



Why foreign STEM PhDs are unlikely to work for US technology startups

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Visa policies to retain United States-trained STEM PhDs are of central importance to national innovation and economic competitiveness. There is also growing interest in “startup” visas that stimulate entrepreneurial activity and job creation, particularly in technology sectors. However, there is little understanding of how visa policies might influence foreign PhDs’ employment in technology startups. This study investigates differences between 2,324 foreign and US PhDs from US research universities using a longitudinal survey of individuals’ preferences and characteristics during graduate school and their subsequent employment in a startup or established firm. Among PhDs whose first job is industrial research & development, 15.8% of US PhDs work in a startup compared with 6.8% of foreign PhDs. Foreign PhDs are as likely as US PhDs to apply to and receive offers for startup jobs, but conditional on receiving an offer, they are 56% less likely to work in a startup. This disparity is partially explained by differences in visa sponsorship between startups and established firms and not by foreign PhDs’ preferences for established firm jobs, risk tolerance, or preference for higher pay. Foreign PhDs who first work in an established firm and subsequently receive a green card are more likely to move to a startup than another established firm, suggesting that permanent residency facilitates startup employment. These findings suggest that US visa policies may deter foreign PhDs from working in startups, thereby restricting startups’ access to a large segment of the STEM PhD workforce and impairing startups’ ability to contribute to innovation and economic growth.

STEM workforce | entrepreneurial workforce | immigration policy | PhD career paths | industrial R&D

US universities attract talented students from around the world to study at research-intensive science and engineering PhD programs. On graduation, many of these PhDs seek positions in industrial research & development (R&D), where they are among the highest-skilled workers and contribute disproportionately to firm innovation and economic growth (1, 2). However, there are growing concerns that US immigration policies are out of step with the needs of today’s innovative firms, giving rise to public debates over ways to revise immigration policies to retain United States-trained STEM PhDs.* While debate has focused on employment in large technology firms and immigrant entrepreneurship, the ways in which US visa policies might influence the employment of foreign STEM PhDs in technology startups are not well understood. As noted in a recent National Academies report (3), there are growing concerns that small firms may experience greater difficulty in securing visas for highly skilled workers, thereby constraining technology startups’ ability to tap into a growing segment of the STEM PhD workforce. This may be especially true in computer science and engineering, where half of doctorates from US universities are foreign born (4, 5). Given the importance of high-growth technology startups to American innovation, job creation, and economic growth, understanding how visa policies might constrain startups’ ability to hire and grow is essential to entrepreneurship policy.

This study contributes to these timely debates by investigating whether foreign PhDs who require an employer-sponsored work

visa are less likely than US PhDs to work in a startup in their first industry job, a career stage when visa concerns are most salient. There are reasons to expect that concerns regarding work visas might influence foreign PhDs’ decision to work in established firms over startups. While the Optional Practical Training (OPT) program allows STEM PhDs to work in the United States for up to 3 y on their F-1 student visa, to remain longer foreign PhDs must obtain an employment-based temporary work visa, such as an H-1B. As such, securing a work visa is a major priority for foreign PhDs entering first-time industry employment. Given established firms’ resources and stability, foreign PhDs may expect that working in an established firm will increase their chances of obtaining a work visa, especially a highly coveted permanent resident visa. However, foreign PhDs may be concerned that startups are less able to secure a work visa and that startup failure would require them to either restart the visa process at a new employer or lose their eligibility to work in the United States entirely. As a result, current visa policies may deter highly skilled foreign PhDs from working in a startup, thereby making it difficult for startups to attract the talent that they need to innovate and compete against large firms.

There are also reasons why startups may be unable or unwilling to hire foreign PhDs. Startups typically have limited resources and managerial attention, and recruiting talented workers is a major activity for founders. This may be particularly challenging for technology startups seeking to hire highly specialized PhDs, as the number of potential employees with the necessary expertise may be small and difficult to find. In addition, the cost and time to sponsor a visa, which can range from \$5,000 to \$10,000 for attorney and filing fees and take several months, can be prohibitive for

Significance

We provide insights from a longitudinal survey that follows a cohort of 2,324 STEM PhDs from US research universities to their first industry employment in a startup or established firm. We show that foreign PhDs apply to and receive job offers from technology startups at the same rate as US PhDs but are less than half as likely to work in a startup. We present evidence that this discrepancy is not explained by foreign PhDs’ preferences for established firm jobs, risk tolerance, or preference for higher pay. We also show differences in visa sponsorship between startups and established firms, suggesting that visa policies may deter foreign PhDs from working in startups.

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*We use the term STEM to refer to life sciences, physical sciences, engineering, and computer science.

resource-constrained and inexperienced startups. Resource-rich established firms, however, have specialized human resource functions that mitigate the costs of hiring foreign workers. As such, startups may be faced with the choice between not recruiting foreign PhDs and thus, drawing from a smaller pool of talent and paying significantly more to hire foreign workers.

This study investigates the first-time industry employment of STEM PhDs in 3 ways. First, we consider general supply (worker) and demand (firm) factors by examining whether foreign and US PhDs differ in their likelihood of applying to startup jobs, reflecting PhDs' revealed intentions to work in a startup, and their likelihood of receiving startup job offers, reflecting startup' intentions to hire them. Second, we investigate whether individual characteristics observed during graduate school, such as stated career preferences, risk tolerance, and preferences for financial pay, explain employment outcomes. Third, we report differences in visa sponsorship between startups and established firms as well as the effect of receiving a permanent resident visa on foreign PhDs' subsequent mobility from established firms to startups. Although we do not provide direct causal evidence that visas explain differences in employment outcomes, the body of evidence suggests that visas play a role in deterring foreign PhDs from working in startups early in their careers.

By focusing on recent doctorates from US universities, our study departs from current debates over entry-level information technology workers coming to the United States from other countries on temporary work visas and displacing US workers for lower wages (2). In contrast, the industry labor market for STEM PhDs is characterized by lower unemployment and higher wages relative to STEM workers with undergraduate or master's degrees, indicating strong labor market demand for these highly specialized workers.[†] Foreign STEM PhDs are also of particular policy and economic interest given that their extraordinary skills place them among the highest priority applicants for permanent resident visas. Moreover, our sample represents young, early-career PhDs who have many years of productivity ahead and are arguably the ideal targets for visa policies intended to attract and retain highly skilled STEM workers to contribute to the US economy.

Methods

A particular challenge in examining employment outcomes using administrative data or population-level surveys is that they often lack detailed microdata on how individuals choose jobs. More critically, these data sources typically do not provide measures of individuals' characteristics and preferences before their first employment and thus, cannot identify whether foreign PhDs are, for example, less likely to work in startups by choice or are constrained in their ability to do so. We overcome these limitations through a longitudinal survey that follows a cohort of science and engineering PhD students from their graduate studies at 39 top-tier US research universities to their subsequent employment in the US private sector. By utilizing detailed survey responses on individuals' preferences and characteristics observed 1 to 3 y before seeking their first industry employment, we are able to both limit omitted variable bias and more precisely identify ex ante determinants of PhDs' early employment outcomes, a career stage when visa concerns are most likely to influence job choice for foreign PhDs. This survey was approved by the Cornell University Institutional Review Board. Informed consent was obtained from each respondent as part of an email invitation to participate in the study.

To obtain the initial survey sample, we identified top-tier US research universities with doctoral programs in science and engineering using the NSF's Survey of Earned Doctorates (7). Our selection of universities was based largely on program size while also ensuring variation in private/public status and geographic region. The 39 universities in our sample produced roughly 40% of graduating science and engineering PhDs in 2009 (*SI Appendix, Table S2* shows the list of fields, and *SI Appendix, Table S3* shows the list of universities). We collected ~30,000 email addresses from department websites and invited PhD students to participate in an online survey in spring 2010. For departments that did not list PhD students' email addresses, we contacted department administrators and asked that they forward a survey link to their graduate students. Overall, 88% of responses for our baseline survey were obtained through

direct email, and 12% were through administrators. Adjusting for 6.3% undeliverable emails, the direct survey approach had an adjusted response rate of 30%. Respondents were surveyed again in 2013, 2016, and 2018 as they progressed through the PhD program and transitioned to postgraduate employment, with an average response rate of 73% of the initial 2010 sample.

We supplemented the survey with hand-curated online career profile data gathered in 2014, 2016, and 2018 from LinkedIn, university websites, and a Google search for all respondents in the baseline PhD survey to ensure comprehensive data on employment outcomes. We first searched for respondents by name and university and then, verified the match by comparing the degree field and years in the PhD program reported in the survey. We rely primarily on survey responses to identify employment outcomes, with the online career data being used to validate the survey and supplement missing data. Among the 8,173 PhDs who were employed full time by 2016, 50.1% of US PhDs and 47.0% of foreign PhDs were still in academia (i.e., postdoctorate, tenure-track faculty, or non-tenure track university), while 41.8% of US PhDs and 46.8% of foreign PhDs were employed in the private sector. While prior studies have shown that visa concerns may influence international students' decisions regarding employment (8) or returning to their home country (9), in our sample we do not observe differences between foreign and US PhDs in the rate at which they leave academia to enter industry employment (*SI Appendix* has details).

To focus our investigation on how visa sponsorship might explain differences between foreign and US PhDs' industry employment in a startup or an established firm, we restrict our sample to PhDs employed in the US private sector.[‡] The sample used in this study consists of 2,324 PhDs who graduated and entered industry employment in the United States in R&D-related occupations between 2010 and 2016. We focus on R&D-related occupations, since these are the most prevalent first industry jobs for science and engineering PhDs (82.5% of industry occupations in our sample) as well as to ensure that our comparison is between PhDs choosing between similar jobs in startups and established firms. R&D-related occupations are identified either by survey-reported work activities (i.e., at least 40% of their work activities are basic research, applied research, and/or development) or by LinkedIn job title (e.g., research scientist, research engineer, software engineer, etc.). We exclude other industry occupations, such as consulting and finance, which are uncommon in startups, as well as startup founders and executives, which are uncommon first-time jobs in established firms.

We asked respondents to the initial PhD survey whether they were a US citizen as well as their visa status during the PhD program if they were not a US citizen. We use these responses to distinguish between US PhDs and foreign PhDs who graduated on a temporary student visa (e.g., F-1) and require a visa to work in the United States.[§] In select analyses, we also include foreign-born PhDs who obtained a permanent resident visa (i.e., a green card) before entering industry employment and do not require a work visa as a comparison with temporary resident foreign PhDs who do require a work visa. For the sample used in this study, 65.4% of PhDs are US citizens, 30.8% are foreign temporary residents, and 3.8% are permanent residents.[¶] Among foreign temporary resident PhDs in our sample, more than half are from 2 countries: China (31.5%) and India (23.7%). The share of foreign PhDs is highest in computer science (49.8%) and engineering (37.8%) and lowest in the life sciences (16.4%).

To identify whether a PhD's first industry job was in a startup or an established firm, we rely on both survey and LinkedIn data on employer age and the number of employees. In the employment survey, we asked respondents to report the approximate number of employees at their employer using a dropdown menu with number ranges as well as whether their employer was founded in the past 5, 6 to 10, or more than 10 y. LinkedIn

[†]In *SI Appendix*, we examine for selection bias by replicating our main analyses using a sample that includes PhDs who remained in academia with substantively identical results. In additional analyses, we find no difference between foreign and US PhDs in the likelihood of remaining in academia or transitioning to industry.

[‡]OPT is an extension of the F-1 student visa allowing eligible STEM graduates from US universities to work in their field of study for up to 29 mo during the period of our study (the duration was increased to 36 mo in 2016). Foreign PhDs use the OPT as a bridge to an H-1B or permanent residency. Recent graduates may work on their OPT without employer sponsorship and are in effect "self-sponsored." However, given that it may take several years to obtain an H-1B or permanent residence, foreign PhDs likely prefer jobs that offer these longer-term visas over jobs that require them to work solely on their OPT.

[¶]We benchmarked our survey to the NSF's SDR (18) for early-career PhDs in the private sector. The SDR sample represents all doctorate-granting universities, while our sample is drawn from top-tier research universities where the share of foreign-born PhDs may be lower. In the SDR sample, 43.9% are US citizens, 51.4% are foreign temporary residents, and 4.7% are permanent residents. Authors' calculations are based on the public use SESTAT Data Tool: <https://ncesdata.nsf.gov/sestat/sestat.html>.

[†]Unemployment rates for STEM PhDs in the United States were ~2% or lower during the period of our study (6).

employer profiles provide information on a similar range of the number of employees as well as the firm founding year. We code employers as startups if they were founded within 5 y and had 100 or fewer employees at the time that a PhD started employment.[#] All other employers are coded as “established” firms, including fast-growing young companies that had over 100 employees (e.g., 23andMe, Uber, etc.) and corporate spinoffs that are typically young and large (e.g., Google Life Sciences spinoff Verily). For PhDs for whom we observe both survey and LinkedIn data, the correspondence between employment types is 95.8%.

Results

The majority of employers in our sample are technology firms, especially among startups, where 31% are computer and information technology, 27% are biotechnology or biomedical, and 15% are R&D services. Leading technology firms, such as Google, Genentech, and Qualcomm, account for a large share of established firm employees. Across industries, 15.8% of US PhDs are startup R&D employees compared with 6.8% of foreign PhDs, illustrating a lower incidence of foreign PhDs working in startups than we might expect given their prevalence in the private sector workforce. This disparity is illustrated in Fig. 1, which presents the percentage of US and foreign PhD industry R&D employees working in startups by degree field.

Job Applications and Job Offers. We first consider whether foreign PhDs differ from US PhDs in their likelihood of applying to and receiving an offer for a startup job in the United States. Examining job applications and offers provides insights into supply- and demand-side explanations for why foreign PhDs are less likely to work in startups. On the supply side, foreign PhDs may be less likely to apply to startup jobs if they expect that startups are unlikely to sponsor them for a work visa or if they think that startups’ greater risk of failure may jeopardize their ability to obtain a visa. On the demand side, startups may be less likely to make offers to foreign PhDs given the time, expense, and uncertainty of sponsoring them for a work visa.

To investigate startup job applications and offers, we sent respondents to the initial PhD survey a follow-up employment survey after graduation ($n = 1,336$ for those employed in industrial R&D; 57% response rate) that asked a range of questions about their job search, including whether they applied to a startup job and whether they received at least 1 startup job offer (*SI Appendix* has details). We did not define the age or size of startups in our question, and responses reflect PhDs’ own perceptions of whether the job was in a startup. Overall, 40.5% of foreign and 47.3% of US PhDs applied for at least 1 startup job, and conditional on applying, 62.1% of foreign and 58.2% of US PhDs received at least 1 startup job offer.^{||} For comparison, 97.7% of foreign and 94.5% of US PhDs applied for at least 1 established firm job, and conditional on applying, 95.1% of foreign and 92.7% of US PhDs received at least 1 established firm job offer.

One limitation of observed job search behavior is that it conflates career preferences that lead individuals to apply to a job with constraints, such as visa sponsorship, that may deter them from applying. For example, a lower rate of foreign PhDs

[#]We calculate firm age at the time that an employee joined the firm by subtracting the firm founding year from the year of a PhD’s first employment. Since firm size was based on the number of employees observed either at the time of the survey or at the time that LinkedIn profiles were obtained, we manually searched for public information on the number of employees at the time that the PhD started employment for firms under 5 y of age and over 100 employees to confirm firm size.

^{||}To investigate potential selection bias in our sample of PhDs in industrial R&D, we examined startup job search and employment outcomes for a sample that also included PhDs who remained in academia. We find no evidence of differences between foreign and US PhDs in the likelihood of applying to startups jobs or remaining in academia. We do find, however, compelling evidence of PhDs’ ex ante stated career preferences predicting ex post employment, with PhDs who prefer faculty careers significantly more likely to remain in academia and significantly less likely to work in a startup or an established firm. Given that selection seems to be based on preferences and not citizenship, restricting our sample to PhDs employed in industrial R&D does not bias our comparison of foreign and US PhD employment in startups.

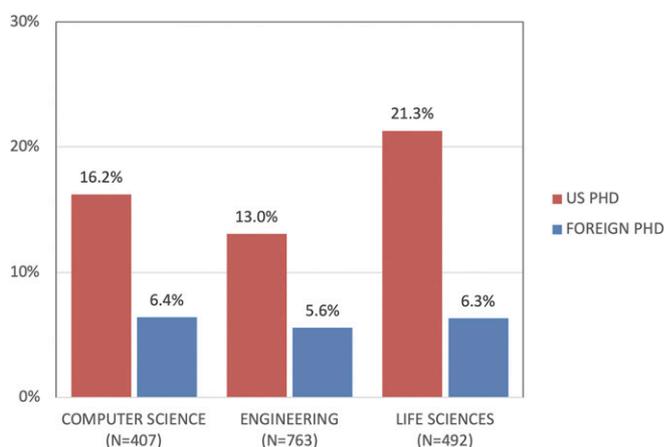


Fig. 1. Share of US and foreign PhD industrial R&D employees working in a startup by field.

applying to startup jobs may reflect visa concerns deterring them from applying or a lower interest in working in a startup. To disentangle these effects, we examine whether stated work interests before entering the labor market predict job applications and job offers. To measure work interests, we asked respondents while in graduate school and before their job search to rate the attractiveness of a range of occupations, including working in a startup and working in an established firm. Each occupation was rated independently on a 5-point Likert scale that ranged from “extremely unattractive,” 1, to “extremely attractive,” 5.^{**} We created a simplified measure that reflects whether individuals were interested in a particular occupation or not, dichotomizing this response with “attractive,” 4, and “extremely attractive,” 5, coded as 1 and other responses coded as 0 (i.e., “not attractive”). As with the job application and job offer questions, responses reflect PhDs’ own perceptions of startup employment. Among our sample of STEM PhDs, 74% of foreign PhDs and 64% of US PhDs reported during graduate school an interest in working in a startup after graduation, and this difference is significant (t statistic = -4.60 , P value = 0.000).

Logistic regression results of the likelihood of applying to and receiving an offer for a startup while controlling for demographic characteristics, year of employment, and degree field are presented in Fig. 2 (*SI Appendix*, Table S6 shows full results). Fig. 2, *Left* shows that both US and foreign PhD students who reported during graduate school an interest in working in a startup are most likely to apply to startup jobs (50.3 and 49.1%, respectively) and are not significantly different from one another ($\chi^2 = 0.05$, P value = 0.825). Foreign PhDs not interested in working in a startup are significantly less likely to apply (31.0%) than foreign PhDs who are interested in working in a startup. Fig. 2, *Center* illustrates that, conditional on applying to a startup job, there is no significant difference between US and foreign PhDs in the likelihood of receiving a startup job offer. However, Fig. 2, *Right* shows that, conditional on receiving a startup job offer, US PhDs interested in working in a startup are most likely to work in a startup (53.9%), while foreign PhDs interested in working in a startup are significantly less likely to do so (35.1%). Foreign PhDs not interested in working in a startup are the least likely to work in a startup (10.6%). We examined for selection bias using a sample that includes PhDs who remained in academia with substantively identical results (*SI Appendix* has details).

Although not presented in Fig. 2, we also included in our analyses foreign PhDs who entered industry employment with a permanent resident visa (i.e., green card) and did not require visa sponsorship to work in the United States. If visa sponsorship

^{**}Our measures of career attractiveness are not mutually exclusive, and thus, individuals could report that working in a startup and in an established firm are both attractive.

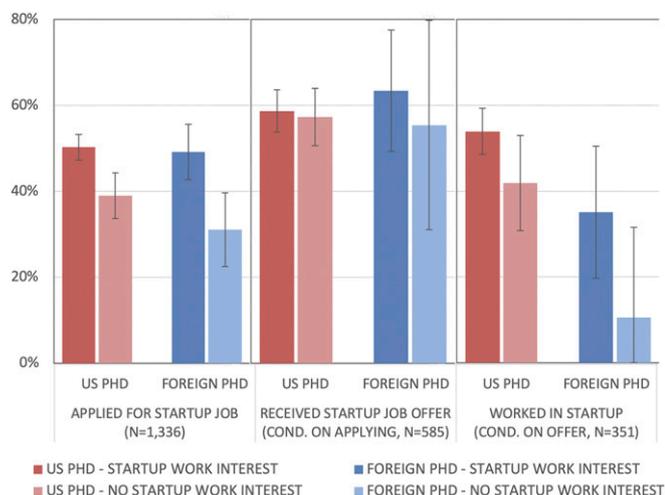


Fig. 2. Estimated likelihood of applying to a startup job (*Left*), receiving a startup job offer conditional on applying (*Center*), and working in a startup conditional on receiving an offer (*Right*) with robust 95% confidence intervals (*SI Appendix, Table S5* has full results). Startup work interest was measured during graduate school and before the job search.

is a key factor explaining why foreign PhDs on a temporary visa are less likely to work in a startup, then we would expect that permanent resident PhDs, who are foreign but already have a work visa, will not differ from US PhDs in their likelihood of working in a startup. However, if other factors associated with being foreign, such as English language proficiency, cultural differences, or discriminatory hiring practices, constrain all foreign PhDs from working in a startup, then we would expect permanent resident PhDs to also be less likely to work in a startup. As reported in *SI Appendix, Table S5*, we find that permanent resident PhDs do not differ significantly from US PhDs in their likelihood of applying to startup jobs, receiving startup offers, or working in a startup. Moreover, conditional on receiving a startup job offer, permanent resident PhDs are more likely to work in a startup than foreign PhDs, indicating that temporary visa status, rather than being foreign per se, is a factor in startup employment outcomes.

Together, these results indicate that foreign PhDs interested in startup employment apply to and receive job offers from startups at the same rate as US PhDs, but among those who receive a startup job offer, roughly 3/4 work instead in an established firm. We examine differences in visa sponsorship between startups and established firms that may influence job choice in the visa progression analysis below.

Determinants of Working in a Startup. We now examine possible explanations for why foreign PhDs are less likely to work in a startup. To do this, we exploit a unique feature of our survey that combines ex ante responses from PhDs while in graduate school and their observed ex post employment using LinkedIn career data for our full sample of PhDs employed in industrial R&D ($n = 2,324$), including PhDs who may not have responded to the follow-up employment survey. While not exhaustive, we focus on 4 factors that might influence foreign PhDs' decision to work in a startup that are of particular relevance for visa policies: 1) work interests for employment in a startup or established firm, 2) risk tolerance, 3) preferences for higher pay, and 4) worker ability.

First, if foreign PhDs prefer to work in established firms over startups, then reducing visa constraints may have little effect on increasing foreign PhD employment in startups. Prior research, however, shows that, relative to US PhDs, foreign PhDs are more likely to start companies (10) and are more interested in both founding companies and working in startups after graduation (11, 12). Thus, if visas deter foreign PhDs from

accepting startups jobs, especially early in their careers, then we would expect that work interests will have less influence on employment outcomes for foreign PhDs, while US PhDs will choose jobs that align with their work interests. Fig. 3 illustrates odds ratios from logistic regressions for separate samples of US and foreign PhDs (*SI Appendix, Table S7* shows full results). We see that US PhDs who were interested in working in a startup during graduate school are more likely to work in a startup after graduation, while foreign PhDs with the same ex ante startup work interest are not significantly more likely to work in a startup. We also note that US PhDs who were more interested in working in an established firm are less likely to work in a startup (i.e., more likely to work in an established firm), providing additional evidence that US PhDs choose jobs that align with their work interests while foreign PhDs who require a temporary work visa do not.

Second, we examine whether risk tolerance explains differences between US and foreign PhDs' startup employment. Prior entrepreneurship research has emphasized that individuals with a higher risk tolerance are more likely to participate in entrepreneurship (13), and greater risk tolerance has been put forth as one explanation for immigrants' higher rates of entrepreneurship (10). A recent study also shows that foreign PhDs are more risk tolerant while in graduate school than their US counterparts (14). However, if visa policies deter foreign PhDs from working in startups, then risk tolerance should play less of a role in explaining startup employment relative to US PhDs. To measure risk tolerance, we asked respondents during graduate school to report their preference between 2 gambles—a sure bet with a lower payoff and a lower probability bet with a higher payoff—on a 10-point scale that ranged from “strongly prefer a 100% chance to win \$1,000” to “strongly prefer a 50% chance to win \$2,000.” Higher values reflect a greater willingness to choose a riskier outcome with a higher potential payoff, which we interpret as a greater risk tolerance. The average risk tolerance values are 2.05 for US PhDs compared with 2.62 for foreign PhDs (t statistic = -4.78 , P value = 0.0001) and 2.22 for established firm employees compared with 2.52 for startup employees (t statistic = -1.98 , P value = 0.048). Fig. 3 illustrates that US PhDs who are more risk tolerant are more likely to work in a startup, while there is no effect for more risk-tolerant foreign PhDs. Thus, despite foreign PhDs on average being more risk tolerant than US PhDs, it seems that risk tolerance does not explain why foreign PhDs are less likely to work in a startup.

Third, we consider whether foreign PhDs' preference for financial pay might influence their decision to work in established firms. Prior studies have shown that resource-constrained startups pay lower salaries to their employees in exchange for equity (15, 16). Indeed, in our survey, the average reported starting salary in a startup is \$95,537 compared with \$108,761 in an established firm, and 75% of startup employees received company equity

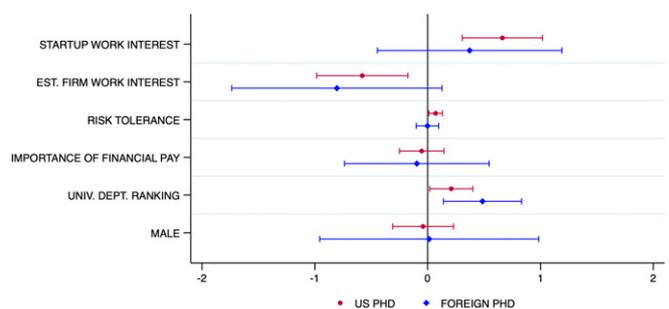


Fig. 3. Odds ratios of working in a startup for US and foreign PhDs with robust 95% confidence intervals (*SI Appendix, Table S6* has full results). Control variables include degree field fixed effects, job start year fixed effects, marital status, children, and postdoctorate before working in industry.

compared with 40% of established firm employees.^{††} To the extent that startups offer lower starting salaries, then PhDs for whom financial pay is more important will likely choose jobs in established firms that pay more. If so, then changes in visa policies may have little effect on foreign PhDs' employment in startups if they are still lured to established firms by higher pay. We use a survey question that asked respondents during graduate school about the importance of a range of attributes regarding their "ideal" job. Specifically, we asked how important financial income is to them on a 5-point Likert scale that ranged from "not at all important," 1, to "extremely important," 5. Fig. 3 shows that the importance of financial pay is not associated with the likelihood of working in a startup for either foreign or US PhDs.

Fourth, an important consideration for entrepreneurship policy is whether visa concerns might deter high-ability foreign PhDs from working in a startup, thereby further constraining startups' access to highly skilled workers. Fig. 3 shows that National Research Council university department rank (17), a signal of PhD ability that is observable to prospective employers, is significantly associated with the likelihood of working in a startup for both foreign and US PhDs, and the effect is significantly stronger for foreign PhDs.^{‡‡} Thus, while foreign PhDs are less likely to work in startups, those who do are more likely to come from higher-ranked university departments. Fig. 3 shows no gender difference for foreign or US PhDs in the likelihood of working in a startup.

One may be concerned that our results are driven in part by foreign PhDs from universities outside entrepreneurial regions experiencing greater difficulty in finding startup jobs. For example, in our sample, 87% of foreign PhDs graduated from universities outside of the San Francisco (i.e., Berkeley, Stanford, or the University of California, San Francisco) and Boston (i.e., Harvard or Massachusetts Institute of Technology) entrepreneurial regions compared with 76% of US PhDs. As reported in *SI Appendix, Table S8*, we find that US PhDs from universities in these 2 entrepreneurial regions are more likely to work in a startup, but foreign PhDs are not. Thus, even foreign PhDs who were embedded in entrepreneurial regions during graduate school are less likely than US PhDs to work in a startup.

Visa Progression. Although the previous analyses suggest that startups attempt to hire foreign and US PhDs at similar rates, the significantly lower rate of foreign PhDs working in startups may be attributable to differences in the types of visa sponsored between startups and established firms. To investigate this, we asked foreign PhDs to report the type of visa that they were sponsored for in their first job ($n = 321$ established firm employees; $n = 38$ startup employees). The small number of observations for foreign startup employees reflects the relative rare incidence of the phenomenon under investigation and is comparable with numbers from the NSF's nationally representative survey of doctorate recipients (SDR) (18).^{§§} Nevertheless, the small sample for foreign PhD startup employees does limit our ability to draw strong comparisons regarding differences in the visa patterns between startups and established firms.

As illustrated in Fig. 4, 24% (9 of 38) of foreign PhDs in startups were not sponsored for a visa and worked on their own OPT, 34% (13 of 38) were sponsored for an H-1B, 26% (10 of 38) were sponsored for a permanent resident visa, and 8% (3 of 38) self-petitioned their own permanent resident visa (e.g., National

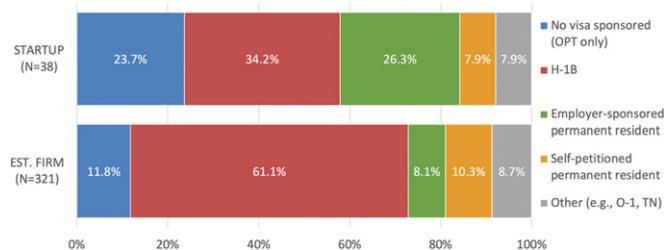


Fig. 4. Share of first work visa type between startups and established firms.

Interest Waiver). In established firms, 12% of foreign PhDs worked on their own OPT without employer sponsorship, 61% were sponsored for an H-1B, 8% were sponsored for a permanent resident visa, and 10% self-petitioned their own permanent resident visa. Although based on a small number of observations, these findings suggest important differences in visa sponsorship between startups and established firms.

To examine visa progression over foreign PhDs' early careers, we explored current visa status at the time of the survey. We focus on foreign PhDs who were employed in industry for at least 4 y ($n = 233$) to allow time for progression from OPT, which is valid for up to 29 mo after graduation for STEM PhDs during the period of our study, to another visa type. Roughly 63% of foreign PhDs have received a permanent resident visa within 4 y of working in industry: 45% employer sponsored, 9% self-petitioned (e.g., National Interest Waiver), and 9% by marriage or family relations. An additional 13% of foreign PhDs are on an H-1B and being sponsored by their employer for a permanent resident visa. Of all permanent resident visas that are employment based, 52% are EB-1, the highest preference category for individuals with extraordinary ability or outstanding researchers, and 48% are EB-2, the second highest preference category for individuals with advanced degrees or exceptional ability, with the majority being employer sponsored.^{¶¶}

We also examined whether receiving a permanent resident visa is related to employee mobility from established firms to startups. Multinomial regression analyses (*SI Appendix, Table S9*) indicate that foreign PhDs who first worked in an established firm and subsequently received a green card are more likely to move to a startup rather than to another established firm or to stay with their first employer. This result holds even after controlling for whether the PhD has been in the workforce for at least 3 y. Moreover, US PhDs who have been working at least 3 y are more likely to move to another established firm but not a startup. These results suggest that permanent residency facilitates foreign PhD employment in startups.^{##}

Policy Analysis. Although we are unable to provide causal evidence that US visa policies directly influence foreign PhD job choice, the body of evidence suggests that visa concerns may deter foreign PhDs from working in startups, even among PhDs who are most interested in working in a startup. To examine whether foreign PhDs might be responsive to reforms that reduce visa constraints to working in a startup, we estimated the counterfactual probability of foreign PhDs working in a startup based on observable characteristics, such as ex ante career interests. If visa sponsorship deters foreign PhDs who are interested in working in a startup from doing so, then we would expect that, in the counterfactual situation where visas do not constrain employment choice, a greater share of foreign PhDs would work in a startup. This may occur, for example, if STEM PhDs with degrees from US universities were eligible for permanent residency on graduation.

^{††}OLS regressions predicting starting salary controlling for job year and degree field fixed effects confirm that startups pay 10.4% (\$11,290) less than established firms, and the difference is significant.

^{‡‡}A seemingly unrelated test comparing coefficient estimates for foreign and US PhDs shows that they are significantly different from one another ($\chi^2 = 4.83$, P value = 0.028).

^{§§}We benchmarked our number of observations to publicly available data from the NSF's SDR for PhDs corresponding to our survey respondents by field, graduation year, and work type. The corresponding SDR data include 1,941 responses compared with 2,324 responses in our survey. In the SDR, 59 temporary resident PhDs work in startups compared with 49 in our survey, indicating that foreign PhDs working in startups are a rare occurrence and lower than we might expect given the prevalence of STEM foreign PhDs in the private sector workforce.

^{¶¶}Eligibility for EB-1 is typically demonstrated through major scientific contributions, publications, patents, international awards, and a high salary commensurate with extraordinary ability. EB-2 eligibility is often demonstrated through an advanced research degree, such as the PhD, and a salary commensurate with exceptional ability.

^{##}We thank the editor for suggesting this analysis, which we detail in *SI Appendix*.

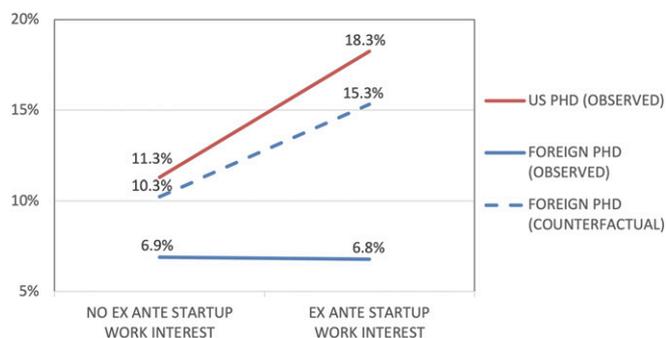


Fig. 5. Share of US and foreign PhDs working in a startup by ex ante stated startup work interest. Solid lines indicate the observed shares; the dotted line is the counterfactual predicted share based on observables for foreign PhDs.

To do this, we first estimated the likelihood of working in a startup for US PhDs given observable ex ante work interests, risk tolerance, demographic characteristics, job start year, and degree field (SI Appendix, Table S9). We then used these estimates to predict the out-of-sample probability of working in a startup for foreign PhDs based on the same observable variables. A critical assumption of this analysis is that, after accounting for observables, the remaining difference between US and foreign PhDs is attributable to visa policies that influence employment outcomes. In other words, we assume that temporary resident foreign PhDs are exogenously treated by work visa requirements that will differentially influence their job choice relative to US citizens who are untreated after controlling for other factors that influence job choice. A limitation of this approach is that it does not account for all possible factors that might constrain foreign PhDs from working in a startup, and the variance explained by our data is modest (SI Appendix, Table S9). Thus, it is conceivable that our estimates could partly reflect unobservable systematic differences between US and foreign PhDs other than visa sponsorship. Nevertheless, the primary objective of this analysis is to provide insights into whether foreign PhDs might be more likely to work in a startup under the counterfactual condition that visa constraints do not influence job choice.

Fig. 5 illustrates the observed share of US and foreign PhDs employed in startups by whether or not they were interested in working in a startup during graduate school. For US PhDs, there is an increase in the share who work in a startup: from 11.3% of US PhDs with no ex ante startup work interest to 18.3% of those with an ex ante interest. For foreign PhDs, however, there is no difference in the observed share working in startups between those who were not interested (6.9%) and those who were (6.8%). The counterfactual predicted share of foreign PhDs who work in a startup is illustrated as the dotted line in Fig. 5, which is quite comparable with the observed share of US PhDs. Notably, among foreign PhDs who were

interested in working in a startup during graduate school, the counterfactual predicted share (15.3%) is more than double the observed share (6.8%). While one might expect the counterfactual share of foreign PhDs working in startups to be higher than US PhDs given the former's stronger interest in working in a startup, the relatively modest number of observable variables limits the precision of this analysis. Nevertheless, these results suggest that visa reforms could increase the overall size of the workforce available to startups.

Discussion

Overall, these findings illustrate a large gap in the startup employment outcomes of foreign and US STEM PhDs with degrees from US universities. Specifically, foreign STEM PhDs who require visa sponsorship are half as likely as their US peers to work in technology startups in their first industry job. This not only has implications for our understanding of science careers and the highly skilled immigrant workforce but also, reveals the burden that current US visa policies place on technology startups. Given the large and growing number of foreign STEM PhDs graduating from US universities, this is a significant issue for high-growth technology startups and the overall innovation economy.

These findings have implications for debates on visa reform relating to highly skilled STEM workers and entrepreneurship. For example, visa policies that facilitate permanent residency may make it easier for technology startups to hire foreign STEM PhDs as well as mitigate the visa concerns steering foreign PhDs away from startups. In addition, although based on a small number of observations, our finding that a large share of foreign PhD startup employees work on OPT suggests that rescinding the OPT STEM extension, which has been the subject of recent policy debate, could severely limit technology startups' ability to hire and retain foreign PhD graduates.

We understand, of course, that the opportunity to work in the United States is a great prize, and incentives are strong for ancillary actors to game the system, such as already occurs in other areas of temporary work visas. Visa reforms that level the playing field for startups will need regulatory structures and auditing systems to prevent fraudulent startup job offers or other workarounds that take advantage of any new or eased visa policies.

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