

The Scale and Selectivity of Foreign-Born PhD Recipients in the US

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Abstract. In this paper we study the scale and selectivity of foreign-born PhD students in science and engineering. We focus on students from China, India, Korea, and Taiwan, which together account for most roughly one-third of S&E PhD students in the US. The selectivity of these students is high, as measured by their fathers' relative education levels. In China and India, fathers of students who receive US S&E PhD's are roughly 15 times more likely to have a BA degree than their contemporaries are to have tertiary education. Over time, selectivity falls for China but the trend for other countries is ambiguous.

I. Introduction

The scale, skills, and selectivity of migrants are among the most economically important characteristics of immigration flows (George Borjas 1987; Jeffrey Grogger and Gordon Hanson 2011). In a standard economic model, they influence relative wages, the distribution of income, and the size of the immigration surplus enjoyed by natives (Borjas 1995, 2009). In this paper we consider the scale and selectivity of a small but skilled segment of immigrants to the United States: students who come to the US to obtain PhDs in science and engineering (S&E).

S&E PhDs are essential inputs in the production of knowledge and are eagerly recruited by companies as well as countries (Devesh Kapur and John McHale, 2005). Science and engineering graduates produce patents at much higher rates than graduates in other fields (Jennifer Hunt and Gauthier-Loiselle, 2010), and top S&E scientists are relatively likely to launch high-tech companies

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(Lynn Zucker and Michael Darby 2009).¹ Attracting S&E graduates thereby enhances a country's potential for economic growth (Charles Jones, 1995a,b).

Although some foreign-born PhDs return to their country of origin upon completing their degrees, most remain in the United States, at least to start their careers. Michael Finn (2010) estimates that for the 2005 cohort of US PhDs, 67% of foreign-born doctorates were working in the United States two years after graduation. Two-year stay rates were highest for S&E graduates, especially in computer and electrical engineering (77%), computer science (75%), physical science (75%), life science (75%), and mathematics (73%). Foreign-born students who obtain their PhDs in the US thus contribute importantly to the stock of US human capital.

In this paper we study the scale and selectivity of foreign-born PhD students in S&E fields. We focus on students from four countries: China, India, Korea, and Taiwan. As we show below, students from these four countries account for the lion's share of foreign-born S&E PhD students in the US.

We analyze data from the National Science Foundation's Survey of Earned Doctorates, which provides a census of all students completing PhDs in the United States since 1960. We focus on S&E PhDs over the most recent 20 years, during which time the scale of immigration has changed considerably. We also analyze changes in one measure of selectivity over time, namely, the share of PhD students whose parents hold bachelor's degrees.

Presumably, the more positively selected are foreign-born PhDs in terms of ability, the more likely they are to contribute to the production of knowledge in the United States. One might expect selectivity to fall as the number of foreign PhD students increases. At the same time, increasing education levels in the home country could lead to rising shares of immigrant PhD students whose parents themselves are college educated.

Recent US policy toward foreign students could also influence the selectivity of entering PhD students from abroad. After September 11, 2001, the US imposed restrictions on student visas that substantially reduced the share of students studying abroad who came to the United States (John Bound, Susan Turner, and Walsh, 2009). Whether these restrictions should have raised or lowered the selectivity of US-bound students is not clear. If visa requirements targeted students' educational backgrounds, selectivity may have risen. If the most qualified students faced the highest opportunity cost of complying with new application conditions, then they may have studied elsewhere instead, reducing the selectivity of US-bound students.

In the next section of the paper, we discuss the SED data in more detail. We then present and discuss our empirical findings.

II. Data

The Survey of Earned Doctorates covers all individuals receiving a PhD from an accredited US institution from 1958 forward. We have complete data through 2007. We focus on data from 1987 and 2007, a 20-year horizon over which the salient trends in the data are apparent. Considering that the

¹ In other related work, Hunt (2011) finds that immigrants entering the US on student or temporary works visas are much more likely to produce patents than individuals entering the country on a green card (the majority of whom would have obtained a permanent visa through having relatives in the United States).

average time-to-degree for PhD students is about six to seven years, depending on the field, 2007 is about the first year in which the effects of post-9/11 visa restrictions could appear in the data. We focus the analysis on graduates in science and engineering fields, for which the link to innovative activity is strongest. We restrict attention to China, India, Korea, and Taiwan. These are the largest sending countries for PhDs and provide variation in terms of recent trends.

The SED provides great detail about each PhD graduate's course of study and educational background. At the same time, it provides rather limited information that is useful for assessing selectivity. It does not provide GRE or TOEFL scores, for example.

The SED does provide data on the student's parents' educational attainment. From this information we construct an indicator equal to one if the student's father holds a bachelor's degree or higher and equal to zero otherwise. The SED also provides information about the mother's educational level, but the father's level of education is generally greater and more predictive of the student's post-graduation plans, so we focus on it.

Parents' education captures only some of the sources of ability differences between PhD recipients. At the same time, it likely captures differences that matter. Studies have generally shown a positive link between a worker's earnings and the schooling of his parents, even after holding other worker characteristics constant (David Lam and Robert Schoeni 1993; Lorraine Dearden 1999).

To account for education trends in home-country education levels, we also compute the share of the father's age cohort in the home country with any tertiary education. To do this we merge the Barro-Lee education data to the SED by country and time period, assuming that a student's parents are 25 years older than the student.

III. Findings

Table 1 reports the number of individuals who received S&E PhD's from US universities in 1987 and 2007. In 1987, China, India, Korea, and Taiwan accounted for 2,374 PhD's, which was 43 percent of all S&E PhD's awarded to international students and 18 percent of all S&E PhD's awarded that year.

In 2007, the number of S&E PhD's awarded to Chinese, Indian, and Korean students expanded, whereas the number awarded to Taiwanese students fell. In total, the four countries accounted for 33 percent of US S&E PhDs awarded in that year. The number of Korean students doubled; the number of Indian students nearly quadrupled. Growth in PhD's awarded to Chinese students was explosive: in twenty years, the number increased by almost a factor of nine. By way of contrast, the number of S&E PhD's awarded to US students rose about 20 percent.

Table 2 presents our selectivity measure. The first row of the table shows the percentage of PhD recipients whose fathers held BA degrees. Taiwan is the lowest, at 39 percent, and India the highest, at 64 percent, with China and Korea at 48 percent. These numbers are all roughly comparable to the 53 percent of American PhD recipients whose fathers held bachelor's degrees.

What's striking about these numbers is how selective foreign PhD recipients are relative to their compatriots. In China, about 1 percent of the recipients' fathers' age cohort had any tertiary education, compared to the 48 percent of recipients' fathers who held a BA. In India, where 64 percent of recipients'

fathers had a bachelor's degree, only 2 percent of the fathers' age cohort had any tertiary schooling. In the emerging economies of Korea and Taiwan, the selectivity of PhD students was not quite as high, but still their fathers were about 10 times as likely to hold a BA as their fathers' age cohort was to be tertiary educated.

By 2007, paternal education of PhD recipients rose in most of the sending countries as well as the US. This may partly reflect rising education levels at home, as observed in the last row of the table. India, Korea and Taiwan provide mixed evidence on the link between the scale and selectivity of PhD migrants. The number of Indians and Koreans receiving S&E PhD's in the US rose substantially between 1987 and 2007, as did the percentage of their fathers who held a BA degree. At the same time, the share of Taiwanese students' fathers who held BA degrees rose, even though their numbers dropped off.

Because of the general increase in home-country schooling, it is hard to say whether PhD students from India, Korea, and Taiwan became more or less selective over time. By an absolute measure, they became more selective. By a relative measure, they became less selective.

There is no ambiguity regarding China. Paternal education levels among Chinese PhD recipients fell between 1987 and 2007, even though home-country education levels were rising. This suggests that large increases in the scale of migration may lead to reductions in selectivity.

IV. Conclusions

Between 1987 and 2007, the number of S&E PhDs awarded by US universities rose by 68 percent. Much of this growth was due to growth among the largest sending countries, China, India, and Korea. PhD's awarded to Chinese students grew explosively over this period, from 460 in 1987 to 4,029 in 2007. PhD's awarded to American students grew by just over 20 percent.

The selectivity of these students is quite high, as measured by their fathers' education level in relation to that of their fellow citizens. In the low-income countries of China and India, the fathers of students who receive S&E PhD's in the United States are roughly 15 times more likely to have a BA degree than their contemporaries are to have tertiary education. In the middle-income countries of Korea and Taiwan, the ratio is lower, at about 4, which is nevertheless considerably higher than it is among American PhD recipients, for whom it is about 1.2.

Because of general increases in home-country education, it is ambiguous whether recent PhD graduates are more selective than those of 20 years ago. The exception is China, where selectivity unambiguously fell. This raises the question of whether reductions in selectivity are the inevitable result of explosive growth in the number of students receiving PhDs. Before drawing conclusions, though, it would be useful to analyze other measures of selectivity that capture different aspects of skill.

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Table 1
Number of US S&E PhD's granted by year and recipient's country of origin

Year/Country of origin	China	India	Korea	Taiwan	Other intl.	US	Total
1987	460	529	544	841	3,129	7,974	13,477
2007	4,029	1,937	1,042	522	5,551	9,613	22,694

Table 2
Education level of US PhD recipients' fathers and recipients' fathers' cohort, by country and year

Year/Country of origin	Measure	China	India	Korea	Taiwan	US
1987	Percentage of recipients' fathers with BA's	48.3	64.1	48.0	38.8	52.5
	Percentage of recipients' fathers' cohort with tertiary education	0.9	1.8	4.0	5.1	31.0
2007	Percentage of recipients' fathers with BA's	44.8	83.5	59.3	61.5	68.6
	Percentage of recipients' fathers' cohort with tertiary education	2.9	4.9	13.7	16.3	55.8