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Are Foreign STEM PhDs More Entrepreneurial?

Entrepreneurial Characteristics, Preferences, and Employment Outcomes of Native and Foreign Science and Engineering PhD Students

Michael Roach, Henry Sauermann, and John Skrentny

8.1 Introduction

A large body of literature shows that immigrant and foreign workers are more likely than US natives to become entrepreneurs (Borjas 1986; Fairlie 2008; Hunt 2011; Fairlie and Lofstrom 2015; Kahn, La Mattina, and MacGarvie 2017). Recent studies have also shown that immigrants play key roles as founders and early employees in technology firms (Hart and Acs 2011) and in entrepreneurial clusters such as Silicon Valley (Saxenian 1994). Although this pattern is well documented, the underlying reasons why immigrants are more entrepreneurial remain an important area of investigation. Some researchers argue that labor market factors such as discrimination (Oreopoulos 2011) or language requirements (Hunt 2011) constrain opportunities for career advancement in existing firms, making entrepreneurship more attractive than wage employment. Moreover, the availability of immi-

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grant networks (Saxenian 2002) or coethnic financing (Bengtsson and Hsu 2015) may encourage or facilitate immigrants' moves to entrepreneurship. Others contend that immigrants differ from natives in individual characteristics and preferences such as risk tolerance (Blume-Kohout 2016) or that they may self-select into science, technology, engineering, and mathematics (STEM) fields that provide greater exposure to entrepreneurial opportunities (Hunt 2011).

Although considerable research effort has been directed toward understanding founding activity among immigrants, little attention has been paid to foreign workers who join start-ups as employees rather than as founders. Such entrepreneurial employees are particularly important in technology-intensive ventures (Baron, Hannan, and Burton 2001; Roach and Sauermann 2015; Kim 2018), where foreign PhDs constitute a significant and particularly productive part of the science and engineering workforce (Stephan and Levin 2007; National Science Board 2014). As such, it is important to understand differences between native and foreign PhD students with respect to individual attributes such as risk preferences or entrepreneurial aspirations, as well as whether such individual characteristics might explain differences between native and foreign PhDs in their likelihood to take employment in technology-based start-ups.

We provide initial comparative evidence on entrepreneurial preferences and outcomes of native and foreign science and engineering doctorates using survey data from more than 5,600 STEM PhD students at 39 US research universities. These students were observed during graduate education and then again after transition into their first-time employment, including becoming founders. As such, the data allow us to compare foreign and native PhD students or start-up employees with respect to their ex-ante entrepreneurial career preferences as well as their ex-post employment.

We report three key findings. First, foreign PhD students differ from their native peers with respect to characteristics and preferences typically associated with entrepreneurship. Specifically, foreign PhD students are more risk tolerant, have greater preferences for autonomy, and are more interested in commercialization activities than are native PhD students. Second, foreign PhD students are more likely than natives to have intentions of becoming founders or joining a start-up as employees, suggesting that they might become important entrepreneurial actors and human capital for technology start-ups. Third, however, foreign PhDs are less likely than native PhDs to either become founders or join start-ups as employees after graduation and instead are more likely to work in established firms. Given the stronger entrepreneurial interests of foreign PhDs prior to entering the private sector, these differences in employment outcomes are unlikely to reflect differences in career preferences and instead point to possible labor market factors that may constrain entrepreneurial activity and start-up employment.

8.2 Data

Our empirical analysis utilizes the Science and Engineering PhD Panel Survey (SEPPS), a national longitudinal survey of 5,669 science and engineering PhD students from 39 top-tier US research universities. To obtain the initial sample, we identified US research universities with doctoral programs in science and engineering fields by consulting the National Science Foundation's reports on earned doctorates (National Science Foundation 2009). Our selection of universities was based primarily on program size while also ensuring variation in private/public status and geographic region. The 39 universities in our sample produced roughly 40 percent of the graduating PhDs in science and engineering fields in 2009.

We collected roughly 30,000 email addresses from department websites and invited individuals to participate in the online survey using a four-contact strategy (one invitation, three reminders). For departments that did not list students' email addresses, we contacted department administrators to request that they forward a survey link to their graduate students. Overall, 88 percent of our responses were obtained directly from respondents, and 12 percent were obtained through administrators. The initial contact for all respondents occurred over a two-week period in February 2010, and all responses were collected within an eight-week window. Adjusting for 6.3 percent undeliverable emails, the direct survey approach achieved an adjusted response rate of 30 percent.[1] Respondents were surveyed again in 2013 and 2016 with an average response rate of 73 percent of the initial 2010 sample. Given our interest in career preferences prior to entering the workforce, we use the most recent survey prior to graduation.

We distinguish between foreign and native PhD students through a survey question that asked whether the respondent was a US citizen during graduate school. PhD students who were US citizens were classified as *native*, while non-US citizens were classified as *foreign*. Approximately 34.3 percent of our sample are foreign PhD students. To examine for potential response bias, we benchmarked our sample to the NSF Survey of Earned Doctorates (SED), where the share of foreign-born science and engineering PhDs graduating in 2012 was 40.2 percent (National Science Foundation 2017).[2] Whereas the SED includes all doctorate-granting universities, our sample is drawn from top-tier R1 universities, where the share of foreign-born PhDs may differ. Given that PhD students at top research universities likely differ in their preferences, ability, and employment opportunities, our results may

1. See Sauermann and Roach (2013) for details on the survey methodology, sample, and response rate.

2. Authors' calculations based on data table 17 for science and engineering fields and graduation years corresponding to the survey used in this study: https://ncses.nsf.gov/pubs/nsf19301/assets/data/tables/sed17-sr-tab017.xlsx.

not be generalizable to all PhD students from US universities. Among the foreign PhD students in our sample, approximately 24.0 percent are from China and 15.7 percent are from India.[3] The share of foreign PhD students is highest in computer science (54.1 percent) and engineering (43.0 percent) and lowest in the life sciences (23.4 percent). Our statistical analyses control for 18 detailed fields of study to account for heterogeneity in the nature of research, norms regarding career paths, and other unobserved factors.

8.3 Results

Building on prior work on predictors of entrepreneurship, we first examine differences between foreign and native PhD students with respect to individual characteristics such as ability and risk tolerance in section 8.3.1. We then study differences in founder intentions and preferences for joining start-up employment in section 8.3.2. In section 8.3.3, we examine foreign PhD students' intentions to remain in the US after graduation. We then compare foreign and native PhDs with respect to their postgraduation outcomes as founders, start-up employees, or established firm employees and explore the extent to which these outcomes may be explained by ex-ante career preferences in section 8.3.4.

8.3.1 Comparing Entrepreneurial Characteristics of Native and Foreign PhD Students

The entrepreneurship literature has examined a range of individual characteristics as predictors of entrepreneurial behaviors and founder transitions (Shane, Locke, and Collins 2003; Astebro, Chen, and Thompson 2011; Kerr, Kerr, and Xu 2017). Recent work suggests that these characteristics may also explain career preferences to join start-ups as an employee (Roach and Sauermann 2015). Our survey allows us to compare foreign and native PhD students with respect to a number of characteristics commonly associated with entrepreneurship, including preferences for specific job attributes such as autonomy and commercialization and individual characteristics such as risk tolerance and ability. Table 8.1 reports mean values for these variables for native and foreign PhD students.

Risk Tolerance. We obtain a proxy for risk tolerance by using a lottery-type question (Charness, Gneezy, and Imas 2013). More specifically, we asked respondents to choose between one of two gambles 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 willing-

3. Foreign PhD students were asked for their nationality in the survey. Approximately 4 percent of respondents did not report their citizenship or nationality. We used LinkedIn data on the country of their undergraduate degree as an indicator of their nationality where possible to fill in missing data.

ness to choose a riskier outcome with a higher potential payoff, which we interpret as a greater tolerance for risk.

Importance of Autonomy and Income. We measure respondents' preferences for autonomy and financial income by asking them to rate the importance of these job attributes, among other job attributes, on a five-point scale from "not at all important" to "extremely important." To measure autonomy, we asked about the importance of "freedom to choose research projects," and to measure income, we asked about the importance of "financial pay (e.g., salary, bonuses)."

Interest in Work Activities. We measure individuals' interest in different work activities on a five-point scale that ranged from "extremely uninteresting" to "extremely interesting." The set of activities included "commercializing research results into products and services" (interest in commercialization), "management or administration" (interest in management), "research that contributes fundamental insights or theories (basic research)" (interest in basic research), and "research that creates knowledge to solve practical problems (applied research)" (interest in applied research).

Ability. We employ two different measures to proxy for ability. First, we use the academic reputation of a PhD student's university department based on the National Research Council's rankings (National Research Council 2010).[4] Although these are department-level research rankings rather than individual-level measures of ability, department quality is observable to prospective employers and is likely an important factor in hiring decisions. Moreover, it is likely that highly ranked departments are more selective in admitting and training PhD students such that department quality is likely correlated with individual ability as well. Second, we obtain a subjective individual-level measure of ability by asking respondents to rate their own (research) ability relative to their peers using a slider scale that ranged from 1 to 10. Although this measure likely captures both true ability and overconfidence (Camerer and Lovallo 1999), we expect that individuals' perceptions of their own ability influence their job search behaviors, their confidence during job interviews, and their own expectations of success, especially in entrepreneurship (Roach and Sauermann 2015; Lazear 2016).

Table 8.1 reports summary statistics for these variables for native PhD students, all foreign PhD students combined, and separately for foreign PhD students from China, India, and Western countries (Western Europe, Canada, and Australia). The table also reports potentially important control variables taken from the survey, including gender and marital status. In addition, to control for social factors that may shape entrepreneurial prefer-

4. NRC rankings are not available for some departments in our sample. In such cases, we used the university average for the broader field of study. For example, if the ranking of the department of electrical engineering for a given university was unavailable, we used the average of all engineering departments at the same university.

Table 8.1 **Summary statistics comparing native and foreign PhD preferences and characteristics**

	Native (n = 3,880)		All foreign (n = 1,792)		China (n = 447)		India (n = 295)		Western (n = 175)	
Variable	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
Risk tolerance	1.88	2.29	2.54	3.00	2.92	3.29	2.68	3.21	1.85	2.18
Importance of autonomy	3.94	0.85	4.06	0.75	3.88	0.73	4.21	0.63	4.07	0.83
Importance of income	3.94	0.74	4.08	0.65	4.09	0.60	4.09	0.68	3.89	0.70
Interest in basic research	3.93	0.98	3.84	0.99	3.43	1.06	4.06	0.85	4.05	0.93
Interest in applied research	4.34	0.68	4.35	0.65	4.25	0.61	4.45	0.61	4.37	0.75
Interest in commercialization	3.27	1.11	3.69	1.02	3.91	0.84	3.78	1.06	3.30	1.17
Interest in management	2.83	1.18	3.03	1.11	3.41	0.95	2.91	1.16	2.62	1.20
Self-assessed ability	6.17	1.66	6.66	1.64	6.79	1.59	6.80	1.55	6.40	1.66
Lab academic norms	4.23	0.77	4.05	0.77	4.05	0.71	4.10	0.77	4.11	0.82
Lab entrepreneurial norms	3.23	0.72	3.40	0.69	3.51	0.68	3.47	0.70	3.23	0.72
Founder role model	0.10	0.30	0.13	0.33	0.12	0.33	0.11	0.31	0.12	0.33
Male	0.58	0.49	0.70	0.46	0.71	0.45	0.75	0.43	0.71	0.46
Married	0.51	0.50	0.55	0.50	0.51	0.50	0.63	0.48	0.55	0.50

Table 8.2a **Differences in preferences and characteristics between foreign and native PhD students**

	All foreign (n = 1,792)		China (n = 447)		India (n = 295)		Western (n = 175)	
Risk tolerance	0.59***	(0.08)	1.02***	(0.14)	0.75***	(0.20)	–0.04	(0.14)
Importance of autonomy	0.13***	(0.02)	–0.04	(0.05)	0.27***	(0.03)	0.12	(0.08)
Importance of income	0.13***	(0.02)	0.14***	(0.03)	0.14**	(0.05)	–0.05	(0.06)
Interest in basic research	–0.03	(0.03)	–0.42***	(0.05)	0.27***	(0.04)	0.11	(0.08)
Interest in applied research	–0.03*	(0.02)	–0.13***	(0.03)	0.02	(0.03)	0.03	(0.06)
Interest in commercialization	0.33***	(0.04)	0.55***	(0.05)	0.31***	(0.08)	0.06	(0.09)
Interest in management	0.21***	(0.04)	0.58***	(0.05)	0.04	(0.09)	–0.14	(0.08)
National Research Council ranking of university dept.	–0.06	(0.03)	–0.13**	(0.04)	–0.09	(0.05)	0.02	(0.04)
Self-assessed ability	0.54***	(0.05)	0.68***	(0.06)	0.68***	(0.07)	0.30*	(0.12)

Note: OLS coefficients regressing preferences and characteristics onto foreign nationality controlling for degree field and university fixed effects (n = 5,669). Robust standard errors clustered on university reported in parentheses; *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

ences during graduate school, we include founder role models, measured as a binary variable according to whether or not the PhD advisor had founded a start-up, and lab norms that encourage working in start-ups, measured on a five-point scale that ranged from "strongly discouraged" to "strongly encouraged" (Roach and Sauermann 2015; Roach 2017).

To account for potential systematic differences across degree fields and universities, we estimate differences in the above individual characteristics using OLS to regress individual preferences and characteristics onto a foreign PhD student categorical variable (foreign is 1, native is 0) while controlling for degree field and university fixed effects. Tables 8.2a and 8.2b show the key coefficients. The first set of results in table 8.2a shows significant differences between foreign and native PhD students even after controlling for detailed degree field (17 science and engineering fields) and university fixed effects (39 universities), while the next three sets of regressions distinguish different groups of foreign PhD students (e.g., Chinese, Indian, Western), with native PhD students as the omitted category. Table 8.2b shows differences between foreign and native PhDs students by major degree field controlling for detailed degree field and university fixed effects. Standard errors are clustered by university.

Focusing first on the results comparing all foreign PhD students to natives, we find that the risk tolerance of foreign PhD students is significantly higher than that of natives (0.59 points higher than the native PhD mean of 1.88). Foreign PhD students also report greater importance of autonomy and income, as well as a higher interest in commercialization activities. We also find that foreign PhD students have a higher self-assessed ability. More detailed regressions that break out certain nationalities show that PhD students from Western countries do not differ much from native

Table 8.2b **Differences in preferences and characteristics between foreign and native PhD students by degree field**

	Life sciences (n = 1,979)		Chemistry (n = 644)		Physics (n = 846)		Engineering (n = 1,612)		Comp. sci. (n = 645)	
Risk tolerance	0.63***	(0.14)	0.79**	(0.23)	0.64**	(0.19)	0.52**	(0.18)	0.32	(0.22)
Importance of autonomy	0.15**	(0.04)	0.16*	(0.07)	0.15*	(0.07)	0.11*	(0.05)	–0.01	(0.06)
Importance of income	0.12**	(0.04)	0.14	(0.08)	0.09	(0.05)	0.12***	(0.03)	0.23**	(0.07)
Interest in basic research	–0.13	(0.07)	–0.06	(0.12)	0.15*	(0.07)	0.08	(0.06)	–0.20**	(0.06)
Interest in applied research	0.01	(0.04)	0.02	(0.05)	–0.02	(0.06)	–0.09**	(0.03)	–0.03	(0.06)
Interest in commercialization	0.49***	(0.07)	0.48***	(0.11)	0.31***	(0.09)	0.14**	(0.05)	0.35***	(0.08)
Interest in management	0.14*	(0.07)	0.41**	(0.15)	0.27***	(0.07)	0.12	(0.06)	0.34**	(0.11)
National Research Council ranking of university dept.	–0.08	(0.05)	0.04	(0.07)	–0.08	(0.06)	–0.14*	(0.06)	–0.04	(0.02)
Self-assessed ability	0.44***	(0.08)	0.72***	(0.14)	0.66***	(0.13)	0.47***	(0.10)	0.49***	(0.11)

Note: OLS coefficients regressing preferences and characteristics onto PhD student nationality (native or foreign) by degree field controlling for degree field and university fixed effects (n = 5,669). Robust standard errors clustered on university reported in parentheses; *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

PhD students, while large differences emerge between native and PhD students from China and India.

Table 8.2b provides additional detail by showing differences between foreign and native PhD students for the broad fields of the life sciences, chemistry, physics, engineering, and computer sciences. Although coefficients vary in magnitude, the overall patterns are consistent across fields. Taken together, we find significant differences between native and foreign PhD students with respect to a number of individual characteristics, including factors commonly associated with entrepreneurship, most notably tolerance for risk, interest in commercialization, and self-assessed ability. Our analyses also suggest the need to go beyond aggregate considerations to distinguish foreign individuals coming from different cultural backgrounds.

8.3.2 Entrepreneurial Career Preferences during Graduate School

To examine how native and foreign PhD students differ in their entrepreneurial career preferences, we asked respondents while in graduate school about the attractiveness of different career paths after graduation as well as their own expectations of becoming founders in the US. To measure founder intentions, we asked, "How likely are you to start your own company?" on a five-point Likert scale ranging from "Definitely will not" (1) to "Definitely will" (5). We code *founder intentions* as 1 for respondents who reported that they "definitely will" (5) start their own company and 0 otherwise. To measure preferences for joining a start-up as an employee, we asked respondents, "Putting job availability aside, how attractive or unattractive do you personally find each of the following careers?," where careers included "start-up 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 five-point scale ranging from "extremely unattractive" (1) to "neither attractive nor unattractive" (3) to "extremely attractive" (5). We code *joiner preferences* as 1 for respondents who reported that a start-up job was "attractive" (4) or "extremely attractive" (5) but did not express a founder intention and 0 otherwise. We note that this measure captures joiner preferences in an absolute sense rather than relative to other careers. As such, a joiner preference does not necessarily imply that other careers were rated as less attractive, nor that joining a start-up was respondents' most preferred career (see Roach and Sauermann 2018). Rather, this measure captures individuals with a predisposition toward working in a start-up.

Table 8.3a compares shares of PhD students with founder intentions and joiner preferences among foreign and native PhD students. Overall, a higher share of foreign PhD students reports entrepreneurial preferences relative to native PhD students. Approximately 21 percent of foreign PhD students express founder intentions during graduate school compared to about 10 percent of native PhD students. Similarly, 49 percent of foreign

Table 8.3a Share of PhD students with entrepreneurial career preferences by nationality

	Native (n = 3,880)	All foreign (n = 1,792)	China (n = 447)	India (n = 295)	Western (n = 175)
Founder interest	10.3%	20.7%	24.1%	25.4%	13.1%
Joiner interest	41.7%	49.1%	50.6%	50.8%	48.3%
Total entrepreneurial interests	52.0%	69.7%	74.7%	76.2%	61.4%

Table 8.3b Share of PhD students with entrepreneurial career preferences by degree field

	Life sciences (n = 1,979)		Chemistry (n = 644)		Physics (n = 846)		Engineering (n = 1,612)		Comp. sci. (n = 645)	
	Native	Foreign	Native	Foreign	Native	Foreign	Native	Foreign	Native	Foreign
Founder interest	6.6%	13.7%	6.7%	19.2%	7.4%	9.8%	16.4%	26.1%	20.2%	27.9%
Joiner interest	38.2%	50.0%	46.0%	56.9%	39.8%	55.8%	46.6%	46.5%	43.4%	45.1%
Total entrepreneurial interests	44.8%	63.7%	52.7%	76.1%	47.1%	65.6%	63.0%	72.7%	63.6%	73.0%

PhD students express a preference for joining a start-up as an employee compared to approximately 42 percent of native PhD students. When analyzing nationalities separately, we see that roughly one-quarter of Chinese and Indian PhD students have founder intentions and roughly half have joiner preferences. A slightly higher share of foreign PhD students from Western countries have entrepreneurial interests compared to natives, but Western PhD students are still less entrepreneurial than Chinese and Indian PhD students with respect to their founder intentions. Comparisons by field in table 8.3b show that significantly higher founder intentions of foreign students hold across all fields with the exception of physics, while stronger joiner intentions are observed in life sciences, chemistry, and physics but not engineering or computer science.

We again estimate a series of regression analyses to account for systematic differences across fields and universities. The dependent variable is a categorical measure indicating whether an individual has a founder interest, a joiner preference, or a preference to work either in an established firm or in academia and not in entrepreneurship.[5] Table 8.4 reports multinomial logistic regression results with established firm career preference (and no entrepreneurial preference) as the reference category for the dependent variable (relative risk ratios reported; values less than 1 indicate a negative relationship).

Model 1 reports the baseline results controlling for demographic charac-

5. For individuals who have no founder interest and have no preference for joining a startup, we compared the ratings of attractiveness of working in an established firm or in a faculty position to assign them to the respective categories.

Table 8.4 **Founder intentions and joiner career preferences during graduate school**

Method	Multinomial logit											
Dependent variable Model	Founder (1a)	Joiner (1b)	Academia (1c)	Founder (2a)	Joiner (2b)	Academia (2c)	Founder (3a)	Joiner (3b)	Academia (3c)	Founder (4a)	Joiner (4b)	Academia (4c)
Foreign PhD	2.88*** (0.39)	1.95*** (0.19)	1.13 (0.12)	1.96*** (0.24)	1.70*** (0.16)	1.21 (0.15)						
Chinese							3.06*** (0.46)	1.83*** (0.24)	0.72 (0.13)	1.81*** (0.27)	1.61*** (0.23)	1.01 (0.22)
Indian							4.45*** (1.08)	2.89*** (0.69)	1.41 (0.42)	2.77*** (0.71)	2.30*** (0.54)	1.23 (0.32)
Western							1.64 (0.50)	1.64* (0.34)	1.19 (0.24)	1.53 (0.50)	1.61* (0.34)	1.07 (0.27)
Other foreign							2.69*** (0.52)	1.88*** (0.23)	1.24 (0.16)	1.93*** (0.35)	1.64*** (0.20)	1.32* (0.19)
Risk tolerance				1.10*** (0.03)	1.02 (0.02)	0.97 (0.02)				1.09*** (0.03)	1.02 (0.02)	0.97 (0.02)
Importance of autonomy				1.91*** (0.14)	1.33*** (0.06)	1.73*** (0.11)				1.91*** (0.14)	1.33*** (0.06)	1.73*** (0.11)
Importance of income				0.85 (0.07)	0.94 (0.06)	0.63*** (0.05)				0.84 (0.07)	0.94 (0.06)	0.62*** (0.05)
Interest in basic research				1.11* (0.06)	1.26*** (0.05)	1.27*** (0.08)				1.11* (0.06)	1.25*** (0.05)	1.27*** (0.08)
Interest in applied research				0.89 (0.10)	0.98 (0.08)	0.59*** (0.05)				0.89 (0.10)	0.98 (0.08)	0.59*** (0.05)
Interest in commercialization				2.59*** (0.19)	1.51*** (0.08)	0.68*** (0.03)				2.58*** (0.18)	1.51*** (0.08)	0.68*** (0.03)
Interest in management				1.33*** (0.08)	1.03 (0.03)	0.99 (0.04)				1.33*** (0.07)	1.03 (0.03)	0.99 (0.04)

(*continued*)

Table 8.4 (continued)

Method	Multinomial logit											
Dependent variable	Founder	Joiner	Academia	Founder	Joiner	Academia	Founder	Joiner	Academia	Founder	Joiner	Academia
Model	(1a)	(1b)	(1c)	(2a)	(2b)	(2c)	(3a)	(3b)	(3c)	(4a)	(4b)	(4c)
National Research Council ranking of university dept.				1.14	0.97	1.00				1.14	0.97	1.00
				(0.08)	(0.05)	(0.07)				(0.08)	(0.05)	(0.07)
Self-assessed ability				1.18***	1.04	1.04				1.18***	1.04	1.04
				(0.05)	(0.03)	(0.03)				(0.05)	(0.03)	(0.03)
Lab entrepreneurial norms				1.19**	1.23***	1.03				1.19**	1.23***	1.03
				(0.07)	(0.07)	(0.06)				(0.07)	(0.07)	(0.06)
Founder role model				1.45**	0.90	0.94				1.46**	0.91	0.94
				(0.18)	(0.09)	(0.11)				(0.18)	(0.09)	(0.11)
Male	4.44***	2.20***	1.45***	4.10***	2.11***	1.36***	4.46***	2.21***	1.46***	4.11***	2.12***	1.37***
	(0.57)	(0.17)	(0.11)	(0.59)	(0.16)	(0.12)	(0.58)	(0.17)	(0.11)	(0.60)	(0.16)	(0.12)
Married	1.12	1.11	1.12	1.13	1.07	0.95	1.12	1.11	1.11	1.12	1.06	0.95
	(0.13)	(0.08)	(0.10)	(0.14)	(0.08)	(0.10)	(0.13)	(0.08)	(0.10)	(0.14)	(0.08)	(0.10)
Children	1.06	1.16	1.25	0.96	1.10	1.29	1.08	1.18	1.25	0.97	1.12	1.28
	(0.21)	(0.20)	(0.24)	(0.21)	(0.20)	(0.29)	(0.21)	(0.20)	(0.24)	(0.21)	(0.20)	(0.28)
Field of study fixed effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
University fixed effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Observations		5,707			5,707			5,707			5,707	
Log-likelihood		–6,801.28			–5,975.60			–6,788.24			–5,971.73	

Note: Coefficients reported as relative risk ratios. The dependent variable consists of four categories: *founder interest* ("definitely will" start own company), *joiner interest* (attracted to start-up employment but not likely to start own company), *academia interest* (not attracted to start-up employment but attracted to academic employment), and the reference group *established firm interest* (not attracted to start-up employment but attracted to established firm employment). In all specifications, native PhD students are the omitted category; coefficient estimates for foreign PhD students together and by nationality are relative to native PhD students. Robust standard errors clustered on university reported in parentheses; *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

teristics, field, and university. Foreign PhD students have an almost three times higher odds of expressing a founder intention than native PhD students relative to an established firm preference (Model 1a) and almost twice the odds of native PhD students to have a joiner preference (Model 1b). These differences persist even when ability and preferences for specific job characteristics are included, although including these variables does lead to a significant reduction in the estimated differences, indicating that they may partly explain why foreign students have stronger entrepreneurial interests (Model 2). Model 3 distinguishes between different nationalities and shows that Chinese and Indians are significantly more likely than native PhD students to have founder intentions (Model 3a) and joiner preferences (Model 3b). PhD students from Western countries do not differ from natives in their founder intentions and are only slightly more likely to have joiner preferences (Model 3b).

Taken together, foreign PhD students report stronger founder intentions as well as preferences for working in a start-up environment than do native PhD students. To some extent, these differences appear to reflect differences in individual characteristics such as risk tolerance, an interest in commercialization, and subjective ability. One potential explanation is that those individuals who come to the US as graduate students are less risk averse and of higher ability than the average person in their home country, resulting in higher levels of such characteristics among foreign PhD students. There may also be selection effects among natives prior to entering the PhD such that US citizens who have strong entrepreneurial interests choose to engage in entrepreneurship early on rather than pursuing a PhD. It is again notable that differences in entrepreneurial interests are more pronounced between natives and foreign PhD students from China and India than between natives and foreign PhD students from Western countries. The latter observation is consistent with recent findings by Hunt (2011) and Kahn et al. (2017), who find that Asian PhD students exhibit a greater interest in entrepreneurship than do European PhD students, who tend to show preferences similar to US natives.

8.3.3 Intentions to Stay

Before turning our attention to employment outcomes, it is important to consider whether foreign PhD students plan to stay in the US. Indeed, the extent to which foreign PhD students with founder intentions or joiner preferences intend to stay and work in the US has important implications for US immigration policies to retain STEM PhD students from US universities (Kahn and MacGarvie 2018).

To gain insights into foreign PhD students' intentions to stay in the US after graduation, we asked them during graduate school, "After completing your current PhD degree and any postdocs, which of the following best describes your future plans?," where the options were to stay in the US permanently, work in the US for a few years before returning to their home

Table 8.5a Foreign PhD students' intentions to stay in the US by nationality

	Founder interest (n = 274)	Joiner interest (n = 682)	All foreign (n = 1,358)	China (n = 447)	India (n = 295)	Western (n = 175)
Stay in the US permanently	41.6%	42.8%	42.2%	17.4%	48.4%	37.9%
Work in US before returning home	37.6%	40.1%	37.2%	54.1%	35.8%	38.6%
Return home after graduation	17.8%	11.9%	15.3%	24.3%	8.8%	15.7%
Move to another country	0.7%	0.9%	0.8%	0.0%	2.3%	2.1%
Don't know yet	2.2%	4.4%	4.6%	4.2%	4.7%	5.7%

Table 8.5b Foreign PhD students' intentions to stay in the US by degree field

	Life Sciences (n = 336)	Chemistry (n = 114)	Physics (n = 195)	Engineering (n = 463)	Comp. sci. (n = 260)
Stay in the US permanently	47.9%	36.8%	38.0%	38.9%	48.1%
Work in US before returning home	33.9%	43.9%	35.9%	39.1%	35.8%
Return home after graduation	13.7%	13.2%	16.4%	17.9%	11.9%
Move to another country	0.3%	1.8%	1.0%	0.7%	1.2%
Don't know yet	4.2%	4.4%	8.7%	3.5%	3.1%

country, return to their home country immediately after graduation, move to some other country, or don't know yet. Table 8.5a reports the share of foreign PhD students' future plans by founder and joiner interests, as well as by nationality. Roughly 80 percent of foreign PhD students with either founder or joiner preferences intend to work in the US at least temporarily after graduation, indicating that entrepreneurially oriented individuals would like to stay and work in the US after graduation. Across nationalities, approximately 70 percent to 80 percent of foreign PhD students have intentions of working in the US at least temporarily, although there are larger differences across nationality in the share who intend to stay in the US permanently and those who intend to eventually return to their home countries. Table 8.5b reports stay intentions by degree field, where again roughly 80 percent of foreign PhDs intend to stay in the US permanently or temporarily after graduation. These shares are consistent with observed aggregate stay rates for science and engineering doctorates in the US, although the observed stay rates by nationality vary (Finn 2012; Kahn and MacGarvie 2018).

Table 8.6a **Current status of PhDs 1–5 years after graduation by nationality**

	Native (n = 3,250)	All foreign (n = 1,504)	China (n = 387)	India (n = 264)	Western (n = 148)
Founder	2.0%	1.9%	2.8%	1.1%	3.4%
Start-up employment	5.3%	3.6%	2.8%	4.9%	5.4%
Established firm employment	29.1%	38.6%	50.4%	48.5%	29.1%
Other industry	14.6%	11.6%	9.6%	9.9%	23.0%
Academia	27.5%	28.5%	20.9%	22.0%	21.6%
Postdoc	12.8%	9.8%	9.8%	6.8%	8.1%
Other nonprofit	8.8%	6.0%	3.6%	6.8%	9.5%

Table 8.6b **Current status of PhDs 1–5 years after graduation by degree field**

	Life sciences (n = 1,565)		Chemistry (n = 549)		Physics (n = 678)		Engineering (n = 1,296)		Comp. sci. (n = 583)	
	Native	Foreign	Native	Foreign	Native	Foreign	Native	Foreign	Native	Foreign
Founder	1.2%	1.5%	0.7%	0.8%	0.8%	0.0%	4.4%	1.9%	2.2%	3.8%
Start-up employment	3.7%	2.7%	5.7%	4.7%	5.4%	3.6%	6.3%	3.5%	10.0%	4.5%
Established firm employment	14.7%	14.9%	34.0%	37.5%	29.7%	22.3%	40.7%	48.7%	51.9%	57.5%
Other industry	19.0%	15.8%	15.4%	11.7%	12.8%	16.1%	12.7%	9.7%	2.6%	7.7%
Academia	34.3%	36.9%	25.9%	31.3%	27.2%	35.8%	18.1%	24.5%	24.4%	19.8%
Postdoc	18.1%	17.3%	9.7%	7.8%	15.5%	17.6%	7.8%	6.4%	4.1%	3.8%
Other nonprofit	9.0%	11.0%	8.6%	6.3%	8.7%	4.7%	10.1%	5.2%	4.8%	2.9%

8.3.4 Postgraduation Entrepreneurial Outcomes: Founding or Joining Start-Ups

We now turn our attention to the ex-post career outcomes of PhDs after graduation. To obtain comprehensive data on employment outcomes, we supplemented the survey with hand-curated career profile data from LinkedIn and Google searches. Using both survey and online search data, we identified postgraduate outcomes for 83.6 percent of first-wave respondents. Tables 8.6a and 8.6b report on the current status of our respondents approximately one to five years after graduation. Specific employment outcomes are for those respondents working in the US only (82.6 percent of foreign PhDs); foreign PhDs who are working outside the US or whose current status was undetermined are not included. Note that 34.7 percent of PhDs in our sample have done a postdoc, with a slightly higher share of native PhDs (36.5 percent) compared to foreign PhDs (31.0 percent). However, individuals who transitioned to academia or industry after having done a postdoc are classified based on the current position in subsequent analyses

so that the postdoc classification only refers to PhDs who were last observed as still being in a postdoc position.

To identify whether PhDs were employed in a start-up or an established firm, we rely on survey and LinkedIn data on employer age and number of employees at the time an individual started working at the company. We code start-ups (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 more than 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).

Approximately 65 percent of Chinese and Indian PhDs are employed in the US private sector, with the vast majority in industrial research and development (R&D) positions in established firms or start-ups. Just over 60 percent of Western PhDs are employed in the private sector, and over one-quarter of these are in other industry careers such as consulting, finance, and patent law. For comparison, roughly 50 percent of native PhDs are employed in the US private sector. Table 8.6b shows that the share of PhDs working in industry varies greatly by field—from 65 percent to 70 percent in engineering and computer science to 35 percent in the life sciences—but the shares of foreign and native PhDs within field are roughly comparable.

We now explore whether foreign and native PhDs differ in their propensity to become founders or to take positions in start-ups after graduation, focusing on the 2,318 PhDs who entered employment in US industrial R&D occupations between 2010 and 2016. To identify R&D occupations, we rely on survey responses regarding work activities (e.g., basic research, development) as well as LinkedIn data on job titles (e.g., research scientist, software engineer). We exclude from our sample individuals employed in consulting, finance, and non-R&D occupations. In addition, we exclude self-employed PhDs and retain only founders of technology companies who are the CEO, CTO, or CSO of their companies. In this industry-only sample, 4.6 percent of foreign PhDs were founders and 7.4 percent worked in start-ups, compared to 6.3 percent of native PhDs who were founders and 14.3 percent who worked in start-ups, indicating that foreign graduates were less likely to become founders and to join start-ups as employees.

To examine these differences more systematically, we estimate multinomial logistic regressions where the dependent variable is whether a PhD was a founder or a start-up employee versus an established firm employee (omitted category of the dependent variable). Table 8.7 shows the results, reporting relative risk ratios (values below 1 indicate a negative relationship). The baseline Model 1 shows that foreign PhDs are significantly less likely than natives to join a start-up and are also somewhat less likely to found their own firms (though sample size for founders is small, leading to imprecise estimates). These differences become even more pronounced once we control

Table 8.7 **Multinomial logistic regressions of entrepreneurial outcomes**

Method	Multinomial logit							
Dependent variable	Founder	Start-up employment	Founder	Start-up employment	Founder	Start-up employment	Founder	Start-up employment
Model	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)	(4a)	(4b)
Foreign PhD	0.76	0.51***	0.59*	0.48***				
	(0.19)	(0.08)	(0.15)	(0.07)				
Chinese					0.67	0.31**	0.48*	0.28**
					(0.25)	(0.12)	(0.18)	(0.11)
Indian					0.34*	0.48	0.25***	0.44*
					(0.15)	(0.18)	(0.10)	(0.17)
Western					1.70	0.74	1.66	0.73
					(0.65)	(0.22)	(0.64)	(0.22)
Other foreign					0.58	0.57**	0.46*	0.54***
					(0.19)	(0.11)	(0.16)	(0.10)
Founder interest			7.81***	1.98**			8.35***	2.02**
			(2.30)	(0.44)			(2.47)	(0.44)
Joiner interest			1.51	1.67**			1.53	1.67***
			(0.47)	(0.27)			(0.48)	(0.26)
Male	1.45	1.04	1.08	0.94	1.44	1.06	1.07	0.96
	(0.37)	(0.14)	(0.30)	(0.14)	(0.37)	(0.15)	(0.30)	(0.14)
Married	1.23	1.11	1.16	1.09	1.27	1.09	1.20	1.08
	(0.24)	(0.16)	(0.24)	(0.16)	(0.25)	(0.16)	(0.24)	(0.16)
Children	1.19	0.87	1.24	0.86	1.20	0.86	1.25	0.84
	(0.26)	(0.20)	(0.28)	(0.20)	(0.26)	(0.21)	(0.28)	(0.21)
Constant	0.03***	0.14***	0.02***	0.09***	0.03***	0.14***	0.02***	0.09***
	(0.02)	(0.05)	(0.01)	(0.04)	(0.02)	(0.05)	(0.01)	(0.04)
Field of study fixed effects	Y	Y	Y	Y	Y	Y	Y	Y
Year started job fixed effects	Y	Y	Y	Y	Y	Y	Y	Y
Observations	2,422		2,422		2,422		2,422	
Log-likelihood	–1,282.42		–1,241.65		–1,278.67		–1,236.12	

Note: Coefficients reported as relative risk ratios relative to established firm employment. In all specifications, native PhDs are the omitted category; coefficient estimates for foreign PhDs together and by nationality are relative to native PhDs. Robust standard errors clustered on university reported in parentheses; *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

for foreign students' ex-ante entrepreneurial career preferences (Model 2). The seemingly inconsistent finding that foreign PhDs have a greater interest in entrepreneurship during graduate school but lower rates of participation in entrepreneurship after graduation is illustrated in figure 8.1. Further analyses distinguishing foreign nationalities show that these patterns are driven largely by Chinese and Indian PhDs, while Western PhDs show entrepreneurial outcomes similar to those of native PhDs.

8.4 Discussion

Foreign PhDs are a large share of the most specialized and advanced STEM workers in the US and may be a particularly important source of human capital for entrepreneurial firms. Although there has been considerable research comparing immigrants and natives with respect to founding activities, less is known about how foreign-born and natives might differ in their characteristics prior to engaging in entrepreneurship. Moreover, and of particular concern for the career paths of STEM PhDs, little attention has been paid to employment in start-ups. Using panel data from 5,660 US PhD graduates, we find that foreign PhD students are more interested in founding or joining start-ups than are natives prior to graduation but are significantly less likely to become founders or to enter start-up employment in their first industry job after graduation.

This apparent inconsistency between ex-ante entrepreneurial preferences and ex-post outcomes suggests that foreign PhDs may face certain constraints in their ability to participate in entrepreneurship that US citizens do not. For example, foreign PhDs with founder intentions may be required to seek employment in large, established firms rather than start their own companies in order to obtain temporary or permanent work visas.[6] As such, immigration policies that enable foreign PhDs to become entrepreneurs may facilitate higher rates of foreign PhDs starting potentially high-growth technology companies. Regarding working in a start-up, start-ups may be less likely to sponsor work visas than established firms, or PhDs may believe that established firms provide a better pathway to either temporary (e.g., H-1B) or permanent work visas (National Academies Press 2007; Roach and Skrentny 2019).

Our chapter also speaks to the results in chapter 2 in this volume by

6. We should note that for new graduates, the F-1 Optional Practical Training work authorization enables foreign doctorates to work on their own company for up to three years with the STEM extension. During this time, foreign founders could self-petition for a permanent resident visa through a National Interest Waiver, or they could be sponsored by the start-up for a temporary or permanent visa. The latter option is only available if the venture secures funding and establishes an independent board of directors with discretion over the founder's employment within the venture. Thus, while there are pathways for new graduates to become founders, they entail significant risk and commitment of resources and also may impair the venture's ability to secure funding or attract key employees.

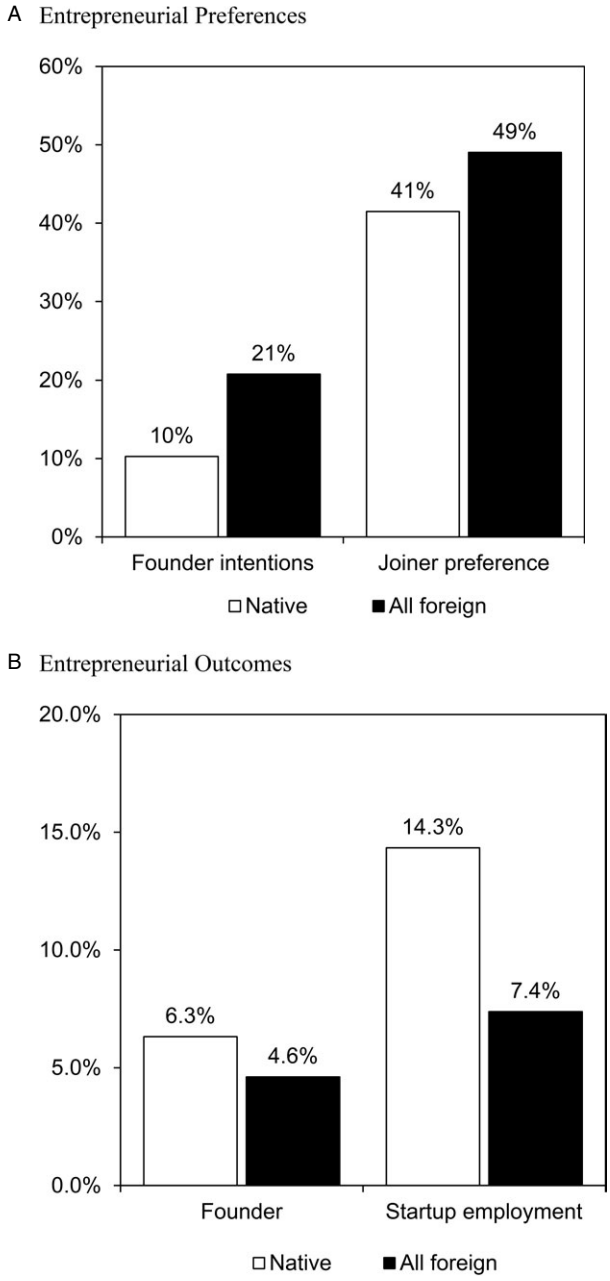

Fig. 8.1 Entrepreneurial preferences and outcomes of native and foreign PhDs

Ganguli and Gaulé. Both chapters, for example, consider career and location preferences of native and foreign PhDs; however, Ganguli and Gaulé focus primarily on differences between foreign and native PhDs with respect to academic career preferences, while we focus on differences in entrepreneurial career preferences. In addition, both chapters point to visa policies as a potential mechanism to explain differences between native and foreign PhDs. In their case, visa policies may shape career preferences, whereas our results suggest that visa policies may shape career outcomes, conditional on preferences. Future research can productively examine how students' beliefs regarding visa policies interact with preferences for locations and for different career paths in academia (such as research or teaching, as emphasized by Ganguli and Gaulé's research [chapter 2]) and in industry (such as established firms or start-ups, as emphasized here).

Although this research takes a novel approach toward understanding STEM PhD career paths by measuring both ex-ante entrepreneurial career preferences and ex-post employment outcomes, future work could fruitfully investigate more deeply the job search and transition processes. Our results suggest that such work should also be sensitive to potential differences between different groups of foreign workers—for example, those from China, India, or Western countries. These individuals may differ not only in their career preferences but also in the labor market constraints they face, such as country-specific quotas for work permits (Amuedo-Dorantes and Furtado 2018; Kahn and MacGarvie 2018).

While this chapter emphasizes the supply-side perspective of individual workers, the observed patterns may also have important implications for firms that often compete for highly skilled human capital. Both individuals' career preferences and institutional constraints are likely to shape the supply of labor to different types of firms and thus may affect firms' ability to grow and innovate. Of course, the patterns we observed will also be shaped by labor market demand. Although the demand side remained only implicit in our study, future work that integrates both supply- and demand-side perspectives may be particularly promising.

Given our limited understanding of the mechanisms underlying our results, we do not yet have a sufficient empirical basis for concrete policy recommendations. However, our results reinforce the notion that foreign science and engineering PhDs are an important potential source of STEM human capital (Stephan and Levin 2007; National Science Board 2014). At the same time, our findings that foreign graduates with entrepreneurial preferences appear to be more constrained from pursuing such careers suggest that the allocation of this human capital may not be optimal. As such, our study provides urgency to research and policy discussions related to retaining and supporting high-skilled foreign-born who come to the US for graduate school. Given the strong entrepreneurial interest of foreign PhDs, foreign graduates may also deserve closer attention in efforts to encour-

age the commercialization of university research through entrepreneurial spinouts.

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