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Immigration Policy and Stay Rates of STEM PhDs ¹

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Introduction

The US trains a large share of the world's PhD scientists. Students produced by these programs who remain in the US after completing their studies are an important source of skilled labour for US universities and firms. Currently, the countries that send the most STEM doctoral students to the US – China and India – are also among those with the highest fraction of students staying in the US after their studies (Finn 2014, NSF 2016). However, the fraction of Chinese and Indian doctoral recipients reporting definite plans to stay in the US has fallen steadily across STEM fields since 2002 (NSF 2016 Appendix Table 3-21).

In this paper, we first estimate stay rates (probability of remaining in the US) using repeated surveys on STEM PhDs from US institutions. Then, we investigate whether the decreasing stay rates of Chinese and Indians may be due to US visa policies regarding Employment-Based permanent visa allocations, and particularly the EB-2 category which applies to those holding advanced degrees and allows temporary residents with these degrees to become permanent residents. Our analyses allow us to measure how tightening visa policies for those with advanced degrees affects the stay rate of foreigners who obtain US STEM PhDs. We also briefly discuss other factors that affect stay rates.

Data and Empirical Model

Data Source

Our data come from the 2010, 2013 and 2015 waves of the National Science Foundation's International Survey of Doctoral Recipients (ISDR) and the semi-longitudinal Survey of Doctoral Recipients (SDR) of people receiving doctorates in the US, matched to the NSF's Survey of Earned Doctorates (SED) that surveys new PhDs. We include in our analysis those who earned their doctorates in 2001 or later (due to data restrictions) with doctorates in STEM fields.

The sample contains 22,470 observations of 16,215 temporary residents at time of PhD completion who were working during the survey year, of whom 68.2% are in the US in the

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survey year, with 13.7% of these reporting that they had since become naturalized citizens, 52.5% reporting permanent resident status, and 32.2% remaining temporary residents.²

Our analysis estimates the probability that a graduating temporary resident PhD remains in the US, conditional on a wide variety of factors including variables for visa policies. We know actual locations only in the year(s) surveyed – 2010, 2013 or 2015 – which could be between 1 and 13 years post-PhD. Thus we do not know when the person actually moved to their current location or made the decision to do so, although once STEM PhDs leave the US, they typically do not return (Kahn and MacGarvie 2016).

For this analysis, it was crucial to connect the location decision to a specific time's visa policies and home country conditions. Consequently, we made what we consider a reasonable assumption, that scientists make their location choice given the visa delays and country conditions around the time of their PhD (a time when they are forced to make some decision.). We then tested this against alternative assumptions, particularly whether they based their decisions on policy and conditions 3 years post-PhD or, alternatively, during the survey year, and found that the variables measured at PhD have superior explanatory power.

Employment-Based Permanent Residency Visas

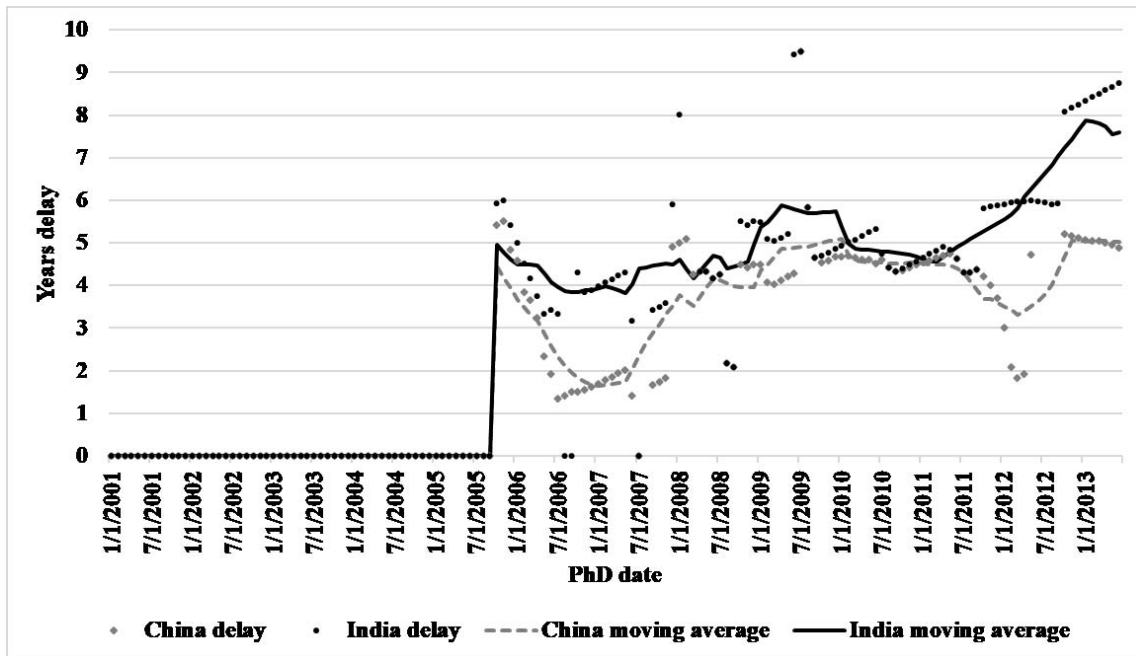
Immigrants to the US can become permanent residents via an employment-based visa. The Immigration Act of 1990 allows 140,000 (or more) employment-based permanent visas each year (excluding those awarded to universities and non-profit employers, not subject to this cap.) Of these, 40,040 are allocated to members of the professions holding advanced degrees (or with exceptional abilities) – the EB-2 category. When total family visas plus employment-based visas granted are greater than 140,000, no country can receive more than 7% of this total (approx. 25,620).³ This total was exceeded in September 2005, and consequently – starting October 2005 – the 7% limit applied to EB-2 applicants from India and China. The delays in processing EB-2 visa requests are different lengths each month and are larger for India than China (Figure 1). Because the delay varies idiosyncratically over the year – with the government compensating for mis-estimations earlier in their fiscal year (beginning Oct.1) by changing delays later – we use the moving average of the visa delay from 6 months before to 6 months after their graduation month.

Employment-based visas require the potential immigrant to remain at the firm until the visa is approved, and applying for these visas typically costs employers between \$10,000- \$25,000 in lawyers' fees. In the meantime, applicants must have a temporary visa such as an H-1B (that, once obtained, can be renewed.)

Control Variables: Demographics, family and education

Demographics and family likely affect the location decisions. We include in our regressions age at PhD and dummies for female, female and married, female and children, male and married, male and children, Black, Asian, and Hispanic, and whether the father had a BA. We control for field of study of PhD and for the prestige of the doctoral institution in this field (Academic Ranking of World Universities 2003-2016). We include dummies for whether the graduate education was at least partially funded by a foreign government. Estimates also include fixed effects for the PhD year and for the survey year.

Figure 1: Years between application and processing dates for an EB-2 permanent visa
(actual monthly delay and year-long moving average)



Control Variables: Country Characteristics

Controls also include information on home countries (HCs). Using World Bank's World Development Indicators, we compute the ratio of HC real GDP (PPP) per capita relative to US GDP per capita and HC R&D expenditures as a percent of GDP, both in the year before PhD receipt. We use the average Polity IV scores in the previous three years as a measure of the democratization of the HC (Marshall and Gurr 2014). We incorporate information on the HC's distance from the US from Mayer and Zignago (2011) and a dummy variable for whether English was an official language of the HC.

We measure the strength of the HC's science base using Scimago Journal and Country Rank (2017) figures for the HC's number of citations per article and Scimago country rankings based on the total number of published documents.

Results

Stay Rates

The average stay rate in our sample was 68.2%. For comparison to Finn (2014), we measure five-year stay rates in the SDR survey of February 2010 (i.e. for those working temporary residents at PhD who received PhDs in March 2004 to January 2007) to be 69.5%, identical to Finn's five year stay rate estimate for those who received PhDs in 2006. In the October 2013 SDR five-year stay rates had risen to 71.5%, yet fallen back to 66.2% in the February 2015 SDR.

Our regressions of the stay rate – all estimated as linear probability models – are shown in Table 1.

Table 1. Linear probability regressions of staying in the US

	(1)	(2)	(3)	(4)
	semi-parametric	compact	with India, China time trends	w.intentions (no pdocs)
Chinese delay in years		-0.0239*** (0.0041)	-0.0193** (0.0075)	-0.0152*** (0.0043)
India dummy for 6,7,8 yr delay		-0.0887*** (0.0267)	-0.0622** (0.0292)	-.0823*** (0.0297)
India dummy for 4 yr delay	-0.016 (0.0319)			
India dummy for 5 yr delay	-0.0286 (0.0299)			
India dummy for 6 yr delay	-0.0948** (0.0391)			
India dummy for 7 yr delay	-0.1268** (0.0556)			
India dummy for 8 yr delay	-0.1283** (0.0565)			
China dummy for 2 yr delay	-0.0637** (0.0292)			
China dummy for 3 yr delay	-0.1019*** (0.0294)			
China dummy for 4 yr delay	-0.0850*** (0.0192)			
China dummy for 5 yr delay	-0.1311*** (0.0232)			
Foreign support in grad.school	-0.3283*** (0.0179)	-0.3292*** (0.0179)	-0.3278*** (0.0180)	-0.1810*** (0.0164)
India	0.1368*** (0.0372)	0.1226*** (0.0308)	0.1783*** (0.0431)	0.1111*** (0.0290)
China	0.2381*** (0.0325)	0.2321*** (0.0319)	0.2535*** (0.0377)	0.2072*** (0.0307)
GDP per cap. HC /US	-0.0166 (0.0299)	-0.0173 (0.0299)	-0.0178 (0.0299)	0.0206 (0.0264)
R&D %GDP in HC	0.0194* (0.0101)	0.0194* (0.0101)	0.0194* (0.0101)	-0.0016 (0.0100)
Country rank 21-50 in pubs	-0.0261 (0.0188)	-0.0268 (0.0188)	-0.0260 (0.0189)	-0.008 (0.0181)
Country rank 51-100 in pubs	0.0925*** (0.0250)	0.0919*** (0.0250)	0.0915*** (0.0250)	0.0658*** (0.0232)
Country rank 101-250 in pubs	0.1267*** (0.0381)	0.1260*** (0.0380)	0.1250*** (0.0381)	0.1128*** (0.0382)
English is HC official language	0.1210*** (0.0204)	0.1206*** (0.0204)	0.1201*** (0.0204)	0.0881*** (0.0192)
Distance to HC	-0.0083*** (0.0026)	-0.0083*** (0.0026)	-0.0083*** (0.0026)	-0.0086*** (0.0025)
Polity	0.0017 (0.0016)	0.0016 (0.0016)	0.0017 (0.0016)	0.0023 (0.0015)
Cites per article in HC bef. PhD	-0.1607*** (0.0187)	-0.1592*** (0.0185)	-0.1585*** (0.0185)	-0.0946*** (0.0169)
Intends to stay at PhD				-0.4811*** (0.0111)
R-squared	0.2107	0.2104	0.2196	0.3970
N	22470	22470	22470	19283

*p<.10, ** p<0.05, *** p<0.01 Includes dummies for survey yr, PhD yr, field, PhD rank, demographics

Employment-Based Permanent Visa Policies

We experimented with different specifications and found that Indians and Chinese responded differently to EB-2 visa delays. To impose least restrictions on functional form, in Table 1 column 1 we enter visa delays as a set of dummies for each of these two countries, with each dummy representing an integer value of delay length (rounded), giving us four dummies for China (2-5 years) and five for India (4-8 years). For Chinese PhDs, all coefficients on the individual delay-length dummies are significantly different from zero (i.e. no delay) and generally become more negative as the delay increases. Statistical tests indicate that a linear delay length variable is a sufficient statistic to capture the impact of EB-2 visa delays on Chinese location. The pattern for India is different, since there is no significant impact of 4 or 5 year delays but large, significant, and quite similar impacts for longer delays of 6, 7 and 8 years. Statistical tests indicate that a single dummy for these long Indian visa delays does a better job of fitting Indian stay rates than the semiparametric model.

We therefore created a compact model (Table 1 Column 2) with a linear Chinese visa delay length variable and a dummy variable for long Indian visa delays (>5.5 years). Results show that on average, each year of visa delay decreases Chinese stay rates by 2.39 percentage points (ppt.), so that the longest delay they faced during this period (of approximately 5 years) decreased the stay rate by approximately 12 ppt. In contrast, delays of more than 5.5 years decreased Indian stay rates by 8.89 ppt.

The key threat to the validity of our results is that visa delays might be picking up time trends in economic and scientific growth in China and India. To minimize this, we modelled time with separate dummies for each PhD year, allowing a flexible relationship between stay rates and time. We also included China and India fixed effects to pick up these countries' time-invariant attractiveness. Moreover, our rich set of time-varying controls for economic, scientific and political conditions in the home country should capture many of the direct factors that could make India and China more attractive to return to.

In addition to this, we estimated an additional specification in which we include country-specific time trends – that is, the China dummy and India dummy each interacted with the year of PhD (Table 1 Column 3). Adding in these trends decreases the coefficients on the visa delay variables somewhat, but does not change the results substantially. We thus remain assured that the EB-2 delays likely had an important effect.

In results not shown, we performed a wide variety of placebo tests (e.g. did the visa delay seem to increase return rates among Chinese or Indian with permanent residency already, or those from similar countries?) and other robustness checks (excluding recession years, excluding Chinese affected by policies inducing return of exceptional scientists, etc.) In all tests, our qualitative results were unchanged.

Except for Finn's work, most previous studies of stay rates of US PhDs have been based on the NSF SED survey that asks graduating US STEM PhDs their intended location post-graduation. However, these might be locations of a temporary postdoc. We have estimated how accurate those intentions are in predicting actual later location in Column 4. We find that (excluding those in postdocs), people who intended at PhD to stay in the US are 48 ppt. less likely to be located in the US *ceteris paribus*. However, even controlling for these intentions, EB-2 visa delays have strong negative impacts on actual survey-year locations, with the coefficient on visa delays very similar to the effect in Column 2 for Indians, but smaller for Chinese. In regressions not shown, we modelled SED intentions to remain and find that visa

delays significantly lowered these intentions for Chinese (by 1.14 ppt.) but not for Indians. We conclude that Chinese partially incorporated the visa delays in their intentions to remain in the US, but that their eventual response to visas was greater than expected. Indians were more optimistic at PhD that visa problems would not prevent their remaining, but actually long delays did prevent their staying.

Effect of J-1 Visa Policy on Stay Rates

On average, those who were located outside the US were much more likely to have been supported by a foreign government during graduate school (13.0% of those in home countries vs. 1.0% in the US and 5.4% in third countries). Many of these students are required to return to their home country for some length of time, either because they held a J-1 visa or due to their scholarship's requirements. Our data allow us to measure whether people had received at least partial funding from foreign governments. As seen in Table 1, foreign support for graduate study is a strong predictor of leaving the US, reducing the stay rate by approximately 33 percentage points, almost half of the average stay rate. However, the number of individuals affected by this policy is small (4.1% of foreign students). Moreover, foreign support is concentrated in fields of study characterized by country-specific human capital, including agricultural and food sciences, environmental sciences, and social sciences such as economics, psychology and political science.

What Other Factors Affect Stay Rates?

GDP per capita in the home country (HC) at PhD, relative to the US, does not affect stay rates in Table 1. However, GDP per capita is highly correlated with measures of countries' science base. The log of citations per article in the scientist's field in the HC does significantly affect stay rates: each 1% increase in citations decreases the likelihood of staying in the country by approximately 0.16 ppt. (Table 1). If we drop the scientific variables, relative GDP per capita has a large and significant coefficient: people from countries with a GDP per capita half of the US's were 4.9 ppt. less likely to stay than those with GDP per capita similar to the US.

Stay rates are higher if the distance to the US is lower and if English is the official language. Surprisingly, stay rates do not differ significantly for those graduating from more highly ranked schools, nor do they differ by the democratization (polity) of the country.

Stay rates are higher for those married at PhD (although less so for men with children), for Asians and for Hispanics. Single men and women have similar stay rates. Father's education has no effect (controlling for countries' science strength). The older the person was when they received their PhD, the lower their stay rate.

Stay rates are very different across fields (Figure 2). Indians and Chinese are concentrated in biological science and computer, engineering, and mathematical sciences (Figure 3). Moreover, this distribution remained similar before and after their EB-2 visas delays. This distribution was unusual: 52.6% of Indian and Chinese students after delays were in the computer, engineering and mathematical sciences, compared to only 26.8% in these fields among all other doctoral recipients (including domestic students).

Figure 2: Location in survey year by PhD field

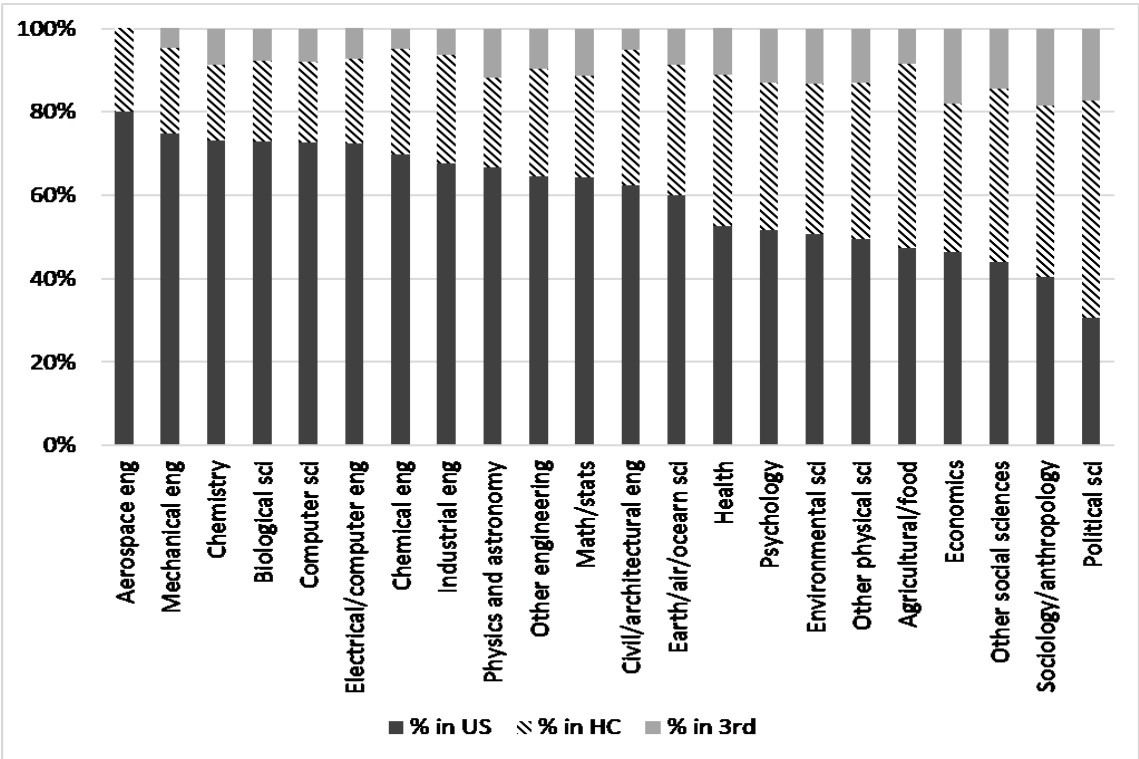
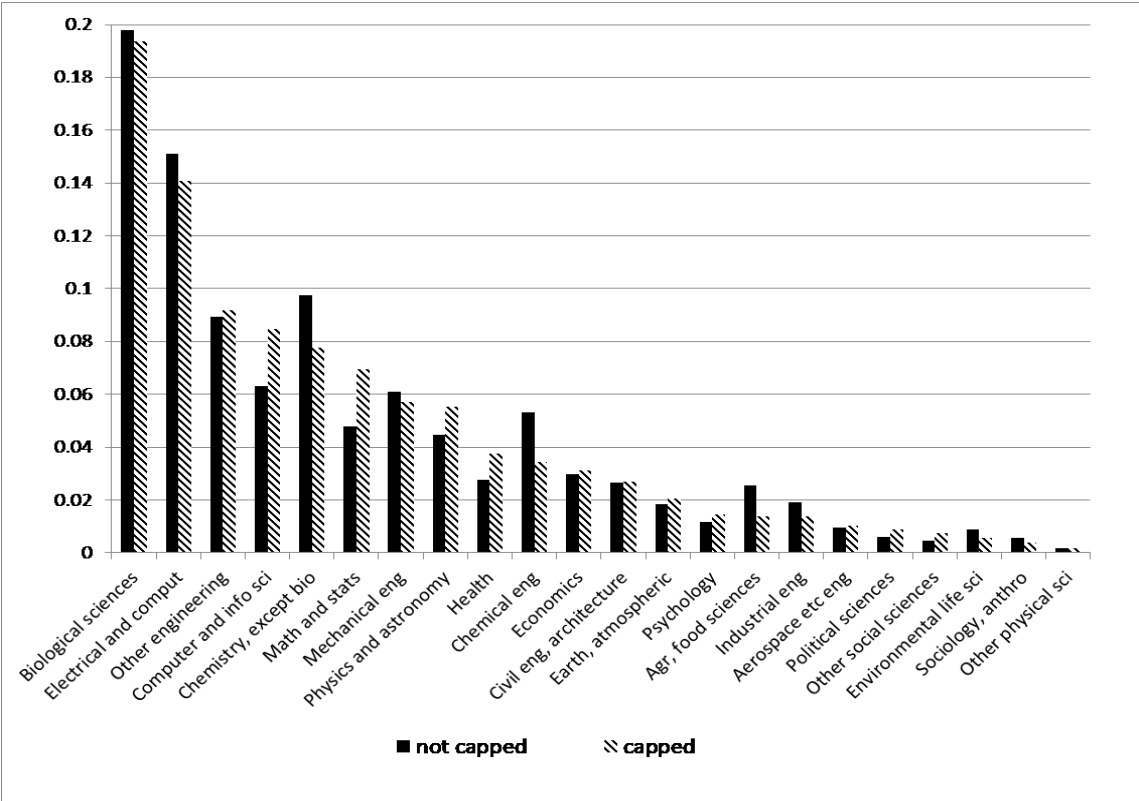


Figure 3: Distribution of Chinese and Indian Students across fields of study



Conclusion

This paper finds that the EB-2 visa delays affecting newly-conferred US Chinese and Indian PhD recipients are associated with a 2.4 percentage point decrease in stay rates for each year of delay for Chinese, while Indian graduates facing delays of at least 5.5 years have a stay rate 8.9 percentage points lower. Chinese and Indian represent a large share of STEM PhDs in fields of study that have high potential to contribute to US economic growth, so this policy limiting their probability of remaining is likely having deleterious effects on US science.

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² Although originally longitudinal, the 2015 SDR dropped most previously-included PhD recipients. In our sample, 11,347 of the 16,215 temporary residents were in only one survey, 3,968 were in two and 1,385 were in all three. Percentages are of observations and are weighted. Note that only those working are affected by employment-based visas. Those not employed are 3.5% of temporary residents at PhD.

³ Applicants employed by universities and other nonprofit institutions such as hospitals and government agencies are not subject to any cap on employment-based visas. Source of EB-2 visa delays from US Dept. of State Visa Bulletins.