	(0.03)
Married	-0.03	0.02	-0.04*	-0.06	-0.02	-0.02
	(0.02)	(0.05)	(0.02)	(0.04)	(0.02)	(0.02)
Num. children	0.01	-0.02	0.00	-0.04	0.02	-0.01
	(0.01)	(0.04)	(0.01)	(0.03)	(0.01)	(0.02)
Prior postdoc	0.02	0.04	0.01	-0.06	0.05	0.05
	(0.02)	(0.07)	(0.02)	(0.05)	(0.03)	(0.04)
Ex ante self-perceived ability	0.02**	0.03	0.02**	-0.00	0.03**	0.01
	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)
NRC department ranking	0.07**	0.03	0.08**	0.09**	0.07**	0.08**
	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)	(0.02)
Publications at graduation	0.02**	0.02	0.02**	0.03**	0.01**	0.02**
	(0.00)	(0.02)	(0.00)	(0.01)	(0.00)	(0.01)
Annual U.S. early-stage VC funding (log)	0.17**	0.28*	0.16**	0.31**	0.13**	0.19**
	(0.04)	(0.12)	(0.04)	(0.07)	(0.04)	(0.06)
U.S. GDP growth rate	0.02	0.04	0.01	0.10	-0.02	0.06
	(0.03)	(0.06)	(0.03)	(0.05)	(0.03)	(0.04)
PhD degree field FE	Y	Y	Y	Y	Y	Y
Constant	3.01**	1.61	3.14**	1.96**	3.32**	2.83**
	(0.32)	(1.23)	(0.38)	(0.68)	(0.38)	(0.52)
Observations	942	128	814	232	710	477
R^2	0.32	0.45	0.32	0.33	0.33	0.35

Robust standard errors clustered on university reported in parentheses; *** p < 0.001, ** p < 0.01, * p < 0.05.

To examine for differences in wages, we use a survey question that asked PhDs to report their starting salary, including bonuses (n=981). In the aggregate, startups pay approximately 12% less than established firms ($100,600 compared to $113,800), and the difference is significant controlling for individual characteristics and degree field, as illustrated in Table 6.

However, this difference is driven primarily by native workers who earn on average $98,400 in startup employment and $111,000 in established firms, and this difference is significant (Table 6, Model 5). Foreign workers, on the other hand, earn approximately the same in startup employment ($121,200) as they do in established firm employment ($122,200), and the difference is not significant (Table 6, Model 4).[16] The average wages for foreign PhDs are quite comparable to U.S. Department of Labor foreign labor certification data for permanent resident visa applications (PERM) matched to our sample of foreign PhDs from U.S. universities who entered the workforce between 2014-2016, where the average offered wage in a startup is $116,400 and the average offered wage for in an established firm is $113,100. On balance we find no evidence that foreign workers earn less than their U.S. counterparts in first time industry employment. Moreover, foreign PhDs employed in startups earn the same as foreign PhDs employed in established firms, while U.S. PhDs employed in startups early less than their counterparts in established firms.

4 Conclusion

The foreign are a large share of the STEM labor force and might be a particularly important source of human capital for entrepreneurial startups. Using panel data from 2,203 U.S. PhD graduates, we find that the foreign born are just as interested in startup jobs as U.S. citizens but are significantly less likely to enter startup employment. Moreover, ex ante career preferences predict actual transitions among citizens but not among immigrants. Both findings provide indirect evidence that the foreign face certain constraints in their job transitions that citizens do not face. Auxiliary findings suggest that the foreign born are as likely to apply for jobs in

[16] The difference between the startup employee coefficient for foreign and U.S. workers is significant: χ^2=21.97, p=0.000.

startups and to receive offers, suggesting that the main drivers of the observed differences in transitions occur in the process of choosing between different job offers. This may reflect that offers from startups and established firms differ with respect to support for visa applications, or in the perceived likelihood that such applications would be successful.

Our results suggest the importance of future research specifically on the labor market outcomes of foreign and of policies and other constraints that may prevent them from entering the kinds of careers they aspire to. Such research can also have important implications for startups who could benefit from a larger and more diverse pool of human capital to grow and to contribute to the U.S. economy. For example, the findings could inform visa policies such as the STEM Jobs Act and the proposed STAPLE Act that would provide permanent residency to PhDs with degrees from U.S., as well as debates pertaining to repealing the STEM-based OPT extension. Such policies could be crucial to startups to ensure they can hire the best and brightest STEM doctorates, thereby increasing their ability to grow and contribute to the U.S. economy.

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Table A1 – Logistic regressions of startup employment

Dependent variable	Startup employee				Ex ante interest in startup
Sample	Full	Native workers	Foreign workers	Ex ante interest in startup	
Model	(1)	(2)	(3)	(4)	(5)
China	-1.08*		-0.60	-1.15*	0.40*
	(0.46)		(0.52)	(0.53)	(0.17)
India	-0.95*		-0.16	-0.89	0.87**
	(0.44)		(0.43)	(0.48)	(0.28)
Other nationality	-0.44*			-0.56*	0.20
	(0.19)			(0.26)	(0.11)
Male	0.09	0.12	-0.46	-0.02	0.66***
	(0.16)	(0.15)	(0.43)	(0.17)	(0.09)
Married	0.13	0.09	0.28	-0.05	0.07
	(0.17)	(0.18)	(0.36)	(0.17)	(0.08)
Num. children	-0.16	-0.23	-0.10	-0.13	0.05
	(0.12)	(0.13)	(0.23)	(0.13)	(0.06)
Prior postdoc	0.15	0.20	-0.43	0.11	-0.20
	(0.13)	(0.14)	(0.39)	(0.15)	(0.13)
Ex ante interest in startup		0.74***	0.33		
		(0.17)	(0.36)		
Ex ante interest in est. firm		-0.61**	-0.22		
		(0.22)	(0.56)		
Ex ante self-perceived ability		-0.06	-0.04	0.01	0.10***
		(0.04)	(0.09)	(0.04)	(0.03)
NRC univ. dept. rank		0.15	0.50**	0.19*	0.03
		(0.09)	(0.17)	(0.09)	(0.04)
Publications at graduation		0.09*	0.07	0.05	-0.01
		(0.05)	(0.07)	(0.04)	(0.02)
Annual U.S. early-stage VC funding (log)		1.03***	1.82**	1.09***	
		(0.25)	(0.69)	(0.25)	
U.S. GDP growth rate		0.19	0.18	0.30	
		(0.18)	(0.42)	(0.18)	
Constant	-3.25***	-11.48***	-19.62***	-11.97***	-0.55*
	(0.45)	(2.23)	(5.75)	(2.34)	(0.24)
PhD degree field FE	Y	Y	Y	Y	Y
Job start year FE	Y				Y
Observations	2203	1475	723	1483	2203.00
Log pseudolikelihood	-722.78	-541.67	-145.34	-513.74	-1338.58