Green Card Quotas and the Misallocation of Talent: Evidence from the STEM Doctoral Labor Market*

Holden A. Diethorn†

April 16, 2023

Click here for the latest version.

Abstract

The rates of startup formation, business dynamism, and productivity growth in the US economy have declined since the early 2000s, and a growing literature seeks to identify common forces driving these trends. In this paper, I show that binding green card quotas may contribute to these declines by diverting the most highly-skilled workers in the economy away from entrepreneurial ventures resulting in a misallocation of talent. Using a simple job choice framework, I show that the sudden emergence of country-specific green card delays in October 2005 incentivized Chinese and Indian STEM doctorates to seek employment at established firms over startups as the latter are more likely to shut down prior to the resolution of delays. A difference-in-differences analysis reveals that STEM doctorates who faced green card delays reduced their likelihoods of working in US startups over established firms in the first decade of their careers by 42%. This suggests that policies enabling foreign-born STEM doctorates to avoid green card delays or maintain green card eligibility in the face of job destruction are likely to increase the share of such doctorates working at startups early in their careers.

Keywords: Startups, Immigration, Misallocation, STEM

JEL Classifications: J61, J68, M13, K37

*This paper is based upon work supported by the National Science Foundation under Grant No. DGE-1661278. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author and do not necessarily reflect the views of the National Science Foundation. This paper uses data provided by the NSF and accessed via the NORC Data Enclave. Any opinions and conclusions expressed herein are those of the author and do not necessarily represent the views of the NSF or NORC. All results have been reviewed to ensure that no confidential information is disclosed. A previous version of this paper appeared under the title "Better Safe than Sorry: The Impact of Green Card Delays on the Propensity of Foreign STEM Doctorates to Work at Startups." Thanks to Pinka Chatterji, Britta Glennon, Chun-Yu Ho, Gerald Marschke, Nicolas Morales, Francesc Ortega, Eduard Storm, and all participants at the SOLE 2021 and AEA 2022 Annual meetings for helpful comments and suggestions.

†NBER. Email: hdiethorn@nber.org

1 Introduction

High-skilled immigrants are key drivers of innovation and entrepreneurship in the US economy. Immigrants are more likely than native-born workers to patent (Kerr and Lincoln, 2010; Hunt, 2011), receive patent citations (Bernstein et al., 2022), and found firms (Hunt, 2011; Kahn, La Mattina, and MacGarvie, 2017; Kerr and Kerr, 2022; Azoulay et al., 2022), including the largest firms in the US economy (Azoulay et al., 2022). Immigrant-founded firms are more likely to perform R&D (Kerr and Kerr, 2022) and obtain patents (Azoulay et al., 2022), with immigrant-owned firms in the high-tech sector exhibiting higher rates of product and process innovation and scientific discovery (Brown et al., 2020). Many high-profile founders of successful startups entered the US as immigrants (e.g., Elon Musk, Sergey Brin, Peter Thiel), and immigrants serve as nonfounder CEOs of prominent US companies (e.g., Microsoft, Google, Twitter).[1] Immigrants are not only important in their role as founders and CEOs, but also as employees hired in the early stages of young firms: startups with higher win rates in the H-1B visa lottery are more likely to receive additional venture capital funding, receive more patents and patent citations, and have a successful exit via an IPO or acquisition (Dimmock, Huang, and Weisbenner, 2021).

Foreign-born STEM doctorates are an increasing source of high-end talent, with the annual number of STEM PhDs awarded to US temporary residents doubling between 2000 and 2020 (National Science Foundation, 2021). Temporary resident doctorates represent over half of all PhDs awarded by US universities in Engineering (59%) and Mathematics and Computer Sciences (59%), with the proportion in these fields—and in the Physical Sciences—rising over time. China and India are by far the largest sources of US-trained foreign-born doctorates, with over 90% of each obtaining PhDs in a STEM field.[2] Chinese and Indian immigrants account for most of the growth in immigrant entrepreneurship and innovation in the US (Kerr and Kerr, 2022), and the greater educational attainment of such immigrants in STEM fields appears as the greatest explanation for the immigrant advantage in innovation and entrepreneurship (Hunt, 2011).

The immigrant advantages in innovative activity and entrepreneurial ability should make high-skilled immigrants an attractive source of talent for startups, and the prospect of working at startups—which themselves are known as engines of innovation—should attract high-skilled immigrants. Indeed, industry-bound foreign-born STEM PhDs are just as likely as their US-born

[1] Immigrant founders and co-founders include Elon Musk (Tesla, SpaceX), Sergey Brin (Google), Peter Thiel (Paypal), and Eduardo Saverin (Facebook). Immigrant nonfounder CEOs include Sundar Pichai (Google) and Satya Nadella (Microsoft). Noubar Afeyan, prior to co-founding biotechnology firm and COVID-19 vaccine developer Moderna, immigrated from Lebanon to Canada before coming to the US to earn a Ph.D. in biochemical engineering from MIT (Anderson, 2020).

[2] Between 2010 and 2020, the number of Chinese doctorates receiving their degrees from US universities (57,027) far exceeded the number of US-trained PhDs from any other country and was more than double the number of US-trained doctorates from India (23,826). Statistics derived from Figures 2, 3, and 9 of National Science Foundation (2021).

counterparts to apply for and receive job offers from startups and are *more* likely to express intentions to become a founder or startup employee prior to graduation (Roach and Skrentny, 2019). Yet, they are half as likely to ultimately accept a job offer from a startup (Roach and Skrentny, 2019) despite evidence that high-growth startups pay competitive wages for high-end talent (Kim, 2018). This suggests that immigration policy-induced barriers—and not immigrant preferences or lack of competitive pay—make it harder for startups to successfully hire newly-minted foreign-born STEM doctorates.

One such barrier faces doctorates from China and India specifically, the top two foreign countries in terms of the number of STEM PhDs graduating in the US. In October 2005, newly-binding quotas on the number of second-category employment-based (EB-2) green cards available to PhDs from China and India led to multiple-year delays in the processing of their EB-2 visa applications. The emergence of these delays increased the risk that a foreign-born doctorate's employer-sponsor would go out of business prior to obtaining a green card, in which case the doctorate would need to secure a new employer with which to restart the lengthy EB-2 visa application process.[3] Since startups are more likely than established firms to shut down in the near-term, visa delays plausibly reduced the desirability of working at startups relative to established firms for Chinese and Indian doctorates.[4] Roach and Skrentny (2019) provide descriptive evidence consistent with such an effect, but are unable to directly estimate the policy's impact as they lack data prior to the onset of green card delays.[5]

This paper provides the first direct causal evidence that green card delays decrease the propensity of foreign STEM doctorates to work at startups early in their careers.[6] To clarify the mechanism for such an effect, I develop a simple job choice framework where jobs at startups and established firms vary in their appeal and job destruction rates, with green card delays reducing the desirabil-

[3]In January 2017, USCIS enacted a new rule allowing workers whose employer went out of business prior to the resolution of green card delays to maintain their place in the green card line so long as they find a new employer to sponsor them for a green card within 60 days. This study analyzes PhD cohorts between 2001 and 2010 who would have graduated well-before this policy was enacted and whom we observe in our data in 2017 at the latest.

[4]Most US startups exit within their first five to ten years, while a small fraction of these startups exhibit very high growth and contribute substantially to job creation in the economy (Haltiwanger, Jarmin, and Miranda, 2013; Decker et al., 2014, 2016).

[5]Roach and Skrentny (2019) conduct an online survey of STEM PhD students enrolled at 39 research-intensive U.S. universities as of Spring 2010. Using responses from follow-up surveys in 2013, 2016, and 2018—augmented by data collected on Linkedin, university websites, and Google searches—the authors find that foreign-born STEM PhDs working at established firms directly after graduation are more likely to switch employment to a startup rather than another established firm after receiving a green card, raising the possibility that green card delays inhibit foreign-born STEM doctorates from starting their careers at startups.

[6]In addition to their analysis of stay rates, Kahn and MacGarvie (2020) considered whether visa delays made Chinese and Indian STEM doctorates less likely to work for small startups, but did not detect significant effects. I discuss the analytical differences between this paper and Kahn and MacGarvie (2020) in Section 6 after first presenting the methods and main results of this paper. Roach and Skrentny (2019) find descriptive evidence that permanent residency policies, rather than differences in preferences between foreign and native STEM doctorates, are responsible for their lower propensity to work at startups directly after graduation, and this paper builds on this descriptive analysis by providing direct causal evidence of the hypothesized effect.

ity of working at startups by lengthening the time one is subject to an increased risk of job (or green card eligibility) destruction. Using a nationally-representative sample of STEM doctorates graduating in the US and a difference-in-differences approach, I find that the announcement of EB-2 green card delays induced a 42% (7.2 pp) reduction in the propensity of temporary resident STEM doctorates facing delays to work at a startup in their first decade of employment, conditional on working in any job at a US for-profit industry employer in the first decade of their post-PhD career.[7] Allowing for country-specific effects reveals that the impact is particularly concentrated among Chinese STEM PhDs who reduce their likelihood of working at startups by 48% (9.2 pp), while Indian PhDs do not appear to reduce their rate of working at startups in response to delays. Instead, Indian PhDs appear to respond to delays along other dimensions including the pursuit of the additional qualifications needed to obtain an EB-1 green card and increasingly seeking permanent residency in Canada as a substitute for US permanent residency. Robustness analyses suggest that green card delays—and not other policies such as the drop in the H-1B visa cap in 2004, the H-1B visa lotteries in 2008 and 2009, or the STEM OPT extension in 2008—are responsible for the estimated effect. When allowing for delay-length-specific impacts, I find that Chinese STEM PhDs were 1.7 percentage points less likely to work in a startup early in their careers for each additional year of delay.

The rates of startup formation and business dynamism in the US economy have declined since the 1980s, accompanied by a decline in the share of high-growth young firms in the economy and the rate of aggregate productivity growth since the early 2000s (Decker et al., 2014, 2016; Akcigit and Ates, 2021, 2023). An emerging literature seeks to identify common sources behind these trends, with Decker et al. (2020) finding that a declining responsiveness of firms to idiosyncratic productivity shocks plausibly drives both declining dynamism and productivity growth and Akcigit and Ates (2021, 2023) showing that an observed decline in knowledge diffusion throughout the US economy jointly explains falling dynamism, rising market concentration, and falling productivity growth. While the mechanisms driving both the weakening responsiveness of firms to productivity shocks and the falling rates of knowledge diffusion between frontier and laggard firms are likely multifaceted, they may be explained in part by immigration policies which both raise labor adjustment costs and divert entrepreneurial talent away from firms that have a comparative advantage in achieving major innovations (Baumol, 1990; Murphy, Shleifer, and Vishny, 1991; Akcigit and Kerr, 2018).[8] This paper finds that green card delays distort highly-skilled foreign-born labor away

[7] Conditioning on working in the US within a decade ensures that results are not due to the reduction in US stay rates in response to visa delays. Restricting to those employed in industry within a decade ensures results are due to a change in the propensity of foreign-born STEM doctorates to work in startups relative to established firms in industry, rather than a change between the propensity to work in academia versus industry.

[8] Decker et al. (2020) suggest that regulatory changes that increase labor adjustment costs—such as changes in employment-at-will doctrines, occupational licensing, non-compete contracts, and zoning regulations that impair geographic mobility—may explain the decline in firm responsiveness. Akcigit and Ates (2021) suggest that falling knowledge diffusion between frontier (i.e., firms in the top 5% in terms of labor productivity) and laggard firms may

from startups and towards established firms, with other work finding that green card delays induce job-lock among those impacted (Hunt and Xie, 2019; Wang, 2021).[9] The diversion of highly-skilled foreign workers away from startups likely contributes to the declining share of high-growth young firms in the economy, declining dynamism, and declining aggregate productivity.[10]

This paper joins other studies of high-skilled immigration that exploit sudden changes in immigration policies to credibly identify the impacts of such policies on the behavior of foreign-born students and workers. One set of studies examines the sudden drop in the H-1B visa cap in fiscal year (FY) 2004, finding that it reduced the quality of prospective undergraduate students from abroad (Kato and Sparber, 2013), reduced the quantity of international enrollments by 10% (Shih, 2016), and increased the number of international students entering careers in academia (Amuedo-Dorantes and Furtado, 2019). Related work finds that US multinational firms responded to the drop in the H-1B visa cap by increasingly offshoring jobs through increases in foreign affiliate employment, particularly in Canada, India, and China (Glennon, 2023). Another set of studies explores the impact of the STEM OPT extension in April 2008, finding that it increased the US stay rates of foreign STEM students directly after graduation, increased the likelihood that foreign students would transition from OPT to work visas, and induced international students to increasingly pursue STEM majors (Demirci, 2019; Amuedo-Dorantes, Furtado, and Xu, 2019). This paper contributes to recent studies analyzing the impact of green card delays on the careers of foreign-born STEM doctorates, with both Khosla (2018) and Kahn and MacGarvie (2020) finding that EB-2 visa delays reduce the stay rates of US-trained foreign-born STEM PhDs.[11] This paper finds that foreign-born STEM PhDs who stay and work in US industry after graduation are less likely to work at a startup within the first decade of their career—a time when they are plausibly closest to the human capital frontier (Deming and Noray, 2020; Aghion et al., 2022).

be explained by the increasing importance of data and AI in production, regulations that favor established firms, increased off-shoring of production, and the increasing proliferation of "patent thickets."

[9] Hunt and Xie (2019) and Wang (2021) both find that workers exhibit a sudden increase in job transition rates upon receiving permanent residency, and Wang (2021) finds that this response is greater for Chinese and Indian workers which suggests that the permanent residency application process reduces job mobility among applicants, especially for those subject to green card delays. Related work finds that the binding H-1B visa cap induces workers towards employment at large firms (Mayda et al., 2018).

[10] Hsieh et al. (2019) find that the misallocation of talent has had large negative effects in the past, with improvements in the allocation of talented women and black men to highly-skilled occupations responsible for up to 40% of the growth in per-capita output between 1960 and 2010. Celik (2023) finds that misallocation of talent in the innovation sector arising from the ability of mediocre inventors from rich families to invest in excessive credentialing decreases the rate of innovation in the economy by 10%. Akcigit and Goldschlag (2023*a*) find that the foreign-born share of US inventors has steadily increased since the early 2000s — largely driven by increases in inventors from China and India — while the share of US inventors working at young firms and the share founding their own firms have each fallen by about 50%. Akcigit and Goldschlag (2023*b*) find that inventors hired by incumbent firms experience a 6 to 11 percent decline in their innovative output relative to similar inventors hired by young firms, suggesting that incumbent firms strategically "poach" inventors to avoid disruptive innovations.

[11] Kahn and MacGarvie (2020) find that Chinese doctorates are 2.1 percentage points less likely to remain in the US for each year of expected delay, while Indian doctorates are only impacted by long delays, with those expecting delays of at least 5.5 years exhibiting a 10.6 percentage point decrease in the stay rate.

This papers findings are highly relevant for contemporary public policy: on January 21, 2022, the Biden Administration updated policies surrounding the National Interest Waiver (NIW) which allows EB-2 green card applicants of exceptional ability to waive the job offer requirement (i.e., allows the worker to self-petition for an EB-2 visa) so long as waiving the requirement is in the US national interest.[12] These new policies increase the ability of international STEM doctorates and entrepreneurs to remain in the US by broadening the types of evidence that may be considered in determining the NIW eligibility of such workers. While Chinese and Indian PhDs obtaining a NIW would still be subject to wait times for their EB-2 green card, eligibility for the green card—and the ability to remain in the US while waiting for their green card—would not be tied to employment, allowing such PhDs to remain in the US and switch employers without the fear of losing green card eligibility. Such policies are likely to increase stay rates among foreign-born STEM PhDs (Khosla, 2018; Kahn and MacGarvie, 2020), increase their job mobility (Hunt and Xie, 2019; Wang, 2021)—and thus mobility-based knowledge diffusion—and, as this paper shows, increase their propensity to work at US startups early in their career.

The rest of the paper is organized as follows. Section 2 provides background on the EB-2 visa application process, explains why visa delays occur, and shows how the length of delays varies over time. Section 3 introduces a simple model of job choice with green card delays and job destruction, showing that green card delays incentivize immigrant workers to pursue employment at established over startup firms, even in the case of risk-neutral agents who value working at startups. Section 4 describes the data used in this paper—the Survey of Doctorate Recipients (SDR) linked with the Survey of Earned Doctorates (SED)—and details the formation of the analytical sample and the difference-in-differences identification approach. Section 5 reports the main results followed by various robustness checks. Section 6 discusses details related to the results, including reasons why Indian STEM PhDs are less sensitive to green card delays despite their longer wait times, and Section 7 gives the main conclusions of this paper and provides future avenues for research.

2 Policy Background

Three major policies guide the typical path to permanent residency for US-trained foreign-born STEM doctorates: 1) F-1 Student Visa and Optional Practical Training (OPT) policy, 2) H-1B temporary resident visa policy, and 3) permanent residency visa ("green card") policies. This section discusses employment-based permanent residency visas and the EB-2 green card delays

[12] See "Actions to Attract STEM Talent and Strengthen our Economy and Competitiveness" issued by the Biden Administration on January 21, 2022. Another policy update broadens the evidence relevant for determining whether an individual is of extraordinary ability (for purposes of a temporary resident O-1A visa) to include research experience at an R1 or R2 university (or foreign equivalent) or performing US grant-funded research in a STEM field. The O-1A visa is an uncapped temporary resident visa—an attractive alternative to the H-1B visa which is capped and typically subject to a lottery.

that comprise the focus of this paper. Readers interested in permanent residency policy in the broader context of student visa and temporary resident visa policy are encouraged to first read Appendix B which describes OPT and H-1B policy.

After receiving an H-1B visa from an employer, a foreign worker wishing to obtain a green card will have to find an employer—typically the current employer—that is willing to sponsor them for permanent residency.[13] Obtaining permanent residency entails a three-step process. First, the employer must file a Permanent Employment Certification (PERM) with the Department of Labor that describes the job for which the foreign worker seeks employment, including the wage offered by the employer and, in an effort to prevent the crowding out of US-born workers by cheap foreign labor, a promise to pay the higher of the proposed wage and the "prevailing wage" for the job as determined by the Department of Labor based on occupational title and work location.[14] After receiving a PERM, the employer then files an Immigrant Petition for Alien Workers (Form I-140) with the U.S. Citizenship and Immigration Services (USCIS). Upon receiving the Form I-140 and a $700 filing fee, the USCIS assigns the date that the Department of Labor received the attached PERM as that application's "priority date." Once USCIS accepts the Form I-140, the foreign-born worker must check the Department of State's Visa Bulletin to see if the priority date associated with their application falls prior to the processing cutoff date established in the Visa Bulletin.[15] If so, the worker then files a Form I-485 along with a $1,140 filing fee to USCIS to transition from a temporary resident to a permanent resident. Before receiving a green card, Form I-485 applicants must undergo an FBI name and fingerprint check (and possibly an interview) before USCIS can approve the application. Once Form I-485 is approved, the individual will have achieved permanent resident status and will receive a green card, at which point they will no longer need to worry about having an employer-sponsor to remain legally in the US.[16]

The maximum number of employment-based green cards available worldwide in each year is equal to 140,000 plus the number of unused family-based visas from the previous fiscal year, and each country is limited to at most 7% of the total green cards issued in each year across all employment-based and family-based categories.[17] If the number of applications sent from members

[13] Argueta (2016) shows that almost all EB-2 visas granted between FY 2004 and FY 2014 were for those individuals already in the US when applying for permanent residency (pg. 6). In 2018, 92% of all EB-2 visas issued were for applicants from within the US (US Department of State). See Argueta (2016), Kandel (2018), and Witsman (2018) for in-depth discussions of permanent residency and per-country caps.

[14] A PERM fulfills a similar function as an LCA for an H-1B worker. A PERM for a worker is filed using Form ETA-9089.

[15] Cutoff dates are set by USCIS so that the number of green cards issued in each category do not exceed annual country-specific and worldwide statutory quotas.

[16] If the employer-sponsor goes out of business after Form I-485 has been filed but before it has been approved, the permanent residency seeker must find a new employer to sponsor their green card. If the applicant had filed their Form I-485 at least 180 days prior to their employer going out of business, they can retain the priority date of their previously accepted Form I-140 so long as their new job is for a similar occupation—this is known as "porting" the visa application (USCIS).

[17] In recent years the 7% per-country cap has amounted to 25,620 visas (Witsman, 2018).

of a given country exceeds the number of visas it can be granted in a fiscal year, those applications in excess are put into a queue to be processed as more visas become available in future fiscal years, with applications from each country-of-origin processed in the order of the application's priority date. Employment-based green cards are spread over multiple categories, with "first preference" (EB-1), "second preference" (EB-2), and "third preference" (EB-3) employment-based visas each capped at 28.6% of the total number of employment-based green cards available in the fiscal year.[18] EB-3 visas are available for workers with at least a Bachelor's degree—while foreign-born STEM doctorates are eligible for EB-3 visas, they are more likely to apply for EB-1 or EB-2 visas. EB-1 visas are used for persons of extraordinary ability, outstanding professors and researchers pursuing a job in higher-education, and multinational managers and executives. EB-1 eligibility is typically demonstrated through major scientific contributions, publications, patents, and international awards, while EB-2 eligibility only requires the individual to have an advanced degree, such as a PhD, and are the visas typically used by industry-employed STEM PhDs to achieve permanent residency status in the US.

China and India both faced short-lasting, intermittent EB-2 visa delays throughout the 1990's. In October 2000, President Bill Clinton signed into law the bipartisan *American Competitiveness in the Twenty-First Century Act* (AC-21), a key provision of which allowed countries that had run up against their 7% green card cap to claim additional visas within the worldwide limit left over due to insufficient demand from other countries. This ushered in a period from May 2001 through September 2005 where the priority date used as the cutoff for processing green card applications was "current" in each month, meaning that no country faced EB-2 visa delays. By October 2005, demand for green cards from China, India, and the rest of the world had risen to such levels that the number of green card applications submitted by Chinese and Indian nationals beyond their 7% caps exceeded the number of available visas unclaimed by the rest of the world. In an attempt to keep the number of employment-based visa issuances within their annual statutory limit, USCIS established country-specific cutoff dates for applicants from China and India so that applicants with a priority date after the cutoff would have to wait to become green card eligible. The left panel of Figure 1 shows the difference between the first day of each visa bulletin month and the priority dates used as the EB-2 visa processing cutoffs for applicants from China and India in that month.[19] Prior studies use these differences—or a moving average of such differences (also plotted)—to measure the expected length of green card delays faced by individuals submitting a

[18] This amounts to 40,040 visas each when assuming no unused family-based visas in the prior fiscal year. If the number of EB-1 visas applied for and granted is below its category-specific cap, then the surplus of EB-1 visa spots is allocated to the EB-2 program. Similarly, any unclaimed EB-2 visa spots are then allocated to the EB-3 program. Another 7.1% of employment-based visas are reserved for EB-4 "special immigrant" visas and another 7.1% for EB-5 "immigrant investors."

[19] Data is from the US Department of State's monthly Visa Bulletins available at https://travel.state.gov/content/travel/en/legal/visa-law0/visa-bulletin.html. Immigrants from the rest of the world have faced only a few short-lasting EB-2 visa delays during the following months since FY 2005: September 2007, July 2012 to October 2012, August 2016 to September 2016, August 2017 to September 2017, September 2018, and August 2019 to September 2019.

Form I-140 in each month (e.g., Khosla, 2018; Kahn and MacGarvie, 2020).

However, the actual visa delays faced by EB-2 visa applicants in each month differ significantly from such measures of expected visa delay length. For example, the May 2007 visa bulletin listed January 8, 2003 as the Indian EB-2 visa cutoff for an "expected visa delay length" of over four years. However, assuming individuals submit their Form I-485 as soon as eligible, those whose employers submitted their Form I-140 in May 2007 with premium processing were actually only delayed for two months since the Indian EB-2 visa cutoff became "current" in the July 2007 visa bulletin (i.e., there was no delay in that month).[20] The right panel of Figure 1 plots the actual visa delay lengths faced by Indian and Chinese EB-2 applicants who submitted their EB-2 visas in each month as measured by the number of years until each priority date first becomes current.[21] The right panel shows that temporary residents from China and India who applied for an EB-2 visa prior to June 2010 faced similar actual delays, with the delay lengths for Indians applying thereafter rising to around ten years of delay compared to China's four years of delay.[22]

Figure 2 shows the number of EB-1, EB-2, and EB-3 visas issued to residents from China, India, and the rest of the world in FY 2000 through FY 2020.[23] The number of EB-2 visas granted to

[20] Employers can pay $2,500 to USCIS for premium processing so that the Form I-140 for their employee is processed within 15 calendar days (USCIS). Individuals may delay filing a Form I-485 if they are currently out of the country or are waiting to first get married so that their spouse would be eligible to use their own green card case to file a Form I-485 as a "derivative applicant." However, delaying the filing of one's Form I-485 despite being eligible to do so is risky for those emigrating from China or India due to the possibility of "retrogression" in priority dates used as processing cutoffs. For China and India, there are several cases where the priority date used for EB-2 visa processing moved backwards ("retrogression"); for example, the priority date used as the processing cutoff for Indian nationals in May 2009 was 02/15/2004, and then in June 2009 the processing cutoff retrogressed to 01/01/2000. Visa retrogression typically occurs later in a fiscal year when the USCIS forecasts that a given country will go over the per-country cap if the processing cutoff is not moved back in time. When a new fiscal year starts, the priority date used as the processing cutoff typically goes to a date comparable to the cutoff used before retrogression occurred.

[21] As the actual visa delay lengths plotted in the right panel of Figure 1 differ remarkably from the "expected visa delay lengths" in the left panel of Figure 1, it is difficult to assess how well these proxies measure the actual expectations of EB-2 applicants. Given the uncertainty experienced by Chinese and Indian EB-2 applicants with regards to visa delay lengths, the main empirical approach in this paper utilizes as its key variable whether or not Chinese or Indian doctorates could expect to face any EB-2 visa delays at all, regardless of duration. As a supplemental analysis, I also estimate regressions using 1) expected visa delay lengths as calculated by previous studies and 2) the actual lengths of delays faced by EB-2 applicants.

[22] As of August 2022, the most recent priority date ever used as a processing cutoff for EB-2 visas was December 1, 2014 for India and April 1, 2019 for China. The number of workers from China and India impacted by EB-2 permanent visa delays is significant. In March 2022, USCIS estimated that 23,983 primary beneficiary EB-2 applicants from China and 269,539 primary beneficiary EB-2 applicants from India had an approved Form I-140 but had not yet been able to file Form-485 due to visa delays (USCIS). On average, each EB-2 primary beneficiary application is accompanied by one dependent (or "derivative") EB-2 application (Kandel, Wilson, and Donovan, 2022), bringing the total number of Chinese and Indian temporary residents awaiting an EB-2 visa to about 48,000 and 540,000, respectively. Given that fewer than 5,000 EB-2 visas per year were granted to India in FY 2016 - 2020 (see Figure 2), wait times are likely to exceed ten years for Indians currently impacted by EB-2 delays; assuming no changes in policy and that 5,000 EB-2 visas are issued to Indians in each year henceforth, the wait time for an Indian EB-2 applicant at the end of the line as of March 2022 would be 108 years.

[23] The dip in FY 2003 employment-based green cards and the spike in FY 2005 are the result of disruptions caused by the transfer of immigration authority from the Department of Justice's Immigration and Naturalization Service to the newly-created Department of Homeland Security's USCIS in FY 2003. Additional green cards were also made available in FY 2005 by legislation allowing a temporary recapture of unused visas from prior years (Kandel, 2018).

temporary residents from the rest of the world more than quintupled between FY 2001 and FY 2020, reflecting an increased demand in the EB-2 category worldwide. By FY 2006 demand had risen enough to trigger visa delays for EB-2 applicants from China and India due to binding per-country caps.[24] While more EB-2 visas tend to be issued to India compared to China, the number of Chinese temporary residents that graduate with a PhD in the US is more than double that of India for these same years, meaning that most EB-2 recipients from India lack doctoral degrees or are trained outside the US (National Science Foundation, 2010, 2021).[25] One way for doctorates to avoid EB-2 visa delays is to pursue the qualifications necessary to obtain an EB-1 visa—a category where delays have typically been short-lived and rare. Figure 2 shows that Indian doctorates, but not Chinese doctorates, seem likely to have pursued this path to avoiding EB-2 delays; between 2000 and 2019, the number of EB-1 visas issued to Indians septupled while those issued to Chinese nationals increased by only 16%. The pattern of the increase in India EB-1 visa issuances is also striking: between FY 2000 and FY 2011, the number of EB-1 visas issued to Chinese and Indian nationals remained quite close, followed by a rapid increase in EB-1 visa issuances to India (but not China) starting in FY 2012, the same year in which expected visa delays substantially increased for Indian (but not Chinese) applicants as shown in the left panel of Figure 1.[26]

With the introduction of visa delays, taking a job at a startup after graduation would become riskier for STEM doctorates from China and India since startups are more likely to go out of business in the near-term compared to established firms. If the employer goes out of business prior to the temporary worker having their Form I-140 processed, then that worker would (prior to 2017) have to forfeit their priority date and restart the entire permanent residency process with another employer, putting oneself in the back of the line. In January 2017, new USCIS rules were enacted to improve the job portability of temporary workers with approved I-140 petitions. Among these were the general enabling of a temporary worker to retain the priority date of their first accepted I-140 petition, allowing these workers "to accept promotions, change employers, or pursue other employment opportunities without fear of losing their place in line for immigrant visas."[27] In January 2022, the USCIS broadened the evidence used for determining whether STEM PhDs who

Figure 2 includes visas used for spouses and children ("derivative applicants") of primary applicants; 60% of EB-1 visas, 50% of EB-2 visas, and 50% of EB-3 visas were issued for derivative applicants in FY 2019 (Department of Homeland Security, 2020).

[24] EB-3 applicants from China and India began to face multiple-year delays in FY 2005, with delays for these countries persisting ever since. Short delays emerged for EB-1 visa applicants from China and India in FY 2006. See Figure A.1 for plots of EB-1 and EB-3 visa delay lengths using the same measures as Figure 1.

[25] See Figure 1C in National Science Foundation (2010) and Figure 3 in National Science Foundation (2021).

[26] May 2012 EB-2 visa cutoff dates for China and India were both set at August 15, 2007; in June 2012, the Indian EB-2 cutoff retrogressed by three years to a cutoff September 1, 2004 while the Chinese cutoff retrogressed by only one month to a cutoff of September 15, 2007. As shown in Figure 1, a significant gap in expected and actual visa delays has persisted ever since.

[27] Another new rule allows temporary workers with a Form I-140 that has been approved for at least 180 days to retain their accepted Form I-140 in cases where their employer goes out-of-business, and H-1B workers who lose their job have a 60 day grace period with which to find a new employer (81 FR 82398).

apply for EB-2 green cards are eligible for a National Interest Waiver (NIW) which allows them to self-sponsor for a green card (USCIS). The present study analyzes PhD cohorts between 2001 and 2010 who would have graduated well-before these policies were enacted and whom we observe in 2017 at the latest.

3 A Model of Immigrant Job Choice with Green Card Delays

Suppose an infinitely-lived risk-neutral foreign-born STEM doctorate i who discounts the future at rate $0 < \delta_i \equiv \frac{\beta_i}{1-\beta_i} < 1$ is choosing whether to accept an initial job offer from a startup versus established firm where $j \in \{s, e\}$ indexes startups and established firms, respectively, and time is indexed by $t \in \{1, \ldots, \infty\}$. Further, assume that startups and established firms offer the same competitive real wage which is known to the worker and which remains the same in each period so that $w_{ijt} = w_i$.[28] Let immigrant utility (U_i) be separable in wages with $u_i(w_i) = w_i$ and a worker-specific taste for working at type j firms $v_i(\phi_{ij})$. Further, let $v_i(\phi_{ie}) = 0$ and $v_i(\phi_{is}) = \phi_i > 0$ so that all immigrants receive some positive increment ϕ_i of utility from working at US startups over established firms. After immigrant workers accept job offers, their jobs are subject to end of period destruction at rate $0 \leq \lambda_j \leq 1$ and we define job security at firm type-j as $b_j \equiv (1 - \lambda_j)$. We set $\lambda_s > \lambda_e$ (and thus $b_s < b_e$) so that job destruction rates are higher (job security is lower) at startups compared to established firms.

For simplicity, assume that workers do not change employer types while subject to green card delays, that the length of green card delays (τ) is known, and that when a job is destroyed prior to green card receipt, the immigrant-worker leaves the US and receives utility normalized to 0 in perpetuity.[29] After receiving a green card, workers can work wherever they would like and, under our simplifying assumptions of $w_{iet} = w_{ist} = w_i$ and $\phi_i > 0$, all flock to US startups and so receive the same utility after obtaining a green card regardless of initial employment. Then we can write immigrant expected utility in each period as:[30]

$$E_t[U_{it}(w_i, \phi_{ij}, b_j)] = \begin{cases} w_i + v_i(\phi_{ij}) + \delta_i b_j U_{i,t+1}(w_i, \phi_{ij}, b_j) & \text{for } \; t \leq \tau, \\ w_i + \phi_i + \delta_i U_{i,t+1}(w_i, \phi_i) & \text{for } \; t > \tau. \end{cases} \tag{1}$$

Immigrants choose whether to work at a startup or established firm at the beginning of $t = 1$.

[28] Kim (2018) finds that high-growth startups and established firms offer similar wages to high-end talent. Startups and established firms are also subject to the same prevailing wages for temporary resident workers as determined by the Department of Labor.

[29] We can think of this as the utility of the wage they receive outside the US assuming that wages outside the US are strictly less than those they would garner in the US. Under this interpretation, w_i can be viewed as the difference between a worker's US wage and foreign wage which we assume is some positive constant.

[30] When an immigrant's job is destroyed after they have already received their green card, we assume that they can find another job at a startup—or create their own startup at which to work—without friction.

Equation (1) and $v_i(\phi_{ie}) = 0$ imply that the expected utility from choosing each job type j at $t = 1$ can be written as:

$$E_1[U_{ij}(w_i, \phi_{ij}, b_j)] = \begin{cases} \sum_{t=1}^{\tau} \left[\delta_i^{t-1} b_s^{t-1}(w_i + \phi_i)\right] + b_s^{\tau} \sum_{t=\tau+1}^{\infty} \left[\delta_i^{t-1}(w_i + \phi_i)\right] & \text{for } j = s, \\ \sum_{t=1}^{\tau} \left[\delta_i^{t-1} b_e^{t-1} w_i\right] + b_e^{\tau} \sum_{t=\tau+1}^{\infty} \left[\delta_i^{t-1}(w_i + \phi_i)\right] & \text{for } j = e, \end{cases} \tag{2}$$

and that immigrants will choose to work at startups when $E_1(U_{is}) \geq E_1(U_{ie})$ which holds when:

$$\left[\overbrace{\frac{1 - \delta_i^{\tau} b_s^{\tau}}{1 - \delta_i b_s}}^{A} - \overbrace{(b_e^{\tau} - b_s^{\tau})\left(\frac{\delta_i^{\tau}}{1 - \delta_i}\right)}^{B}\right] \phi_i \geq \left[\overbrace{\frac{1 - \delta_i^{\tau} b_e^{\tau}}{1 - \delta_i b_e} - \frac{1 - \delta_i^{\tau} b_s^{\tau}}{1 - \delta_i b_s}}^{C} + \overbrace{(b_e^{\tau} - b_s^{\tau})\left(\frac{\delta_i^{\tau}}{1 - \delta_i}\right)}^{D}\right] w_i. \tag{3}$$

That is, immigrants will work at startups when their taste for working at startups (ϕ_i) is high enough so that the extra utility they can expect to get during the τ periods of green card delays from working at a startup (A) compensates for the lower chance that they will be able to receive a green card and thus ϕ_i for the rest of their life (B), the lower chance that they will be able to receive w_i during the green card delay period (C), and the lower chance that they will be able to receive a green card and thus w_i for the rest of their life (D). Rearranging (3) yields:

$$\frac{\phi_i}{w_i} \geq \frac{\left[\frac{1-\delta_i^{\tau} b_e^{\tau}}{1-\delta_i b_e} - \frac{1-\delta_i^{\tau} b_s^{\tau}}{1-\delta_i b_s} + (b_e^{\tau} - b_s^{\tau})\left(\frac{\delta_i^{\tau}}{1-\delta_i}\right)\right]}{\left[\frac{1-\delta_i^{\tau} b_s^{\tau}}{1-\delta_i b_s} - (b_e^{\tau} - b_s^{\tau})\left(\frac{\delta_i^{\tau}}{1-\delta_i}\right)\right]} \equiv \Omega, \tag{4}$$

where

$$\lim_{b_s \to b_e} \Omega = 0, \quad \lim_{\delta_i \to 0} \Omega = 0, \quad \lim_{\tau \to 0} \Omega = 0, \quad \text{and} \quad \lim_{\tau \to \infty} \Omega = \frac{\delta_i(b_e - b_s)}{1 - \delta_i b_e} > 0,$$

meaning that immigrant-workers in this framework would always choose to work at startups if startup jobs had the same security as jobs at established firms, if they only cared about current period utility,[31] if there were no green card delays, or if their taste for working at startups relative to their taste for wages exceeded the threshold given in the last expression. For immigrant-workers with tastes for working at startups below this threshold, increases in green card delays will push immigrant-workers towards choosing initial employment at an established firm over a startup.

[31] Workers who more heavily discount the future will place less value on job security and are thus more willing to initially work at startups. This is consistent with Sauermann (2017) who finds that startup employees place a lower value on job security than workers at other types of firms.

4 Data and Empirical Strategy

This paper uses individual-level data from the NSF's Survey of Doctorate Recipients (SDR) linked with the NSF's Survey of Earned Doctorates (SED).[32] The SED is a census of all doctorate recipients earning their degree in the US and collects various demographic and background characteristics of each doctorate including age, sex, race, birth country, residency/citizenship status, fine field of study, and the university where each doctorate earned their PhD. The SDR is a longitudinal biennial survey of STEM doctorates sampled from the SED and contains information on each individual's salary, employment sector, and whether each doctorate's current employer is a new business founded within five years prior to the survey date.[33] The analytical sample is comprised of doctorates from SDR-SED data who earned a PhD between fiscal years 2001 and 2010 and who reported working in a job at a US for-profit nonacademic employer (i.e., "worked in industry") within ten years post-PhD.[34]

4.1 Dependent Variable

For each sample member, I create an indicator variable for whether, within ten years post-PhD, they report ever having worked for an employer that "came into being as a new business within the past 5 years" (i.e., a startup firm).[35] I use this as the dependent variable in difference-in-differences regressions estimating the degree to which the announcement of permanent residency delays for Chinese and Indian doctorates led them to reduce their propensity to work in startup firms within ten years of PhD receipt, conditional on being employed by any for-profit business in the United States during this time span.[36]

[32] These microdata are restricted-use and so were accessed remotely through the National Opinion Research Center (NORC) data enclave. All results have been reviewed to ensure that no confidential information is disclosed.

[33] For more information about the SDR, see https://www.nsf.gov/statistics/srvydoctoratework/#sd.

[34] The analysis uses data from all SDR waves between 2003 and 2017. For the main analysis, I follow Roach and Skrentny (2019) in restricting the sample to those doctorates that are employed in industry to explore how visa delays may have changed the preference for working at a startup firm as opposed to an established firm in industry. I also report regressions without this restriction in Table A.2.

[35] This question was part of the 1997, 1999, 2001, and 2003 SDR waves, but was removed for the 2006 and 2008 waves before reappearing as part of the SDR starting with the 2010 wave. For individuals graduating in 2001-2002, I use their response in the SDR 2003 and 2010 waves to construct the startup indicator; for those graduating in 2003-2004, I use their responses in the SDR 2010 and 2013 waves; for those graduating in 2005-2006, I use their responses in the SDR 2010, 2013, and 2015 waves; for those graduating in 2007-2009, I use their responses in the SDR 2010, 2013, 2015, and 2017 waves; and for those graduating in 2010, I use their responses in the SDR 2013, 2015, and 2017 waves. To control for differences in the number of years observed for each cohort and the timing of the waves used in construction of the dependent variable between these groups, I include survey group fixed effects constructed by grouping together the first and last SDR waves in which an individual is observed, as well as fixed effects for the graduation year of the doctorate.

[36] The unit of observation for the regression analysis is thus person-level, rather than person-year level. In our context, person-year level regressions would be problematic because, in such a setup, the probability of observing an individual working in a startup firm in a given year is in part dependent upon the success rates of the startup firm(s) for which an individual works: this is because a STEM doctorate who works at a startup right after graduation and remains with this (successful) company will likely only report working for a business founded in the last five years on one or two SDR surveys before the firm "ages out" of startup status, whereas a person who jumps from one failing

I construct the variable based on whether a person works at a startup within ten years of graduation for analytical reasons and to address data constraints. First, a sizable number of STEM PhDs—even those that go on to work in industry—work in academia as postdoctoral researchers ("postdocs") as their first job after graduation; including up to ten years after graduation is, in most cases, long enough to capture the employment decisions of the sizable number of STEM doctorates who first complete postdoctoral training in academia prior to working in industry.[37] Second, Deming and Noray (2020) find that the earnings premium for STEM majors is highest at labor market entry and declines by over half in the first decade of employment. This finding provides motivation for restricting the dependent variable to early in a STEM doctorate's career, when the skills learned through doctoral training are likely at their highest value to an employer due to the workers shorter distance from the human capital frontier (Aghion et al., 2022). Other reasons for constructing the dependent variable in this way are to maintain as broad a sample as possible for the analysis. First, the SDR unfortunately excluded the startup question on the 2006 and 2008 survey waves, meaning that the startup status of employers for those graduating in 2003 were not observed until the re-introduction of the startup question in SDR 2010, which is seven years out from graduation. Additionally, in 2010 the SDR expanded its sample size to include additional individuals who graduated as early as 2001, and so inclusion of such individuals requires limiting the dependent variable to no less than nine years.[38]

Temporary resident STEM doctorates can spend up to three years in OPT status and then normally up to six years in H-1B status, likely applying for an EB-2 visa by the fifth year of H-1B status so as to be eligible for annual H-1B visa extensions (beyond the sixth year) that may be necessary while waiting for an EB-2 visa. If temporary resident STEM doctorates were typically employed for eight years (e.g., three years as OPT and five years as H-1B) before applying for a green card, then there would be an opportunity for these doctorates to work in a startup initially and then later move to an established firm to apply for a green card if the startup failed. If this were the case, then we might not expect EB-2 visa delays to have much of an impact on the propensity of Chinese and Indian temporary resident STEM doctorates to work at a startup within ten years. However, evidence suggests that temporary resident STEM doctorates are likely to obtain permanent residency status much quicker than ten years. Roach and Skrentny (2019) find that 63% of the foreign PhDs in their survey who work in industry received a green card within

startup to another might be able to report working for a startup across more years. Additionally, a person-level approach allows the use of an alternative dependent variable that reports whether a person's first job observed in industry is at a startup.

[37] In biomedical science and physical science, over half of new US-trained PhDs from recent cohorts enter postdoc employment, which lasts an average of four to five years. Engineering has also seen an increase in the postdoc rate over time, with about 30% of new PhDs in recent cohorts completing three years of postdoc training on average (Figure A.2 in Diethorn and Marschke (2023)). Table 1 in Diethorn and Marschke (2023) shows that 65% of biomedical PhDs employed in industry are postdoc-trained.

[38] See footnote 35 above for more details.

four years, and Kahn and MacGarvie (2020) report that about two-thirds of temporary resident STEM doctorates in the NSF's National Survey of College Graduates (NSCG) who graduated after 2000 and obtained a family-based or employer-based green card by 2015 did so within three years of graduation.[39] Kahn and MacGarvie (2020) estimate that the average EB-2 visa processing time for temporary resident PhDs facing no delays is 1.5 years, meaning that temporary resident STEM doctorates are likely to apply for an EB-2 visa through their employer at approximately 1.5 years after graduation.[40] Given this relatively quick time from PhD graduation to EB-2 visa application—paired with previous research finding that the permanent residency application process causes significant job lock before applicants receive green cards (Hunt and Xie, 2019; Wang, 2021)—it seems unlikely that temporary resident STEM doctorates typically plan to take an industry job at one employer before applying for permanent residency at another.

Within ten years, we may expect temporary resident PhDs subject to visa delays to reduce their likelihood of working at startups through two channels. The first channel is due to temporary resident STEM doctorates impacted by visa delays reducing their propensity to take initial industry employment at a startup so as to reduce the risk that their eventual employer-sponsor for permanent residency will go out of business prior to resolution of EB-2 visa delays. In addition to this "initial employment" channel, there is also a job-switching channel: those impacted by visa delays may be less likely to switch employers within ten years. If we imagine the case where doctorates randomly sort across startups versus established firms with the same probability, but differ in the rate of job switching, those who switch jobs more frequently would be more likely to work at a startup within a given period compared to those with lower rates of job switching. To check the degree to which results are sensitive to the job switching channel, I include as a robustness check an alternative set of regressions where the dependent variable is an indicator variable for if a STEM doctorate's *first* industry job observed in the data within ten years of graduation is at a startup firm.[41]

4.2 Treatment Period/Cohorts

The EB-2 visa delay officially went into effect starting the first day of FY 2006, but there is ample reason to believe that Chinese and Indian doctorates who graduated in FY 2005 were able to anticipate the emergence of new EB-2 visa delays and respond pre-emptively: the US Department of State repeatedly warned of impending employment-based green card delays in its publicly-released monthly "visa bulletins" starting in September 2004 and continuing throughout FY 2005.[42] There-

[39] This excludes Chinese and Indian PhDs since both faced visa delays.

[40] For FY 2016 through FY 2020, the average processing times for Form I-140 (non-premium filed) and I-485 (employment-based) were 6.3 months and 10.7 months, respectively, which together adds up to about 1.5 years (USCIS).

[41] Due to the biennial nature of the SDR, combined with the exclusion of the startup question from the 2006 and 2008 waves as previously discussed in footnote 35, this robustness exercise does not necessarily capture each doctorate at their first industry employer in all cases.

[42] See Appendix C for the various warnings issued by the State Department throughout FY 2005.

fore, I designate the beginning of the treatment period as FY 2005 to correspond with the first announcement of impending green card delays. To ensure that all doctorates in the analytical sample are observed at least seven years out from graduation, I include doctorates graduating in FY 2010 as the final treated cohort.[43] I follow Kahn and MacGarvie (2020) in treating Chinese and Indian temporary resident doctorates graduating in FY 2001 as not having expected to face visa delays, and so define the pre-treatment period as starting in FY 2001 and ending in FY 2004. Previous years are excluded from the study due to the existence of visa delays during these years that could have expected to continue prior to the October 2000 passage of the *American Competitiveness in the Twenty-First Century Act* (AC-21).[44]

4.3 Treatment and Control Groups

The treatment group is defined as STEM doctorates from China and India whom are temporary residents at the time of graduation, and the control group consists of STEM doctorates who would be unaffected by EB-2 visa delays: US citizens, permanent residents, and temporary residents from other countries at the time of PhD graduation.[45] Figure 3 shows that the treatment and control groups follow similar pre-treatment trends in the propensity to work at startups within ten years, with around 20% of doctorates working at startups for both treatment and control group members graduating in FY 2001 through FY 2004. In FY 2005—the first treatment period—we see the emergence of an approximate 10 percentage-point gap in the startup rate of the treatment and control groups that persists over the entirety of the treatment period, with the startup rate

[43] As discussed in Section 2, USCIS enacted new policies in January 2017 that improved the ability of those impacted by visa delays to change employers while retaining their initial priority date. SDR 2017, which is the final survey wave used in this study, has a reference date of February 1, 2017, which is only shortly after the new policies were enacted.

[44] AC-21 contains a provision allowing countries exceeding the per-country 7% cap on permanent residency visas to claim any additional visas available under the worldwide limit that go unclaimed due to insufficient demand from residents of other countries. This new rule resulted in the elimination of visa delays for Chinese and Indian EB-2 applicants in May 2001, and so doctorates from China and India graduating in FY 2001 would have done so after the passage of AC-21, and likely after the US State Department announced the elimination of visa delays on April 16, 2000 as part of the May 2001 visa bulletin. As a robustness check, Table 6 reports results where doctorates graduating in FY 2001 are excluded from the analytical sample.

[45] It may be argued that temporary residents and nontemporary residents are subject to different time-varying and unobserved circumstances that impact their propensity to work at startups. Therefore, I test the sensitivity of results to changing the composition of the control group, including estimating specifications where only temporary resident doctorates from the rest of the world form the control group. The drawbacks associated with only using temporary residents from other countries as the control group is not only that this greatly reduces sample size, but that temporary resident doctorates from other countries may have been impacted both by Department of State visa delay warnings—which included warnings of worldwide visa delays (e.g., see the May 8, 2005 warning in Appendix C)—and the EB-2 visa delays that they actually faced at various points during the treatment period (September 2007, July 2012 to October 2012, August 2016 to September 2016, and August 2017 to September 2017). Additionally, temporary residents from other countries may have been impacted by policy uncertainty with regards to whether country-specific caps on employment-based visas would be eliminated and replaced with a first-come, first-served policy. Such a policy change, in the absence of an increase in the total cap on employment-based visas worldwide, would likely mean the emergence of worldwide EB-2 visa delays (Kandel, 2020). Therefore, I also consider specifications that exclude temporary residents from the control group.

of the treatment group and control group hovering around 10% and 20% in the treatment period, respectively. This descriptive finding is consistent with Roach and Skrentny (2019) who, using data collected starting in 2010, find that foreign STEM PhDs are about half as likely as US PhDs to accept employment at a startup.

While the similar pre-treatment paths of the treatment and control groups suggest that these groups are similar, in Table 1 I compare the demographics of the treatment and control groups in the pre-treatment and treatment periods. I find that there are some differences between these groups: doctorates in the treatment group tend to be younger, finish their PhD more quickly, are more likely to be married at time of PhD, are more likely to have been financially supported on a research assistantship during graduate school, and are less likely to be female in both the pre-treatment and treatment period. Given these differences, the main specification for this study includes the variables listed in Table A.1 as controls which includes the variables summarized in Table 1 as well as field of study, PhD institution where received degree, whether the doctorate is earning or has earned a professional medical degree, interactions between the female indicator and various other demographic variables including age, race, marriage status at time of PhD, and whether or not any children were living at home with the doctorate at time of PhD.

4.4 Empirical Specification

The main specification in this study is represented by the following person-level difference-in-differences (DD) linear probability model:

$$Startup_{icg} = \alpha + \gamma Treat\_group_{ic} + \delta Delay_{icg} + \boldsymbol{X_i\beta} + \boldsymbol{\lambda_c} + \boldsymbol{\lambda_g} + \varepsilon_{icg}, \tag{5}$$

where $Startup_{icg}$ equals 1 if doctorate i from country c who graduated in year g is observed working in a startup firm within ten years post-PhD, conditional on that doctorate being observed working at any for-profit firm within ten years. Country-of-birth fixed effects are given by $\boldsymbol{\lambda_c}$, year-of-graduation (PhD cohort) fixed effects are given by $\boldsymbol{\lambda_g}$, and ε_{icg} is an idiosyncratic error term. $Treat\_group_{ic}$ is an indicator variable for if doctorate i was a temporary resident at time of graduation and was either born in China or India. The EB-2 visa delay treatment variable, $Delay_{icg}$, equals 0 for all individuals graduating before FY 2005. For individuals graduating in FY 2005 or later, it equals 1 for Chinese and Indian doctorates who were temporary residents at the time of graduation (i.e., $Treat\_group_{ic} = 1$) and equals 0 for everyone else.[46] $\boldsymbol{X_i}$ is a vector of individual-level controls that contains the demographic variables from Table A.1 as well as fixed effects for fine field of study, fixed effects for the PhD-granting university of the doctorate, and

[46]Note that an indicator variable for the treatment period is subsumed by graduation year fixed effects.

survey-group fixed effects.[47]

The parameter of interest δ gives the impact of EB-2 visa delays on the share of Chinese and Indian temporary-resident STEM doctorates working in a startup in the first decade of their career conditional on having worked at any US for-profit firm during that time. An identifying assumption is that the treatment group, in the absence of EB-2 visa delays, would have followed the same trend as the control group in the treatment period, conditional on the included controls.[48] Standard errors are clustered on cells constructed based on whether the graduation year was before or after FY 2005, temporary resident status at time of graduation, and country-of-birth, resulting in 500 clusters for the main specification.[49] Since temporary resident doctorates from India and China faced visa delays of different lengths, and since these doctorates may differ in significant ways, I also estimate regressions that replace the treatment group indicator variable ($Treat\_group_{ic}$) with two separate indicator variables: one for Chinese temporary resident doctorates and the other for Indian temporary resident doctorates. Similarly, in these same specifications, I replace the visa delay treatment variable ($Delay_{icg}$) with two separate indicator variables: one formed by interacting $Delay_{icg}$ with the indicator variable for Chinese temporary resident doctorates and the other formed by interacting $Delay_{icg}$ with the indicator variable for Indian temporary resident doctorates. Lastly, in Section 5.3 I estimate regressions that measure the impact of the country-specific *length* of visa delays on the propensity that Chinese and Indian temporary resident doctorates work at startups.

5 Results

5.1 Main Results

Table 2 reports estimates of the impact of EB-2 green card delays on the propensity of industry-employed Chinese and Indian STEM doctorates to work at a startup within ten years post-PhD.[50]

[47] Survey-group fixed effects ("year-groups") are constructed by grouping together the first SDR wave and the last SDR wave that the doctorate is observed. PhD institution fixed effects control for the impact of an individual's PhD institution and surrounding neighborhood on an individual's propensity to work at a startup. Field of study fixed effects control for the possibility that some fields of study are more likely to lead an individual to work at a startup. I use the fine field of studies provided in the SED to construct field fixed effects. Figure A.3 breaks down sample members by broad field of degree, foreign-born status, and whether the doctorate worked in a startup within ten years of PhD graduation. So that cells are large enough to satisfy confidentiality requirements, in Figure A.3 I group together similar fine fields into more broad fields of study and report the foreign-born break down of each field rather than breaking down by India and China.

[48] I also consider specifications with a treatment-group-specific linear time trend to test the robustness of results to relaxing the common trends assumption so that the identification assumption is instead that the treatment group would have continued to follow along its pre-existing linear time trend in the absence of permanent residency delays.

[49] This represents the unit of policy implementation. Amuedo-Dorantes, Furtado, and Xu (2019) construct similar cells for clustering standard errors when estimating the impact of the April 2008 STEM OPT extension on the propensity of student visa holders to major in STEM. As a robustness check, I also report results from clustering at country-of-birth level for the main specification in Table 6.

[50] Table A.2 reports results from the same specifications as Table 2 after removing the sample restriction that PhDs work at a US for-profit firm within ten years post-PhD. Results for Chinese doctorates are highly significant across all specifications, albeit with smaller magnitudes. In Table A.3, I report estimates of the impact of visa delays

Column (1) shows estimates from a basic DD specification with survey-group fixed effects as the only control, and column (2) shows the estimate after including demographic controls and fixed effects for graduation year, birth country, fine field of study, and PhD university.[51] The magnitudes of the estimates increase after the inclusion of controls, with the results in Panel A suggesting that EB-2 visa delays decreased the propensity of STEM doctorates facing such delays to work at startups by 7.2 percentage points (42%).[52] Panel B gives results from specifications that allow for country-specific heterogeneity in the impact of visa delays on working at startups: we find that Chinese STEM doctorates reduce their likelihood of working at startups by 9.2 percentage points (48%), while there appears to be no effect for Indian doctorates despite their longer visa delays.[53] This heterogeneity in response to visa delays is similar in spirit to the finding in Kahn and MacGarvie (2020) that Indian PhDs were less sensitive to visa delays than Chinese PhDs when considering whether to stay in the US after graduation.[54]

Allowing for Treatment-Group-Specific Linear Time Trends Column (3) shows results after allowing for treatment-group-specific linear time trends. Panel B shows that the resulting estimate for Chinese temporary resident doctorates remains statistically significant and similar in magnitude to the estimate obtained in column (2), while the estimate in Panel A remains stable but only marginally significant. As before, industry-employed Indian doctorates do not appear to reduce the likelihood of working at startups after the announcement of visa delays.

Robustness to Changes in the Control Group Columns (4) - (6) show the sensitivity of estimates to changes in the control group. Panel A reports statistically significant estimates of the impact of visa delays on working at startups when only native STEM doctorates form the control group, and marginally significant estimates when the control group is limited to other foreign-born STEM doctorates. The point estimate remains negative, but is statistically insignificant, when the control group is limited solely to temporary residents from other countries. This insignificance is

on the propensity of US-employed foreign STEM doctorates to work in industry within ten years post-PhD and find some evidence that Chinese doctorates may reduce their likelihood of working in industry in response to visa delays, although this result is not robust across all control groups. This is similar in spirit to the results in Amuedo-Dorantes, Furtado, and Xu (2019): while the FY 2004 drop in the H-1B visa cap led foreign-born graduates with either a B.A. or a professional degree to increase their likelihood of working in academia, such was not the case for doctorate degree holders who appear to "pursue careers in academia regardless of H-1B policy."

[51] For clarity, the "basic" DD specification is of the form:

$$Startup_{icg} = \alpha + \lambda Treat\_period_g + \gamma Treat\_group_{ic} + \delta Delay_{icg} + \varepsilon_{icg},$$

and also includes the survey group fixed effects discussed in footnote 35. Excluding survey group fixed effects has no appreciable effect on the magnitude or significance of results.

[52] About 17.2% of industry-employed PhDs from treatment countries worked in startups in the pre-treatment period.

[53] About 19.0% of temporary resident Chinese STEM doctorates work at startups within ten years post-PhD during the pre-treatment period.

[54] See discussion in Section 6 for why Indian doctorates may be less sensitive than Chinese doctorates to visa delays.

the result of both shrinkage of the point estimate and a substantial increase in the standard error compared to column (2). When estimating specifications that allow for country-specific effects, I find that the estimated reduction in the propensity of Chinese doctorates to work in startups after the emergence of visa delays remains statistically significant across all specifications, although the magnitude of the estimated effect is reduced once limiting the control group to only temporary residents from other countries. Indian doctorates, on the other hand, appear insensitive to visa delays for all but one specification. Altogether, it appears that visa delays significantly reduced the propensity of industry-employed Chinese PhDs to work at a startup within ten years of graduation, and that this result is robust to considering alternative control groups.

Robustness to Changes in the Dependent Variable The green card delay-induced reduction in the share of temporary resident doctorates working at startups within ten years of graduation could have occurred through a reduced propensity to initially seek employment at a startup firm or a reduction in job mobility that makes those who initially obtain employment at an established firm less likely to move to a startup employer within ten years.[55] To check the degree to which the results in Table 2 are due to job lock rather than initial employment choices, Table 3 reports estimates from specifications where the dependent variable takes the form of an indicator variable for if a STEM doctorate's *first* industry job observed in the data is at a startup firm. We find similar results using this new dependent variable, suggesting that the initial employment channel is the main driver of the results in Table 2.

5.2 Threats to Identification

Nonparallel Trends The validity of the difference-in-differences approach relies on the assumption that the control and treatment groups would follow along common trends in the absence of the treatment. While this assumption cannot be explicitly tested, it is more plausible in cases where the pre-treatment trends of the control group and treatment group are close to parallel. Figure 3 shows that the treatment and control groups exhibit similar trends and levels, which suggests that the common trends assumption is plausible. For a more rigorous test of parallel pre-treatment trends, I estimate regressions where I limit the sample to the pre-treatment period and estimate regressions that include a treatment-group-specific linear trend as well as the same controls used in the main regressions. The parameter of interest is the coefficient on the treatment-group-specific linear trend. For each control group considered, Table 4 reports a coefficient estimate that is not statistically different from zero, which is consistent with parallel trends between treatment and control groups in the pre-treatment period. The magnitude of the coefficient on the treatment-

[55] Previous research finds that visa delays led to job lock (Hunt and Xie, 2019; Wang, 2021). Roach and Skrentny (2019) find that foreign-born doctorates who first obtain employment at an established firm and then receive a green card are more likely to move to a startup rather than to another established firm or to stay with their initial employer.

group-specific linear trend variable in Panel A and for China in Panel B is smallest when using the control group associated with the preferred specification reported in column (2) of Table 2. For this preferred specification, we also reported results from regressions that relax the parallel trends assumption by including a treatment-group-specific linear time trend variable as a control, finding similar results in column (3) in Table 2 as we did in column (2).

Changes in H-1B Policy Another concern is that the large reduction in the H-1B visa cap in FY 2004 could be driving the results, rather than permanent residency delays.[56] If this is the case, we would expect to find a persistent and statistically significant treatment effect for Chinese and Indian doctorates that begins in FY 2004, and we would also expect temporary resident doctorates from other countries to be impacted in FY 2004 and beyond since they are also subject to the H-1B visa cap. To test for this possibility, I estimate regressions that allow for dynamic treatment effects in the treatment period and include placebo terms for FY 2003 and FY 2004.[57] Table 5 shows that the estimated coefficients on the placebo terms are insignificant except for the FY 2004 placebo term associated with Indian temporary resident doctorates. If the drop in the H-1B visa cap in FY 2004 caused Indian PhDs to increasingly prefer established firms over startup firms, we would expect the effect to remain statistically significant across treatment years since the cap remained at the same decreased level for all these years; instead, Indian PhDs appear unaffected in the three years following the drop in the H-1B visa cap. Furthermore, if the drop in the H-1B visa cap were driving the results, we would expect temporary resident doctorates from other H-1B cap-constrained countries to reduce their likelihood of working in a startup in FY 2004 and beyond; however, in results reported in Table A.4, I find no evidence that the drop in the H-1B visa cap caused newly-minted doctorates from these other H-1B visa cap-constrained countries to reduce their likelihood of working in a startup in FY 2004.

Additionally, if increasing tightness in the market for H-1B workers privileges established firms over startup firms, and if this—and not permanent residency delays—were to explain the results in this paper, we might expect that the estimated effects for FY 2008 and 2009 would be significantly larger than the estimated effects for other years. This is because FY 2008 and 2009 were years when H-1B visa demand was at its greatest such that the H-1B quota was met within the first week of the H-1B visa application period. However, Table 5 shows that the estimated impact does not appear much different in these years. In fact, the estimated effect for FY 2008 is the lowest of all the estimated effects during the treatment period for Chinese STEM doctorates, and the estimated effects for Indian STEM PhDs in FY 2008 and 2009 are less than half the effect size estimated

[56] Mayda et al. (2018) find that the drop in the H-1B visa cap led to an increasing concentration of new H-1B visa approvals going to larger firms with a record of intense use of the H-1B program. However, Mayda et al. (2018) note that doctorates make up fewer than 10% of H-1B recipients at for-profit firms between FY 2002 and FY 2009.

[57] This exercise also serves as an alternative method for check for differences in pre-treatment trends between treatment and control groups.

in FY 2004. Altogether, these findings suggest that the decrease in the propensity of industry-employed Chinese STEM doctorates to work in startups within ten years post-PhD is driven by the emergence of permanent residency delays, and not by increasing tightness in the market for H-1B workers.

Changes in OPT Policy Another possibility is that other changes in visa policies during the treatment period could be driving the results rather than permanent residency delays. In April 2008, the optional practical training (OPT) program for students with degrees in STEM fields was extended by 17 months; however, it is unclear how this would impact the propensity of STEM doctorates to work in startups.[58] Nevertheless, I re-estimate the main specification after dropping doctorates that graduated after FY 2007 to reduce the chance that estimates are impacted by the OPT extension. Table 6 Column (1) shows that results are robust to excluding doctorates graduating after FY 2007, and so it is unlikely that the OPT extension is driving the main results.[59] These results also suggest that the main findings are unlikely to be driven by the H-1B visa lotteries that occurred in FY 2008 and 2009, or by the reduced number of post-PhD years observed for those graduating in the most recent cohorts included in the sample utilized for the main results.

Partially-Treated "Pre-Treatment" Cohort Another concern is that there existed EB-2 visa delays for Chinese and Indian temporary resident doctorates between October 2000 and April 2001, and so it is possible that some doctorates graduating in FY 2001 could have been impacted by these delays. Therefore, I re-estimate the main specification after dropping doctorates graduating in FY 2001 and report the results in Table 6 Column (2). The estimated impact of visa delays on the propensity of Chinese temporary resident doctorates to work in startups increases after removing FY 2001 from the pre-treatment period, which could suggest that some Chinese STEM doctorates graduating in FY 2001 reduced their propensity to work in startups due to these delays; however, it remains the case that Chinese and Indian temporary resident doctorates graduating in FY 2001 would have done so after Congress passed AC-21 in October 2000, and likely after the subsequent elimination of EB-2 visa delays announced by the Department of State on April 16, 2001, and so this casts some doubt on this interpretation.

Demand-Side Effects A further concern is that the declining share of Chinese STEM PhDs working at startups is a labor demand-side, rather than supply-side, effect. Decker et al. (2014) note that the startup rate for the high-tech sector has declined since 2000, including during the Great

[58] By increasing the number of years a temporary resident doctorate could stay in the US prior to obtaining a green card, it may have increased the propensity to work at a startup early in one's career. Alternatively, it may have attracted temporary residents to established firms that may be better able to afford filing multiple H-1B applications on one's behalf in the event that a first H-1B application is unsuccessful in the H-1B visa lottery.

[59] See Table A.5 for a version of Table 6 robustness check results where the control group is limited to temporary resident doctorates from other countries.

Recession, with either no change or a decline in the average number of workers employed at each startup. While this might explain why, on average, a worker in the US might be less likely to work at a startup, it is unclear that this would uniquely impact the fraction of Chinese temporary resident doctorates working at startups as US citizens, permanent residents, and temporary residents from other countries also faced the same economic environment, and so cohort fixed effects should control for such economy-wide shocks and trends.

Decker et al. (2016) show substantial heterogeneity across different areas of the high-tech sector in terms of employment growth and the dispersion of employment across firms within each area. In particular, Decker et al. (2016) notes that the manufacturing of goods like computers and semiconductors once made up the largest share of high-tech employment but has steadily declined and has since been surpassed by the areas of Services and Information which includes activities such as data hosting, processing services, and software publishing. These changes in the industries comprising the high-tech sector could impact the demand for doctorates from different fields of study, and so I re-estimate the main specification after controlling for field-by-cohort fixed effects using the broad fields of study listed in Figure A.3. Table 6 Column (4) shows that the estimated impact of EB-2 visa delays attenuates when including field-by-cohort fixed effects, suggesting that changes in business dynamism across industries may play some part in the declining share of Chinese temporary resident doctorates working at startups. However, much of the estimated effect remains and is highly significant, leaving much room for the hypothesized labor supply-side explanation characterized in Section 3.

Another possibility is that the emergence of EB-2 visa delays made Chinese and Indian temporary resident doctorates more appealing to employers. For instance, as noted in Wang (2021), the period of job lock induced by EB-2 visa delays may incentivize firms to increase investment in the general human capital of these workers as job lock converts general human capital into quasi firm-specific skills that firms can exploit to reap surplus benefits. However, the increasing attractiveness of workers subject to EB-2 visa constraints should hold for both established and startup firms, and it is unclear which type of firm stands more to gain from reduced worker mobility. One might imagine that the success of startup firms is more sensitive to the voluntary turnover of highly-specialized labor compared to established firms due to higher relative costs of recruiting and training new workers, and so we might expect startup firms to be relatively more attracted to workers subject to visa delays compared to established firms experienced in handling voluntary labor turnover.[60] This demand-side effect would work to *increase*, rather than decrease, the fraction of Chinese and Indian temporary resident doctorates working at startups as opposed to established firms after the emergence of EB-2 visa delays. However, it could be the case that established firms

[60]Established firms tend to be larger in size, and so may also be better at reallocating the job tasks previously performed by an exiting employee to one or more employees remaining at the firm.

are better able to train workers, and thus can extract the most value out of job-locked temporary resident doctorates, making Chinese and Indian doctorates more appealing to established firms relative to startups after the onset of visa delays. However, Wang (2021) does not find evidence that employers exploit substantial monopsony power over temporary residents, instead finding that firms reap only a small surplus from hiring job-locked temporary-resident workers; this casts doubt on such a demand-side mechanism explanation of the results.

5.3 Visa Delay Length and the Propensity to Work at Startups

The framework in Section 3 implies that the length of visa delays, and not merely the existence of multiple-year visa delays, impacts the propensity of foreign STEM doctorates to work in startups. Since temporary resident doctorates from the same PhD cohort and country-of-birth are likely to face similar visa delays, the dynamic treatment effect estimates in Table 5 can shed some light on whether Chinese and Indian PhDs were sensitive to changes in such delays. Figure 4 Panel A plots the estimated effects from the first column of Table 5 and Panel B plots the estimated country-specific effects from the second and third columns. While there is some variability in the estimated effect of visa delays across cohorts, there is considerable overlap in confidence intervals during the treatment period, which suggests that differences in expected visa delay lengths may not have caused significant differences in the rate of working at startups across cohorts. As before, Indian doctorates do not generally appear to alter their propensity to work in startups in response to visa delays, although all point estimates are negative and those associated with FY 2008 and 2010 are statistically significant. As Indian doctorates in more recent cohorts have faced longer visa delays, this suggests the possibility that Indian doctorates are only sensitive to long visa delays.[61]

A more direct approach is to measure the length of the expected delay for each doctorate and to include these delay lengths as main variables of interest in a regression specification, such as in Kahn and MacGarvie (2020). The difficulty of this approach is in deciding on a measure for the visa delay length that Chinese and Indian doctorates would expect to face at the time of making their decision to apply for an EB-2 visa. Kahn and MacGarvie (2020) construct their measure of the visa delay length in any month by looking at the US Department of State's visa bulletin in each month and, for both China and India, calculating the number of years between the visa bulletin date and the priority date used as the cutoff for the processing of EB-2 visas in that month. For example, the priority date used for the processing cutoff of Indian EB-2 visas in the June 2007 visa bulletin was April 1, 2004, and so the visa delay length in that month would be calculated as being over three years using the method in Kahn and MacGarvie (2020).[62] I calculate the visa delay

[61] Kahn and MacGarvie (2020) find that Indian doctorates only change their stay rate when facing expected visa delays exceeding five years.

[62] For brevity, I refer to this as the "KM" method of calculating visa delay lengths. This method was also used to calculate visa delay lengths in Khosla (2018).

length in each month using the KM method and plot these visa delay lengths in the left panel of Figure 1, which reassuringly produces a graph very similar to "Fig. 1" in Kahn and MacGarvie (2020).

Using the NSF's National Survey of College Graduates (NSCG), Kahn and MacGarvie (2020) find that 67% of foreign STEM PhDs who received their PhD after 2000 and subsequently received a permanent residency visa by 2015 did so within three years of PhD receipt. They also find that the median processing time for EB-2 visas for those not subject to visa delays is 1.5 years, suggesting that the median foreign STEM PhD submits an EB-2 visa application 1.5 years post-PhD and so begins the process of preparing the application at an earlier point.[63] Of course, not all doctorates are the same, and so the date each begins applying for an EB-2 visa is likely to vary. Because of this, Kahn and MacGarvie (2020) suggest using a 3-year symmetric triangular-weighted moving average of monthly visa delay lengths centered on 1 year after PhD completion as their preferred proxy for visa delay length. This form of weighting results in the visa delay length at 1 year after PhD receiving the largest weight, where the weights decrease linearly moving away from 1 year post-PhD. Kahn and MacGarvie (2020) also consider an unweighted 12-month moving average of visa delay lengths centered on each doctorate's PhD graduation date as an alternative measure. Both these measures are plotted in the left panel of Figure 1 for both China and India.

In Table 7, I use these two KM measures of visa delay length to test if expected visa delay length is related to the propensity of working in a startup within ten years. For both measures, I find no impact of visa delay length on working at startups when the visa delay length enters linearly into the specification as in columns (1) - (4). To allow for more flexibility, I follow Kahn and MacGarvie (2020) by rounding the visa delay length of each individual to the nearest year and then creating a set of indicator variables for different rounded visa delay lengths. For both KM measures of visa delay length, I find that Chinese STEM doctorates with an expected visa delay length of about 3 years reduce their propensity to work in startups within ten years, but that those facing five year delays are not impacted. This is a curious finding as one would expect that longer expected visa delay lengths would, at the very least, also reduce the propensity of working at startups. Furthermore, we find that Indian PhDs facing approximately 3-year delays are *more* likely than those facing no delays to work at a startup, but that this result does not generalize to visa delays of greater lengths. These patterns suggest either that visa delay lengths do not have a systematic impact on the propensity of foreign STEM workers to work in startups, or that the KM measures of visa delay length may fail to approximate the visa delay lengths actually expected by Chinese and Indian STEM doctorates.

[63] For FY 2016 through FY 2020, the average processing times for Form I-140 (non-premium filed) and I-485 (employment-based) were 6.3 months and 10.7 months, respectively, which together adds up to about 1.5 years (USCIS).

As previously discussed in Section 2, the KM measures of expected visa delay length differ significantly from the actual visa delay lengths faced by immigrants submitting a Form I-140 in each month. As an alternative to the KM method, I measure the visa delay length in each month by calculating how many years until the priority date first becomes current and I plot these actual visa delay lengths in the right panel of Figure 1.[64] Admittedly, it is unrealistic to expect that Chinese and Indian PhDs could forecast the correct visa delay length, but testing how actual visa delay lengths impact the likelihood that a foreign STEM doctorate works in a startup within ten years is interesting in its own right since those able to obtain a green card more quickly may be more likely to work at a startup within ten years. This is because the foreign STEM doctorate would no longer need to worry about their employer staying in business in order to remain in the US after receiving a green card.

In Table 8, I use two measures of the actual visa delay length faced by EB-2 applicants to test if visa delay length is related to the propensity of working in a startup within ten years. The first measure assumes that each foreign STEM doctorate and their employer submits an EB-2 visa application (Form I-140) one year after graduation, and the second measure assumes that the application is submitted 1.5 years after graduation. We find that for each additional year of visa delay, a Chinese STEM doctorate is 1.7 percentage points less likely to work in a startup within ten years. When allowing for a more flexible specification, we find that Chinese STEM doctorates facing delays of any length are less likely to work in a startup than those facing no delays. Indian doctorates do not appear sensitive to visa delay lengths as most estimates for Indian PhDs are either insignificant using both visa delay measures or only significant for a single measure. Altogether, it appears that the propensity of Indian doctorates to work in startups may not be sensitive to visa delay length, while Chinese doctorates are 1.7 percentage points less likely to work in a startup within ten years for each additional year of visa delay.[65]

6 Discussion

6.1 Sources of Country-Specific Heterogeneity

Given that Indian doctorates face longer EB-2 visa delays than Chinese doctorates, it is somewhat puzzling that Chinese temporary resident doctorates reduce their propensity to work in startups

[64] For simplicity, I impute a visa delay length of ten years for all individuals whose priority date has never fallen within the cutoff date used for issuing EB-2 visas—this roughly accords with the visa delay length measured using the KM method in the relevant months.

[65] In regressions not shown, I re-estimate the specifications in Table 7 and Table 8 after limiting the control group to temporary resident doctorates from other countries. Point estimates generally remain similar, but results are not typically significant due to an increase in standard errors. For instance, when limiting the control group to temporary residents, I find that Chinese doctorates reduce their propensity to work in startups by 1.2 percentage points for each additional year of (actual) visa delay, but this result is not statistically significant due to a 44% increase in the standard error relative to that in column (4) of Table 8.

whereas Indian doctorates do not. While surprising, this finding is in the same spirit as Kahn and MacGarvie (2020) who find that Chinese doctorates reduce their stay rate in the US for each additional year of visa delays, but that Indian doctorates only reduce their stay rate for delays exceeding five years. It is important to note that while we find no overall effect of visa delays on the propensity of Indian PhDs graduating during the treatment period to work at startups, we do find limited evidence that some cohorts of Indian PhDs may have reduced their propensity to work at startups. Figure 4 shows that allowing for dynamic treatment effects of green card delays on Indian PhDs' startup rate yields negative point estimates for all treatment cohorts (2005-2010) but are only significant for the 2008 and 2010 cohorts. It is possible that a larger sample of data on Indian PhDs would uncover a more general effect, especially if the strong negative effect estimated for Indian PhDs during FY 2004 is the result of sampling error.[66] Notwithstanding this possibility, there exist plausible explanations for why Indian STEM PhDs do not appear as sensitive as Chinese PhDs to visa delays.

One possible explanation is that there exists a traditional path to permanent residency for Indian doctorates that operates through employment at established firms with Indian headquarters, which are consistently among the top recipients of H-1B visas. However, USCIS data on the number of H-1B petitions granted to each firm seemingly fails to support this explanation, as very few doctorates appear as either initial or continuing H-1B workers at these firms (e.g., USCIS, 2012).[67] Another explanation is that Indian doctorates are more likely to avoid visa delays through marriage to either a US citizen or a temporary resident from another country without visa delays.[68] Using the 2005 through 2017 waves of the *American Community Survey* (ACS), I find that 13.4% of Indian PhDs and 8.2% of Chinese PhDs living in the US were married to either a US spouse or a spouse born from another country besides India or China.[69] While Indian PhDs were 63.4% more likely than Chinese PhDs to be married to a spouse that would allow them to bypass visa delays, this calculation implies that 86.6% of Indian PhDs in the US would still be subject to visa delays.

Another possibility is that Indian PhDs are more likely than Chinese PhDs to avoid EB-2 visa delays by pursuing the qualifications necessary for an EB-1 visa. Indians who applied for EB-2 or EB-3 visas as far back as 2015 have not yet been able to receive a green card. Meanwhile, EB-1

[66] In the general setup without dynamic treatment effects, FY 2004 appears during the pre-treatment period. Given our finding a significant drop in the propensity of Indian PhDs in the 2004 cohort to work in startups within ten years, this could drive a null result.

[67] Accenture, Cognizant, Infosys, Tata, and Wipro are all "outsourcing" companies that heavily employ Indian workers in computer-related occupations but report low numbers of doctorates among their H-1B applicants. Companies such as Intel, Microsoft, and Google are more likely to employ doctorates through the H-1B program.

[68] Permanent residency applications allow petitioners to use one's own priority date to file for permanent residency on behalf of a spouse or child (U.S. Department of State), and so if Indian doctorates are more likely than Chinese doctorates to marry temporary residents from the rest of the world, then they would be more likely to avoid EB-2 visa delays through this marriage channel.

[69] Data from IPUMS USA (Ruggles et al., 2021). Calculations utilize person weights. 8.7% of Indian PhDs and 4.9% of Chinese PhDs were married to a US spouse.

visa delays for Indian applicants have been short and rare, with no delays as of August 2022.[70] Figure 2 shows that the number of EB-1 visas issued to Indians began to noticeably diverge from the number of EB-1 visas granted to Chinese applicants starting in 2012, with an especially large uptick in 2020. While some proportion of these visas are issued to Indian PhDs in academia, Roach and Skrentny (2019) find that, among PhDs who had been employed in industry for at least 4 years (as of 2018) and who had received permanent residency visas, 52% had done so through applying for an EB-1 visa versus 48% who had done so through an EB-2 visa.[71] This suggests that the EB-1 has become a viable choice for PhDs working in industry and is likely to be especially attractive for Indians who would otherwise face prohibitively-long EB-2 visa delays.

Another possibility is that Indian STEM PhDs are less responsive to EB-2 visa delays because they view permanent residency in Canada as a closer substitute to US permanent residency than do Chinese STEM PhDs.[72] That is, job destruction at a US startup prior to green car receipt is less costly to Indians because they view employment in Canada as yielding a similar level of satisfaction. Figure 5 plots Canadian data on the number of Indians and Chinese granted permanent residency in Canada in each year.[73] The number of Indians granted permanent residency more than doubled between 2016 and 2019 while the number of Chinese granted permanent residency remained relatively stagnant.[74] Canadian immigration policies that expedite the permanent residency process for talented workers are an attractive option to Indians, with 49,765 (58%) of the 85,590 Indians granted Canadian permanent residency in 2019 doing so through the merit-based Express Entry program which has a typical turn-around time of six months or less.[75] Indian STEM PhDs who graduated from the US are likely to score well in the merit-based system given their level of education and language proficiency, and so Canadian permanent residency is likely an attractive and viable (back-up) option.[76]

[70] There are some instances of multiple-year delays. For example, Indian EB-1 applicants with priority dates as early as April 2018 had yet to receive a visa number by September 2020, while those who applied in a previous month and filed a Form I-485 at the earliest possible date would have been able to receive their visa without significant delay.

[71] Given the long wait times associated with Indian EB-2 visas, it is likely that almost all Indian PhDs reporting to have received an employment-based green card by the end of the sample period in Roach and Skrentny (2019) would have had to apply through the EB-1 category.

[72] One reason Canadian permanent residency may increasingly be seen as a substitute to US permanent residency is due to the increasing proliferation of and employment at Canadian affiliates of US multinational firms (Glennon, 2023).

[73] Data is from Immigration, Refugees and Citizenship Canada (IRCC).

[74] 39,705 Indians and 26,785 Chinese were granted Canadian permanent residency in 2016; this number increased to 85,590 Indians and 30,245 Chinese in 2019. The sudden decrease in 2020 is likely due to the COVID-19 pandemic.

[75] See `https://www.immigration.ca/how-express-entry-works` for more information on Express Entry. The Federal Skilled Worker (FSW) program does not require previous residency in Canada.

[76] Roach, Sauermann, and Skrentny (2020) find that Indian STEM PhDs are more likely than their Chinese counterparts to intend to work in another country besides the US or their home country directly after graduation; while only 2.3% of Indian STEM PhDs intend to work in another country over staying in the US or moving back home, none of the Chinese STEM PhDs in their sample indicated such a desire. Additionally, a greater share of Indian STEM PhDs than Chinese STEM PhDs intend to stay permanently in the US (48.4% vs. 17.4%), while a smaller share intend on working in the US prior returning home (35.8% vs. 54.1%) or returning to their home

Indian STEM PhDs have a greater preference for autonomy than both native and Chinese STEM PhDs (Roach, Sauermann, and Skrentny, 2020), and so if startups are viewed as granting greater levels of autonomy to workers, then Indian STEM PhDs will place a higher value on working at startups compared to other PhDs. The model in Section 3 implies that foreign-born STEM PhDs that place a higher value on working at startups will be more likely to work at startups in the face of visa delays, and that for sufficiently high values are not impacted by green card delays. A higher preference for working at startups, combined with greater preference for outside options (i.e., working in Canada), could drive Indian STEM PhDs to be more willing to bear the risk of working at a US startup while facing green card delays.

6.2 Comparison to Kahn and MacGarvie (2020)

Kahn and MacGarvie (2020) find insignificant estimates for the impact of visa delay length on the propensity of doctorates to work in startups. As discussed in Section 2 and Section 5.3, this could be due to differences in the KM measure of expected visa delay length and actual visa delay length. However, there are other differences between the analysis in this paper and that in Kahn and MacGarvie (2020). First, I consider person-level specifications where, in addition to temporary resident doctorates, I include native-born citizens, naturalized citizens, and permanent resident doctorates in the analytical sample; Kahn and MacGarvie (2020) consider person-year specifications which limit the analytical sample to temporary resident doctorates only since their main outcome of interest is US stay rates.[77]

Another difference is that Kahn and MacGarvie (2020) limit their definition of a startup to a business founded in the last five years with fewer than 25 employees, whereas the present study includes no limitation on the size of the employer. Decker et al. (2014) emphasize the importance of high-growth startups and young firms to overall job creation. First, new firms account for fewer than 10% of all firms but are responsible for about 20% of firm-level gross job creation. However, the role played by startups in gross job creation goes beyond their first year of existence. Decker et al. (2014) find that job creation is greatest in the earliest stages of a firm, with high-growth firms (those experiencing over a 25% increase in employment per year) tending to be young, representing 15% of all firms and 50% of gross job creation. Access to foreign-born talent is likely important to the ability of startups to becomes successful and quickly grow, as evidenced in Dimmock, Huang, and Weisbenner (2021), and so restricting the dependent variable to young firms with fewer than

country directly after graduation (8.8% vs. 24.3%). While not dispositive, it appears likely that a greater share of Indian STEM PhDs than Chinese STEM PhDs would view working in another country (e.g., Canada) as an attractive alternative in the case that they are unable to stay in the US permanently.

[77] Column (6) of Table 2 contains specifications where only temporary residents are included in the analytical sample. See footnote 36 for discussion of potential complications of a person-year approach in the given context. Another difference is that the analytical sample used in this paper includes doctorates graduating between 2001 and 2010 whereas Kahn and MacGarvie (2020) also include PhDs graduating between FY 2011 and 2013.

25 employees after as much as five years in operation would tend to count doctorates entering low-growth companies as working at startups while excluding those working at young high-growth firms with the greatest potential to impact innovation and job creation in the long run.[78]

Nevertheless, it is the case that greater than 90% of all true startups (i.e., firms in their first year of existence) employ fewer than 20 workers (Decker et al., 2014), and so limiting the definition of startups based on size is useful if wanting to separate the propensity of doctorates to work at true startups from their propensity to work at young high-growth firms, notwithstanding concerns over the inclusion of low-growth young firms as startups. Therefore, I report results using the same definition of startups as in Kahn and MacGarvie (2020) in Table A.6 and find that EB-2 visa delays decreased the propensity of Chinese doctorates to work in small startups, with estimates attenuated relative to those reported in Table 2 where high-growth firms founded within five years are included as startups.

The confluence of multiple factors—using a person-year level approach, limiting the dependent variable to only consider startups as firms founded in the last five years with fewer than 25 employees, only utilizing temporary resident doctorates in the control group, and using measures of expected visa delay length that differ from the actual length of delays—may have led to the insignificant results reported in Kahn and MacGarvie (2020) for the impact of EB-2 visa delays on the propensity of Chinese and Indian temporary resident doctorates to work at startups.

7 Conclusion

The ability of startups to innovate and grow is not only vital to their own success, but also fundamental to long-term economic growth, job creation, and a dynamic economy (Schumpeter, 1943; Kirzner, 1973; Decker et al., 2014). Startups not only bring about innovation through their own entrepreneurial activities, but also act as a competitive force that spurs established firms in technologically sophisticated industries to increase innovation themselves (Aghion et al., 2009). Startups exhibit an "up-or-out" dynamic, with most startups failing, but a small fraction exhibiting rapid growth and contributing disproportionately to overall job creation in the economy (Haltiwanger, Jarmin, and Miranda, 2013; Decker et al., 2014).[79] Given the important role of startups in spurring

[78] For example, Amazon was founded in 1994 and employed 256 employees by 1997 (SEC). Google was founded in September of 1998 and reported employing 260 workers as of 2001, over 50 of whom reportedly held doctorates (`http://web.archive.org/web/20011212085049/http://www.google.com/corporate/execs.html`). Facebook was founded in 2004 and reported employing over 2000 workers by December 2010 (SEC). Netflix, founded in 1998, reported 270 employees by the end of 1999 (SEC). Roach and Skrentny (2019) limit their definition of startups to firms founded in the last five years with fewer than 100 employees, which, as mentioned therein, leaves out young firms experiencing the highest growth rates during their sample period such as 23andMe and Uber.

[79] Previous research suggests that firm entry has persistent effects on US economic growth, and that the decrease in the rate of firm entry during the Great Recession may have contributed to the slow recovery (Gourio, Messer, and Siemer, 2016; Clementi and Palazzo, 2016).

innovation and job creation, immigration policies that hinder the ability of startups to attract high-end talent likely reduce innovation and growth in the economy as a whole by both reducing the success rate of existing startups and deterring startup formation.

In October 2005, doctorates from China and India began to face multiple-year delays in the processing of their EB-2 permanent residency visa applications. Using a difference-in-differences identification strategy, I find that US industry-bound Chinese and Indian STEM doctorates were 7.2 percentage points (42%) less likely to work at a startup in the first decade of their careers after the emergence of visa delays. This main result is driven by Chinese doctorates reducing their propensity to work in startups by 9.2 percentage points (48%), with each additional year of delay resulting in a 1.7 percentage-point reduction. Indian PhDs do not appear to change their propensity to work at startups in response to visa delays; instead, evidence suggests that Indian PhDs respond to delays by increasingly pursuing the qualifications necessary for an EB-1 green card and seeking permanent residency in Canada as a substitute for living in the US.

Previous research finds that increases in the restrictiveness of high-skilled immigration policy lead to distortions in the allocation of workers and students across borders (Kato and Sparber, 2013; Shih, 2016; Khosla, 2018; Kahn and MacGarvie, 2020; Glennon, 2023), fields of study (Amuedo-Dorantes, Furtado, and Xu, 2019), employment sectors (Amuedo-Dorantes and Furtado, 2019), and for-profit firms in industry (Mayda et al., 2018). This paper adds to the literature in finding that green card delays divert US-trained foreign-born STEM PhDs away from employment at startups and towards jobs at established firms where the rate of job destruction—and thus green card eligibility destruction—is lower. Prior research shows an immigrant advantage in innovation and entrepreneurship (Hunt, 2011; Kahn, La Mattina, and MacGarvie, 2017; Brown et al., 2020; Kerr and Kerr, 2022; Bernstein et al., 2022; Azoulay et al., 2022), that new firms have a competitive advantage in achieving major innovations (Akcigit and Kerr, 2018), and that immigrants hired in the early stages of startups increase the quantity and quality of innovations at startups and their success rates (Dimmock, Huang, and Weisbenner, 2021); thus, green card delays may result in lower rates of innovation, economic dynamism, and productivity growth in the US economy.

The allocation of talent to its most productive uses is important for economic growth (Baumol, 1990; Murphy, Shleifer, and Vishny, 1991), with Hsieh et al. (2019) finding that improvement in the allocation of talent between 1960 and 2010 explains up to 40% of the growth in aggregate output per person and Celik (2023) finding that misallocation of talent in the innovation sector decreases the rate of innovation in the economy by 10%. Akcigit and Goldschlag find that the share of US inventors working at young firms has fallen by about half since 2000, and that this diversion of inventor talent away from young firms and towards established firms reduces the inventive output of US inventors by 6 to 11 percent (Akcigit and Goldschlag, 2023*a*,*b*). Murphy, Shleifer, and Vishny (1991) cite two human capital-based explanations for slowing aggregate productivity growth:

sluggish growth in the quality of the US human capital stock and the misallocation of talent throughout the economy. Green card delays operate through both these channels, reducing US net brain gain as US-trained foreign-born STEM doctorates are pushed out of the country (Khosla, 2018; Kahn and MacGarvie, 2020) and, as this paper shows, diverting talent away from startups and towards established firms.[80]

The results in this paper suggest that reducing or eliminating visa delays for Chinese STEM doctorates would make working at startups a more attractive option for these workers early in their careers. Policies that could achieve this outcome include stapling a green card to the diploma of every foreign STEM doctorate, increasing the number of EB-2 visas available to STEM doctorates, introducing a Startup Visa program that allows freshly-minted foreign STEM doctorates to start their own businesses, or finding ways to reduce the problems faced by EB-2 applicants if their employer goes out of business before visa delays are resolved. Policy changes enacted by the current and previous administrations have moved policy in this direction: in January 2017, USCIS implemented a new set of rules allowing temporary workers with an approved Form I-140 to change employers while retaining the priority date on their earliest accepted Form I-140, and also eliminated the automatic revocation of an approved Form I-140 for temporary workers whose employer goes out-of-business 180 days or more after Form I-140 approval. On January 21, 2022, the USCIS increased the ability of international STEM doctorates and entrepreneurs to remain in the US by broadening the types of evidence that may be considered in determining whether workers can self-sponsor for an EB-2 visa through a National Interest Waiver. One avenue for future research is to analyze if these rule changes subsequently increased the propensity of temporary resident doctorates facing visa delays to stay in the US, seek industry employment, and work at startups. Another is to use a matched employer-employee dataset of the doctoral workforce to estimate how permanent residency delays impacted the number of startups in STEM PhD-intensive industries and the outcomes (e.g., patenting, revenue, productivity) of startups versus established firms in these industries.

Lastly, it is important to note the trade-offs inherent in any policy which aims to reduce the green card wait times for Chinese and Indian PhDs but does not increase the total number of EB-2 visas available worldwide. One such policy that has garnered bipartisan support during the last decade is to eliminate the 7% per-country cap on employment-based visas.[81] This would transition the US to a *first-come, first-served* employment-based visas policy that would likely reduce green

[80] Murphy, Shleifer, and Vishny (1991) use engineers as their typification of entrepreneurial workers. The majority of US-trained engineering PhDs are temporary residents at time of graduation (National Science Foundation, 2021), with many likely to face green card delays.

[81] An early version of such a bill appeared as the "Fairness for High-Skilled Immigrants Act of 2011" (H.R.3012). By December 2, 2020, both the House and Senate had passed versions of a similar bill (H.R. 1044 and S.386, respectively) that would have phased out the per-country employment-based green card caps, but differences between the House and Senate versions precluded its passage into law before the end of the 116th Congress.

card delays for immigrants from India. However, in the absence of an increase in the total number of employment-based green cards available, this would result in the emergence of lengthy green card delays for immigrants from the rest of the world, which could reduce their propensities to stay in the US or work at startups early in their careers.[82]

References

Aghion, Philippe, Richard Blundell, Rachel Griffith, Peter Howitt, and Susanne Prantl. 2009. "The Effects of Entry on Incumbent Innovation and Productivity." *The Review of Economics and Statistics*, 91(1): 20–32.

Aghion, Philippe, Ufuk Akcigit, Ari Hyytinen, and Otto Toivanen. 2022. "A Year Older, A Year Wiser (and Farther from Frontier): Invention Rents and Human Capital Depreciation." *The Review of Economics and Statistics*, 1–31.

Akcigit, Ufuk and Nathan Goldschlag. 2023*a*. "Measuring the Characteristics and Employment Dynamics of U.S. Inventors." NBER Working Paper No. 31086.

Akcigit, Ufuk and Nathan Goldschlag. 2023*b*. "Where Have All the "Creative Talents" Gone? Employment Dynamics of US Inventors." NBER Working Paper No. 31085.

Akcigit, Ufuk and Sina T. Ates. 2021. "Ten Facts on Declining Business Dynamism and Lessons from Endogenous Growth Theory." *American Economic Journal: Macroeconomics*, 13(1): 257–298.

Akcigit, Ufuk and Sina T. Ates. 2023. "What Happened to U.S. Business Dynamism?" *Journal of Political Economy (forthcoming)*.

Akcigit, Ufuk and William R. Kerr. 2018. "Growth through Heterogenous Innovations." *Journal of Political Economy*, 126(4): 1374–1443.

Amuedo-Dorantes, Catalina and Delia Furtado. 2019. "Settling for Academia? H-1B Visas and the Career Choices of International Students in the United States." *Journal of Human Resources*, 54(2): 401–429.

Amuedo-Dorantes, Catalina, Delia Furtado, and Huanan Xu. 2019. "OPT Policy Changes and Foreign Born STEM Talent in the U.S." *Labour Economics*, 61.

Anderson, Stuart. 2020. "Immigrant-Founded Moderna Leading The Way In Covid-19 Response." *Forbes*, https://www.forbes.com/sites/stuartanderson/2020/08/11/immigrant-founded-moderna-leading-the-way-in-covid-19-response/?sh=11b5c09261b0.

[82] If S.386 were to have been written into law in 2020, by FY 2030 EB-2 visa applicants could have expected to wait 37 years worldwide to receive their green card (Kandel, 2020).

Argueta, Carla N. 2016. "Numerical Limits on Permanent Employment-based Immigration: Analysis of the Per-Country Ceilings." Congressional Research Service (CRS) Report R42048.

Azoulay, Pierre, Benjamin F. Jones, J. Daniel Kim, and Javier Miranda. 2022. "Immigration and Entrepreneurship in the United States." *American Economic Review: Insights*, 4(1): 71–88.

Baumol, William J. 1990. "Entrepreneurship: Productive, Unproductive, and Destructive." *Journal of Political Economy*, 98(5): 893–921.

Bernstein, Shai, Rebecca Diamond, Abhisit Jiranaphawiboon, Timothy James McQuade, and Beatriz Pousada. 2022. "The Contribution of High-Skilled Immigrants to Innovation in the United States." NBER Working Paper No. 30797.

Brown, J. David, John S. Earle, Mee Jung Kim, and Kyung Min Lee. 2020. "Immigrant Entrepreneurs and Innovation in the US High-Tech Sector." In *The Roles of Immigrants and Foreign Students in US Science, Innovation, and Entrepreneurship*. 149–171. University of Chicago Press.

Celik, Murat Alp. 2023. "Does the Cream Always Rise to the Top? The Misallocation of Talent in Innovation." *Journal of Monetary Economics*, 133: 105–128.

Clementi, Gian Luca and Berardino Palazzo. 2016. "Entry, Exit, Firm Dynamics, and Aggregate Fluctuations." *American Economic Journal: Macroeconomics*, 8(3): 1–41.

Decker, Ryan A., John Haltiwanger, Ron S. Jarmin, and Javier Miranda. 2016. "Where Has All the Skewness Gone? The Decline in High-Growth (Young) Firms in the U.S." *European Economic Review*, 86: 4–23.

Decker, Ryan, John Haltiwanger, Ron Jarmin, and Javier Miranda. 2014. "The Role of Entrepreneurship in US Job Creation and Economic Dynamism." *Journal of Economic Perspectives*, 28(3): 3–24.

Decker, Ryan, John Haltiwanger, Ron S. Jarmin, and Javier Miranda. 2020. "Changing Business Dynamism and Productivity: Shocks versus Responsiveness." *American Economic Review*, 110(12): 3952–3990.

Deming, David J. and Kadeem Noray. 2020. "Earnings Dynamics, Changing Job Skills, and STEM Careers." *Quarterly Journal of Economics*, 135(4): 1965–2005.

Demirci, Murat. 2019. "Transition of International Science, Technology, Engineering, and Mathematics Students to the U.S. Labor Market: The Role of Visa Policy." *Economic Inquiry*, 57(3): 1367–1391.

Department of Homeland Security. 2020. "2019 Yearbook of Immigration Statistics." U.S. Department of Homeland Security, Office of Immigration Statistics. https://www.dhs.gov/sites/default/files/publications/immigration-statistics/yearbook/2019/yearbook_immigration_statistics_2019.pdf.

Diethorn, Holden A. and Gerald R. Marschke. 2023. "Task Mismatch and Salary Penalties: Evidence from the Biomedical PhD Labor Market." NBER Working Paper No. 30919.

Dimmock, Stephen G., Jiekun Huang, and Scott J. Weisbenner. 2021. "Give Me Your Tired, Your Poor, Your High-Skilled Labor: H-1B Lottery Outcomes and Entrepreneurial Success." *Management Science*, 68(9): 6950–6970.

Doran, Kirk, Alexander Gelber, and Adam Isen. 2022. "The Effects of High-Skilled Immigration Policy on Firms: Evidence from Visa Lotteries." *Journal of Political Economy*, 130(10): 2501–2533.

Glennon, Britta. 2023. "How Do Restrictions on High-Skilled Immigration Affect Offshoring? Evidence from the H-1B Program." *Management Science*.

Gourio, François, Todd Messer, and Michael Siemer. 2016. "Firm Entry and Macroeconomic Dynamics: A State-Level Analysis." *American Economic Review: Papers & Proceedings*, 106(5): 214–218.

Haltiwanger, John, Ron S. Jarmin, and Javier Miranda. 2013. "Who Creates Jobs? Small Versus Large Versus Young." *The Review of Economics and Statistics*, 95(2): 347–361.

Hsieh, Chang-Tai, Erik Hurst, Charles I. Jones, and Peter J. Klenow. 2019. "The Allocation of Talent and U.S. Economic Growth." *Econometrica*, 87(5): 1439–1474.

Hunt, Jennifer. 2011. "Which Immigrants Are Most Innovative and Entrepreneurial? Distinctions by Visa Entry." *Journal of Labor Economics*, 29(3): 417–457.

Hunt, Jennifer and Bin Xie. 2019. "How Restricted is the Job Mobility of Skilled Temporary Work Visa Holders?" *Journal of Policy Analysis and Management*, 38(1): 41–64.

Kahn, Shulamit and Megan MacGarvie. 2020. "The Impact of Permanent Residency Delays for STEM PhDs: Who Leaves and Why." *Research Policy*, 49(9).

Kahn, Shulamit, Giulia La Mattina, and Megan J. MacGarvie. 2017. "'Misfits', 'Stars', and Immigrant Entrepreneurship." *Small Business Economics*, 49: 533–557.

Kandel, William A. 2018. "Permanent Employment-Based Immigration and the Per-Country Ceiling." Congressional Research Service (CRS) Report R45447.

Kandel, William A. 2020. "The Employment-Based Immigration Backlog." Congressional Research Service (CRS) Report R46291.

Kandel, William A., Jill H. Wilson, and Sarah A. Donovan. 2022. "U.S. Employment-Based Immigration Policy." Congressional Research Service (CRS) Report R47164.

Kato, Takao and Chad Sparber. 2013. "Quotas and Quality: The Effect of H-1B Visa Restrictions on the Pool of Prospective Undergraduate Students from Abroad." *The Review of Economics and Statistics*, 95(1): 109–126.

Kerr, Sari Pekkala and William R. Kerr. 2022. "Immigration Policy Levers for US Innovation and Startups." In *Innovation and Public Policy*. 85–115. University of Chicago Press.

Kerr, William R. and William F. Lincoln. 2010. "The Supply Side of Innovation: H-1B Visa Reforms and U.S. Ethnic Invention." *Journal of Labor Economics*, 28(3): 473–508.

Khosla, Pooja. 2018. "Wait Time for Perminent Residency and the Retention of Immigrant Doctoral Recipients in the U.S." *Economic Analysis and Policy*, 57: 33–43.

Kim, J. Daniel. 2018. "Is there a startup wage premium? Evidence from MIT graduates." *Research Policy*, 47: 637–649.

Kirzner, Israel. 1973. *Competition and Entrepreneurship.* The University of Chicago Press.

Mayda, Anna Maria, Francesc Ortega, Giovanni Peri, Kevin Shih, and Chad Sparber. 2018. "The Effect of the H-1B Quota on the Employment and Selection of Foreign-Born Labor." *European Economic Review*, 108: 105–128.

Murphy, Kevin M., Andrei Shleifer, and Robert W. Vishny. 1991. "The Allocation of Talent: Implications for Growth." *The Quarterly Journal of Economics*, 106(2): 503–530.

National Science Foundation. 2010. "Doctorate Recipients from U.S. Universities 2009." National Science Foundation (NSF) Special Report 11-306.

National Science Foundation. 2021. "Doctorate Recipients from U.S. Universities 2020." National Science Foundation (NSF) Special Report 22-300. https://ncses.nsf.gov/pubs/nsf22300/report.

Pathak, Parag A., Alex Rees-Jones, and Tayfun Sönmez. 2022. "Immigration Lottery Design: Engineered and Coincidental Consequences of H-1B Reforms." *The Review of Economics and Statistics*, 1–43.

Roach, Michael and John Skrentny. 2019. "Why Foreign STEM PhDs are Unlikely to Work for US Technology Startups." *Proceedings of the National Academy of Sciences*, 116(34): 16805–16810.

Roach, Michael, Henry Sauermann, and John Skrentny. 2020. "Are Foreign STEM PhDs More Entrepreneurial? Entrepreneurial Characteristics, Preferences, and Employment Outcomes of native and Foreign Science and Engineering PhD Students." In *The Roles of Immigrants and Foreign Students in US Science, Innovation, and Entrepreneurship*. 207–228. University of Chicago Press.

Ruggles, Steven, Sarah Flood, Sophia Foster, Ronald Goekn, Jose Pacas, Megan Schouweiler, and Matthew Sobek. 2021. "IPUMS USA: Version 11.0 [dataset]." Minneapolis, MN: IPUMS.

Sauermann, Henry. 2017. "Fire in the belly? Employee motives and innovative performance in start-ups versus established firms." *Strategic Entrepreneurship Journal*, 12(4): 423–454.

Schumpeter, Joseph A. 1943. *Capitalism, Socialism, and Democracy.* George Allen & Unwin.

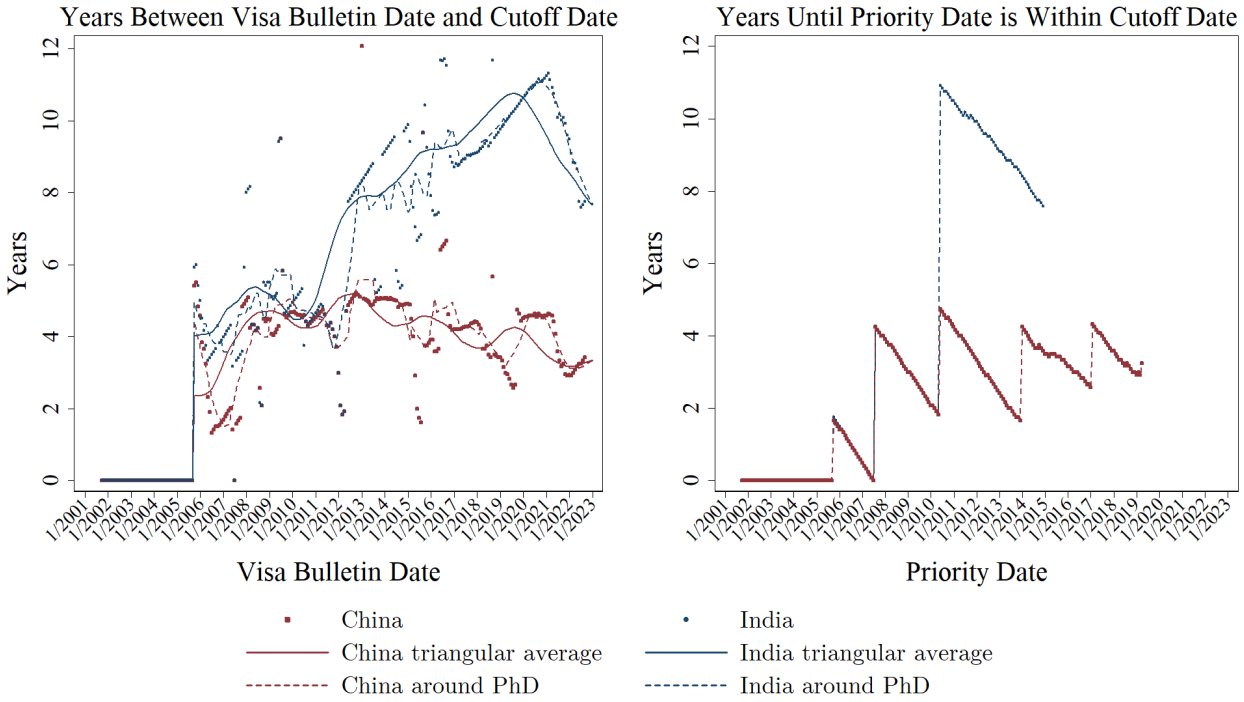
Shih, Kevin. 2016. "Labor Market Openness, H-1B Visa Policy, and the Scale of International Student Enrollment in the United States." *Economic Inquiry*, 54(1): 121–138.

Wang, Xuening. 2021. "US Permanent Residency, Job Mobility, and Earnings." *Journal of Labor Economics*, 39(3): 639–671.

Witsman, Katherine. 2018. "Annual Flow Report, Lawful Permanent Residents: 2017." Office of Immigration Statistics Report, U.S. Department of Homeland Security.

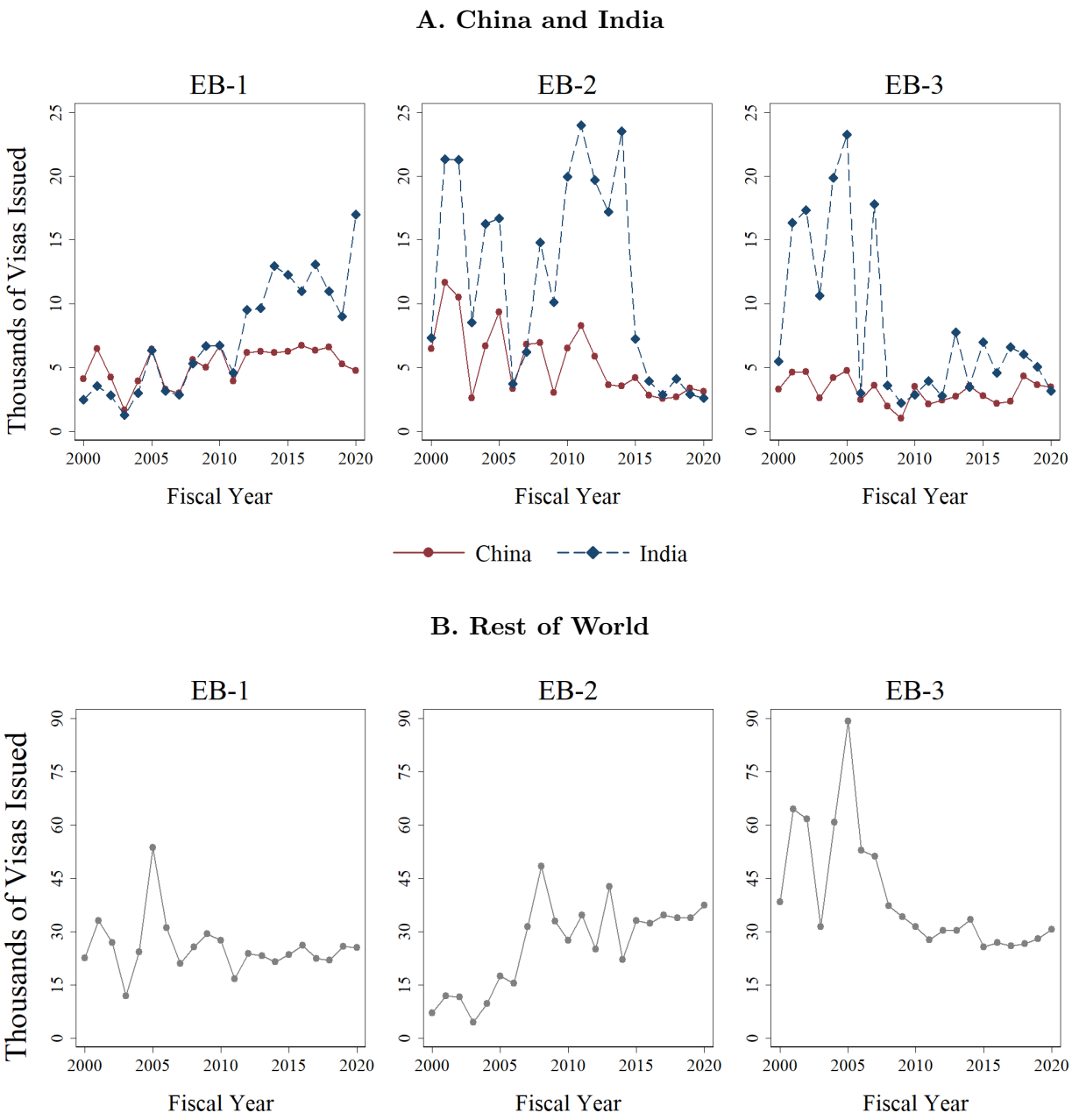
Figures

Figure 1: Measures of EB-2 Visa Delay Length by Month



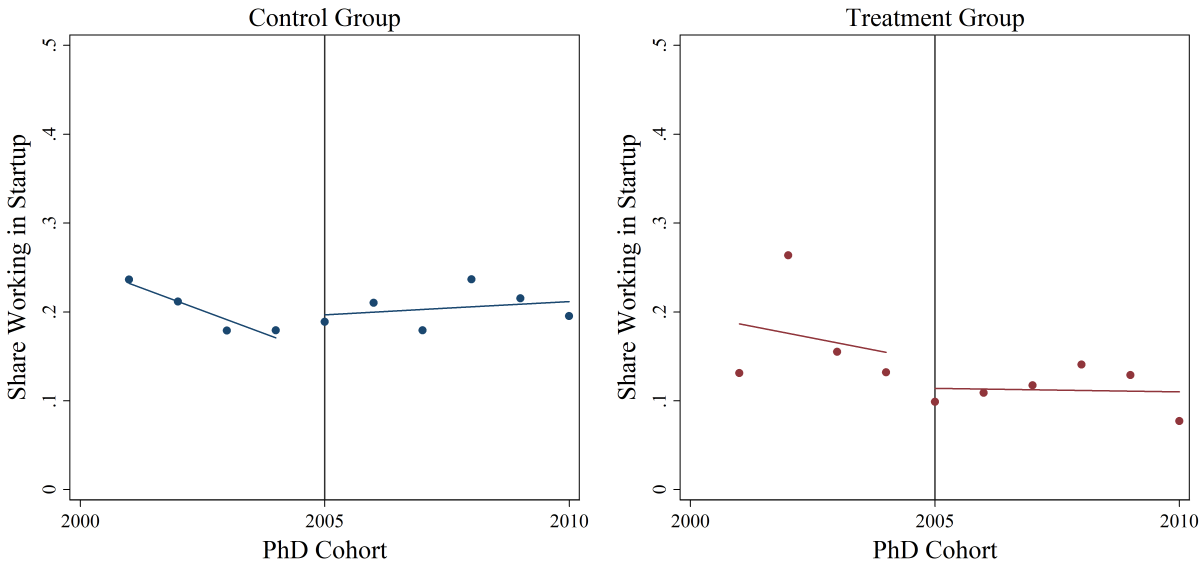
Notes: The left panel of Figure 1 shows the number of years between the visa bulletin date and EB-2 visa application priority date used as the cutoff for processing EB-2 visas from China and India for each month. The solid lines show triangular-weighted 3-year moving averages of these gaps for China and India, where the weights are centered at 1 year after each visa bulletin date. The dashed lines show a 12-month moving average of these gaps, centered on the visa bulletin month. These measures are used to represent expected visa delay lengths in Kahn and MacGarvie (2020). The right panel of Figure 1 shows the number of years before a given EB-2 visa application priority date first becomes current, which is when Chinese or Indian doctorates with the given priority date would first be able to file Form I-485 to adjust their status to that of a permanent resident and receive their green card. As of August 2022, the the most recent priority date ever used as a processing cutoff for EB-2 visas was December 1, 2014 for India and April 1, 2019 for China.

Figure 2: Employment-Based Visas Issued Subject to Numerical Limitation by Category



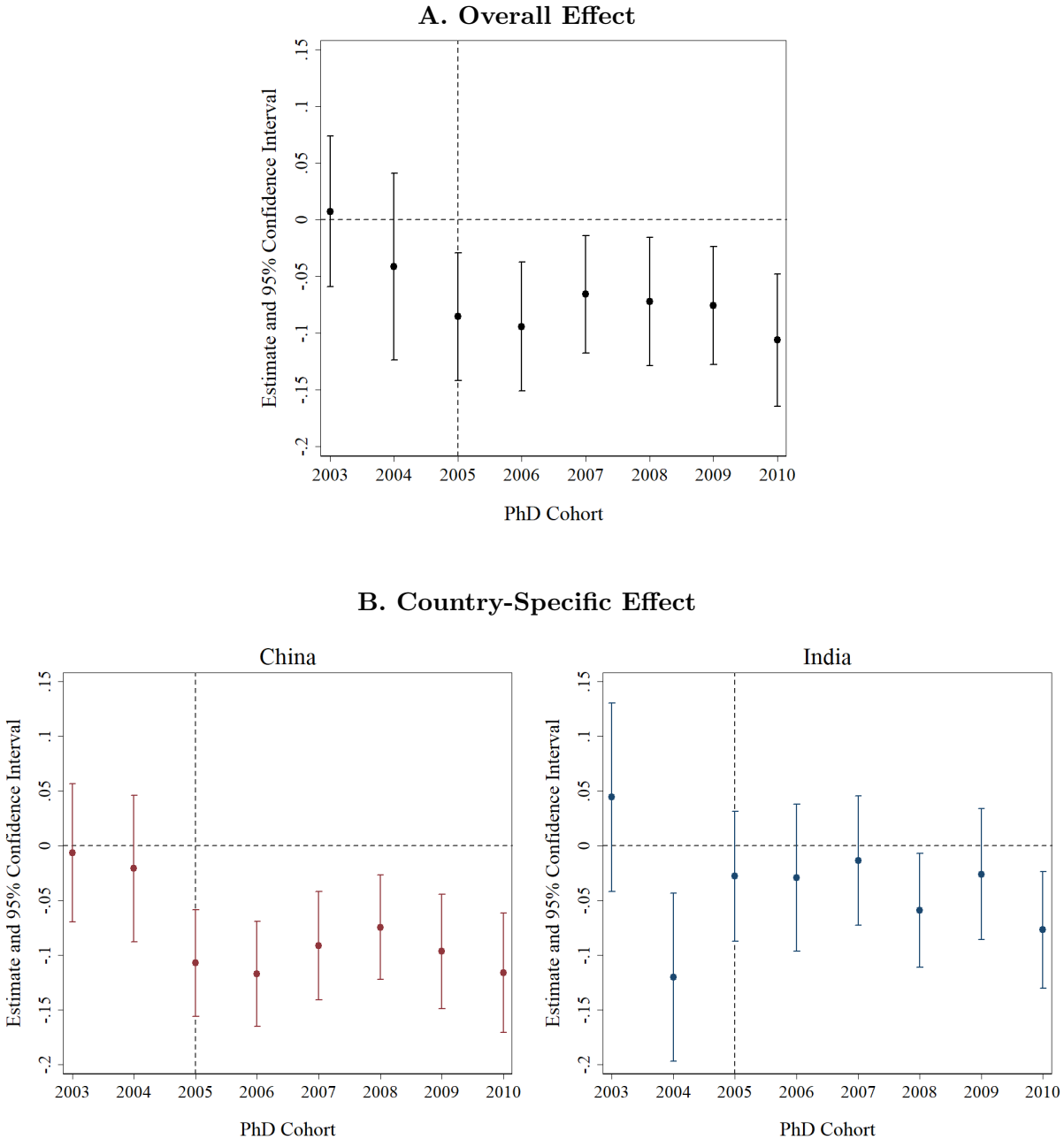
Notes: Figure 2 shows the number of EB-1, EB-2, and EB-3 visas issued subject to numerical limitation to immigrants born in China, India, and the rest of the world in each fiscal year. Data from Table V of the Department of States' annual Report of the Visa Office which can be accessed at
https://travel.state.gov/content/travel/en/legal/visa-law0/visa-statistics/annual-reports.html.

Figure 3: Share of Industry-Employed Doctorates Working in Startups within Ten Years by PhD Cohort



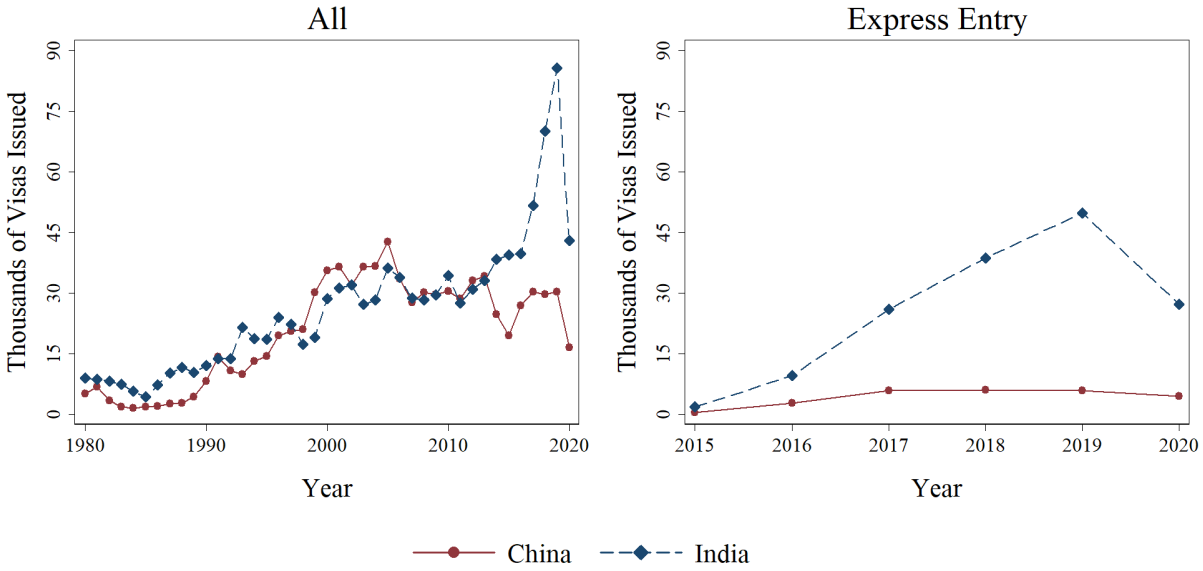
Notes: Figure 3 shows the share of industry-employed doctorates working in startup firms within ten years by PhD cohort and treatment status. The treatment group contains Chinese and Indian doctorates who were temporary residents at the time of PhD graduation. The control group contains US citizen doctorates, foreign-born doctorates who were permanent residents at the time of graduation, and doctorates from other countries who were temporary residents at the time of graduation. Startups are defined as new businesses reported to have been founded within the five years preceding the hiring of the doctorate.

Figure 4: Dynamic Impact of EB-2 Visa Delays by Country



Notes: Panel A plots the estimated effect of EB-2 visa delays on the propensity of industry-employed PhDs facing delays to work at startups, allowing the effect to vary over time. Panel B plots estimated effects that allow for the impact to vary by country. Coefficients reported in the first (Panel A), second, and third column of Table 5 are plotted with vertical bands representing the 95% confidence interval for each estimate.

Figure 5: Permanent Residency Admissions to Canada by Country (1980-2020)



Notes: The left panel of Figure 5 plots the number of Indians and Chinese receiving permanent residency in Canada in each year. The right panel shows the number of Indian and Chinese who obtain permanent residency through the competitive merit-based Express Entry system founded in 2015. Data is from Immigration, Refugees and Citizenship Canada (IRCC). The left panel is constructed using data for 2015 through 2020 from https://www.cic.gc.ca/opendata-donneesouvertes/data/IRCC_M_PRadmiss_0013_E.xlsx and for 1980 through 2014 from https://www.cic.gc.ca/opendata-donneesouvertes/data/IRCC_PRadmiss_0004_E.xls. The right panel uses data from https://www.cic.gc.ca/opendata-donneesouvertes/data/IRCC_M_EEadmiss_0004_E.xlsx.

Tables

Table 1: Summary Statistics

Period:	Pre-Treatment		Treatment	
Group:	Treatment	Control	Treatment	Control
Startup	0.17	0.20	0.11	0.20
China-born	0.75	0.04	0.66	0.04
India-born	0.25	0.02	0.34	0.02
Foreign-born	1.00	0.34	1.00	0.39
Temp. Resident	1.00	0.15	1.00	0.19
Perm. Resident	0.00	0.07	0.00	0.07
Age at PhD	30.27	32.56	29.89	31.60
Female	0.20	0.34	0.27	0.36
Asian	NA	0.18	NA	0.23
Minority	0.00	0.10	0.01	0.12
PhD Length	5.34	6.63	5.58	6.38
Married at PhD	0.69	0.48	0.63	0.47
Child at PhD	0.29	0.24	0.23	0.22
Fellowship during PhD	0.11	0.16	0.09	0.18
RA during PhD	0.66	0.33	0.65	0.33
TA during PhD	0.13	0.09	0.18	0.10
Mother's Highest Education: BA	0.35	0.22	0.27	0.25
Mother's Highest Education: > BA	0.08	0.22	0.13	0.22
Father's Highest Education: BA	0.46	0.21	0.39	0.23
Father's Highest Education: > BA	0.15	0.34	0.17	0.33
N	283	1614	1566	5990

Notes: This table reports weighted means for treatment and control groups in the pre-treatment period (FY 2001-2004) and treatment period (FY 2005-2010) where the weights used for each doctorate are those from the initial SDR wave wherein each doctorate is observed. Sample counts are unweighted. The treatment group includes Chinese and Indian PhDs who are temporary residents at the time of PhD graduation. The control group includes US citizen PhDs, foreign-born PhDs who were permanent residents at time of PhD graduation, and PhDs from other countries who were temporary residents at time of PhD graduation. "NA" used when small cell sizes in a category cannot be reported. Over 99% of doctorates in the treatment sample report Asian ethnicity across the the full sample period.

Table 2: Impact of EB-2 Visa Delays on Propensity of Industry-Employed PhDs to Work in Startup Firms within 10 Years

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A. Overall Effect						
Visa Delayed	-0.0569**	-0.0724***	-0.0677*	-0.0789***	-0.0550*	-0.0397
	(0.0227)	(0.0195)	(0.0392)	(0.0188)	(0.0290)	(0.0340)
R^2	0.020	0.159	0.159	0.189	0.207	0.244
N	9453	9453	9453	6613	4689	3217
Panel B. Country-Specific Effects						
Visa Delayed * China	-0.0758***	-0.0924***	-0.106***	-0.0924***	-0.0812***	-0.0638**
	(0.0135)	(0.0139)	(0.0267)	(0.0163)	(0.0248)	(0.0280)
Visa Delayed * India	-0.000616	-0.0169	0.0389	-0.0405*	0.0182	0.0343
	(0.0135)	(0.0185)	(0.0356)	(0.0222)	(0.0280)	(0.0363)
R^2	0.020	0.159	0.159	0.189	0.208	0.245
N	9453	9453	9453	6613	4689	3217
Controls						
Individual-level		✓	✓	✓	✓	✓
Fixed Effects		✓	✓	✓	✓	✓
Group-specific trend			✓			
Control Group PhDs						
US-born	✓	✓	✓	✓		
Foreign-born	✓	✓	✓		✓	
Temp. Residents Only						✓

Notes: This table reports the results of individual-level regressions used to estimate the impact of EB-2 visa delays on the propensity of Chinese and Indian PhDs to work at a startup within 10 years post-PhD. The sample includes all doctorates in the SDR graduating between FY 2001 and FY 2010 who are employed by a US for-profit firm within 10 years post-PhD and for whom I can identify whether they worked at a startup within 10 years. All regressions control for constructed survey year fixed effects based on the first and last SDR survey wave for which each doctorate is observed. "Individual-level" controls include all controls listed in Table A.1. "Fixed Effects" include cohort fixed effects, birth-country fixed effects, field of study fixed effects, and PhD university fixed effects. Robust standard errors clustered on cells constructed based on whether graduation year was before or after FY 2005, temporary resident status at time of graduation, and country-of-birth are reported in parentheses. All estimates produced using survey weights. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3: Impact of EB-2 Visa Delays on Propensity of PhDs to Work in Startup Firms in First Industry Job Observed within 10 Years

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A. Overall Effect						
Visa Delayed	-0.0541***	-0.0703***	-0.0603*	-0.0799***	-0.0503**	-0.0528*
	(0.0185)	(0.0158)	(0.0328)	(0.0153)	(0.0249)	(0.0317)
R^2	0.017	0.156	0.156	0.184	0.204	0.246
N	9453	9453	9453	6613	4689	3217
Panel B. Country-Specific Effects						
Visa Delayed * China	-0.0704***	-0.0865***	-0.0842***	-0.0892***	-0.0711***	-0.0733***
	(0.0127)	(0.0114)	(0.0258)	(0.0136)	(0.0211)	(0.0256)
Visa Delayed * India	-0.00805	-0.0261	0.00989	-0.0536***	0.00794	0.0104
	(0.0130)	(0.0163)	(0.0364)	(0.0198)	(0.0249)	(0.0332)
R^2	0.017	0.156	0.156	0.184	0.205	0.247
N	9453	9453	9453	6613	4689	3217
Controls						
Individual-level		✓	✓	✓	✓	✓
Fixed Effects		✓	✓	✓	✓	✓
Group-specific trend			✓			
Control Group PhDs						
US-born	✓	✓	✓	✓		
Foreign-born	✓	✓	✓		✓	
Temp. Residents Only						✓

Notes: This table reports the results of individual-level regressions used to estimate the impact of EB-2 visa delays on the propensity of Chinese and Indian PhDs to work at a startup as their first job in industry observed within 10 years post-PhD. The sample includes all doctorates in the SDR graduating between FY 2001 and FY 2010 who are employed by a US for-profit firm within 10 years post-PhD and for whom I can identify whether they worked at a startup within 10 years. All regressions control for constructed survey year fixed effects based on the first and last SDR survey wave for which each doctorate is observed. "Individual-level" controls include all controls listed in Table A.1. "Fixed Effects" include cohort fixed effects, birth-country fixed effects, field of study fixed effects, and PhD university fixed effects. Robust standard errors clustered on cells constructed based on whether graduation year was before or after FY 2005, temporary resident status at time of graduation, and country-of-birth are reported in parentheses. All estimates produced using survey weights. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4: Tests for Differential Pre-Treatment Trends

	(1)	(2)	(3)	(4)
Panel A. Overall Effect				
Treatment Group * Time Trend	0.0125	0.0192	0.0243	0.0447
	(0.0201)	(0.0275)	(0.0354)	(0.0401)
R^2	0.398	0.441	0.648	0.740
N	1897	1354	826	537
Panel B. Country-Specific Effects				
Treatment Group * Time Trend * China	0.0211	0.0314	0.0315	0.0607
	(0.0177)	(0.0251)	(0.0298)	(0.0381)
Treatment Group * Time Trend * India	-0.0167	-0.0145	-0.0112	0.00449
	(0.0220)	(0.0260)	(0.0316)	(0.0447)
R^2	0.399	0.442	0.651	0.741
N	1897	1354	826	537
Control Group PhDs				
US-born	✓	✓		
Foreign-born	✓		✓	
Temp. Residents Only				✓

Notes: This table reports results from regressions where the analytical sample is restricted to the pre-treatment period (FY 2001-2004) and the main parameter of interest is the coefficient on the treatment-group-specific time trend variable. See notes for Table 2 for more information on sample and controls. All regressions include the same controls as specification (2) in Table 2. Robust standard errors clustered on cells constructed based on whether graduation year was before or after FY 2005, temporary resident status at time of graduation, and country-of-birth are reported in parentheses. All estimates produced using survey weights. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5: Dynamic Impact of EB-2 Visa Delays

	(A) Overall Effect	(B) Country-Specific Effects	
	China & India	China	India
Two Years Before Treatment (FY 2003)	0.00735	-0.00622	0.0444
	(0.0339)	(0.0322)	(0.0439)
One Year Before Treatment (FY 2004)	-0.0410	-0.0207	-0.120***
	(0.0420)	(0.0341)	(0.0392)
First Treatment Year (FY 2005)	-0.0853***	-0.107***	-0.0277
	(0.0287)	(0.0249)	(0.0303)
Second Treatment Year (FY 2006)	-0.0940***	-0.117***	-0.0292
	(0.0289)	(0.0244)	(0.0342)
Third Treatment Year (FY 2007)	-0.0655**	-0.0912***	-0.0135
	(0.0264)	(0.0253)	(0.0301)
Fourth Treatment Year (FY 2008)	-0.0721**	-0.0743***	-0.0590**
	(0.0288)	(0.0243)	(0.0266)
Fifth Treatment Year (FY 2009)	-0.0756***	-0.0965***	-0.0260
	(0.0266)	(0.0266)	(0.0305)
Sixth Treatment Year (FY 2010)	-0.106***	-0.116***	-0.0768***
	(0.0298)	(0.0278)	(0.0271)
R^2	0.159	0.159	0.159
N	9453	9453	9453

Notes: This table reports estimates from regressions where the impact of EB-2 visa delays is allowed to vary across cohorts. Estimates reported in column (A) and column (B) are from separate regressions analogous to those in Panel A and Panel B of Table 2. See notes to Table 2 for details on the sample and controls. All regressions include the same controls and control group members as specification (2) in Table 2. Robust standard errors clustered on cells constructed based on whether graduation year was before or after FY 2005, temporary resident status at time of graduation, and country-of-birth are reported in parentheses. All estimates produced using survey weights.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6: Robustness Checks

	(1)	(2)	(3)	(4)
Panel A. Overall Effect				
Visa Delayed	-0.0664***	-0.104***	-0.0724***	-0.0463**
	(0.0234)	(0.0260)	(0.0243)	(0.0192)
R^2	0.213	0.168	0.159	0.143
N	5279	8890	9453	9453
Panel B. Country-Specific Effects				
Visa Delayed * China	-0.0883***	-0.130***	-0.0924***	-0.0653***
	(0.0180)	(0.0171)	(0.0147)	(0.0165)
Visa Delayed * India	-0.00449	-0.0303	-0.0169	0.00740
	(0.0225)	(0.0227)	(0.0191)	(0.0196)
R^2	0.213	0.168	0.159	0.144
N	5279	8890	9453	9453
Robustness Checks				
Exclude PhDs graduating after FY 2007	✓			
Exclude PhDs graduating in FY 2001		✓		
Cluster S.E. at Country/State Level			✓	
Field-by-Cohort Fixed Effects				✓

Notes: This table reports estimates from various robustness checks of the estimates in column (2) of Table 2. In the first column, doctorates graduating after FY 2007 are excluded from the sample to reduce the chance that results are driven by the April 2008 STEM OPT extension. In the second column, doctorates graduating in FY 2001 are excluded from the sample due to the presence of short visa delays during FY 2001. In the third column, standard errors are clustered at country-of-birth level. In the fourth column, we include field-cohort fixed effects to control for possible field-specific demands shocks facing different cohorts. See notes to Table 2 for details on the sample and controls. All estimates produced using survey weights. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7: Impact of Visa Delay Length Calculated Using KM Method

	(1)	(2)	(3)	(4)	(5)	(6)
Years Delayed	-0.00466	-0.00503				
	(0.00695)	(0.00615)				
China * Years Delayed			-0.00675	-0.00769		
			(0.00821)	(0.00698)		
India * Years Delayed			-0.00141	-0.000306		
			(0.00339)	(0.00301)		
China * 2 Years Delayed					-0.0356	0.0340
					(0.0273)	(0.0343)
China * 3 Years Delayed					-0.0653**	-0.0581**
					(0.0264)	(0.0262)
China * 4 Years Delayed					0.00306	-0.0429*
					(0.0289)	(0.0259)
China * 5 Years Delayed					-0.0452	-0.0267
					(0.0341)	(0.0304)
India * 3 Years Delayed					0.0885***	
					(0.0225)	
India * 4 Years Delayed					-0.0126	0.0192
					(0.0178)	(0.0184)
India * 5 Years Delayed					-0.00183	-0.00760
					(0.0153)	(0.0144)
India * 6 Years Delayed					-0.0189	
					(0.0212)	
R^2	0.158	0.158	0.158	0.158	0.159	0.158
N	9453	9453	9453	9453	9453	9453
Delay Length Metric						
Triangular-weighted MA		✓		✓		✓
12-month MA	✓		✓		✓	

Notes: See notes to Table 2 for details on the sample and controls. "Triangular-weighted MA" refers to a 3-year triangular-weighted moving average of visa delay lengths centered on 1 year post-PhD. "12-month MA" is a 12-month moving average of visa delay lengths centered around the month of PhD completion. All regressions include the same controls and control group members as specification (2) in Table 2. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 8: Impact of Visa Delay Length Calculated Using Number of Years Until Priority Date First Current

	(1)	(2)	(3)	(4)	(5)	(6)
Years Delayed	-0.00605	-0.00579				
	(0.00417)	(0.00435)				
China * Years Delayed			-0.0110	-0.0169***		
			(0.00743)	(0.00581)		
India * Years Delayed			-0.00334	-0.00106		
			(0.00247)	(0.00174)		
China * 1 Year Delayed					-0.0616***	-0.0652***
					(0.0217)	(0.0219)
China * 2 Years Delayed					-0.0509*	-0.0479*
					(0.0274)	(0.0262)
China * 3 Years Delayed					-0.0430**	-0.0771***
					(0.0212)	(0.0183)
China * 4 Years Delayed					-0.0597***	-0.0797***
					(0.0221)	(0.0181)
China * 5 Years Delayed					-0.0708**	-0.0718***
					(0.0280)	(0.0246)
India * 1 Year Delayed					0.0109	0.00560
					(0.0242)	(0.0242)
India * 2 Year Delayed					0.00441	-0.120***
					(0.0202)	(0.0245)
India * 3 Years Delayed					-0.0413**	0.0267
					(0.0197)	(0.0211)
India * 4 Years Delayed					0.0189	-0.0373*
					(0.0215)	(0.0226)
India * 10 Years Delayed					-0.0355	-0.0190
					(0.0241)	(0.0209)
R^2	0.158	0.158	0.158	0.158	0.159	0.160
N	9453	9453	9453	9453	9453	9453
Assumed Application Date						
12 Months Post-PhD	✓		✓		✓	
18 Months Post-PhD		✓		✓		✓

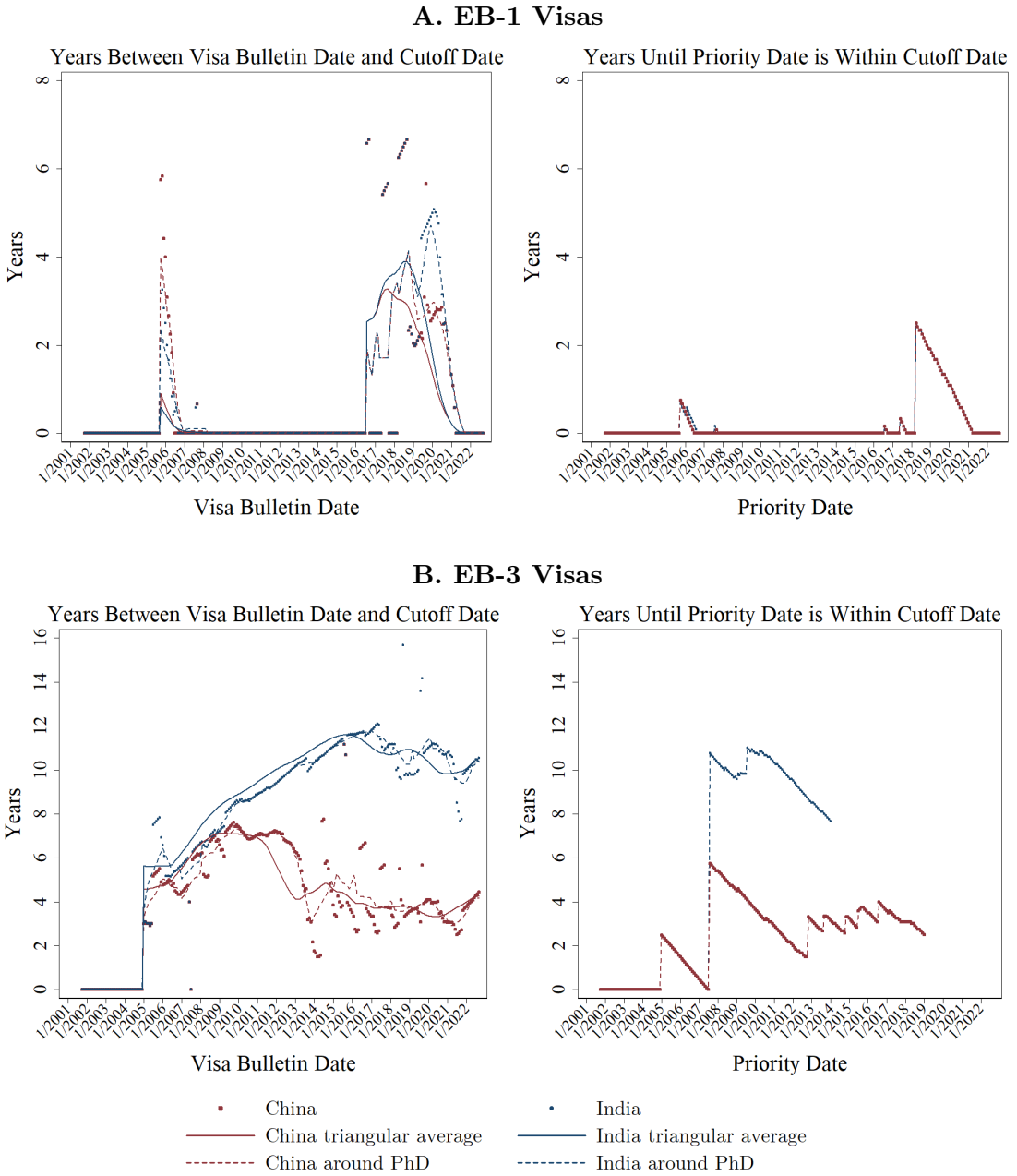
Notes: See notes to Table 2 for details on the sample and controls. All regressions include the same controls and control group members as specification (2) in Table 2. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix

Table of Contents

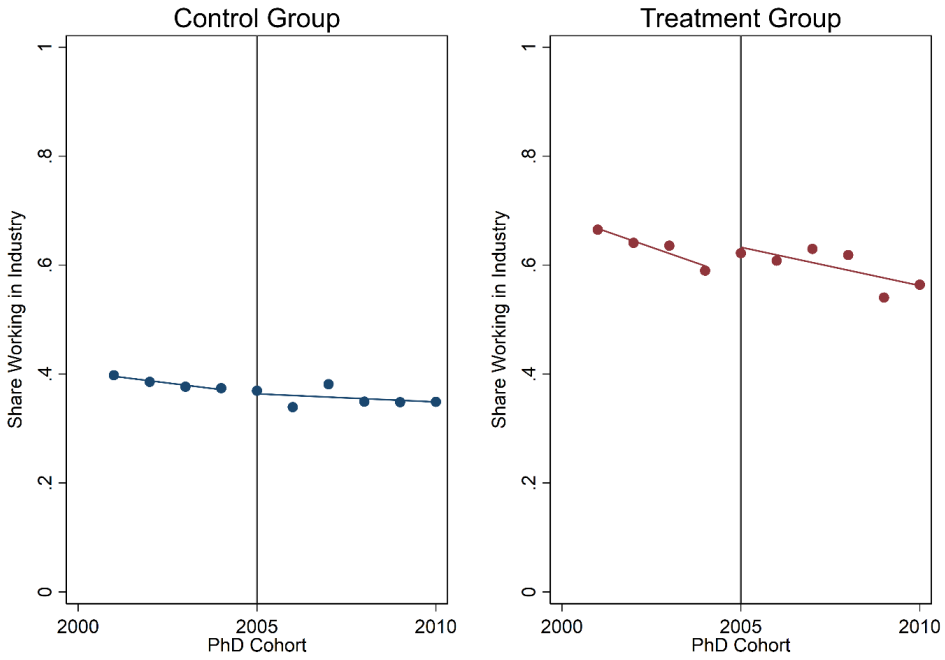
A Supplementary Figures and Tables

Figure A.1: Measures of EB-1 and EB-3 Visa Delay Lengths by Month



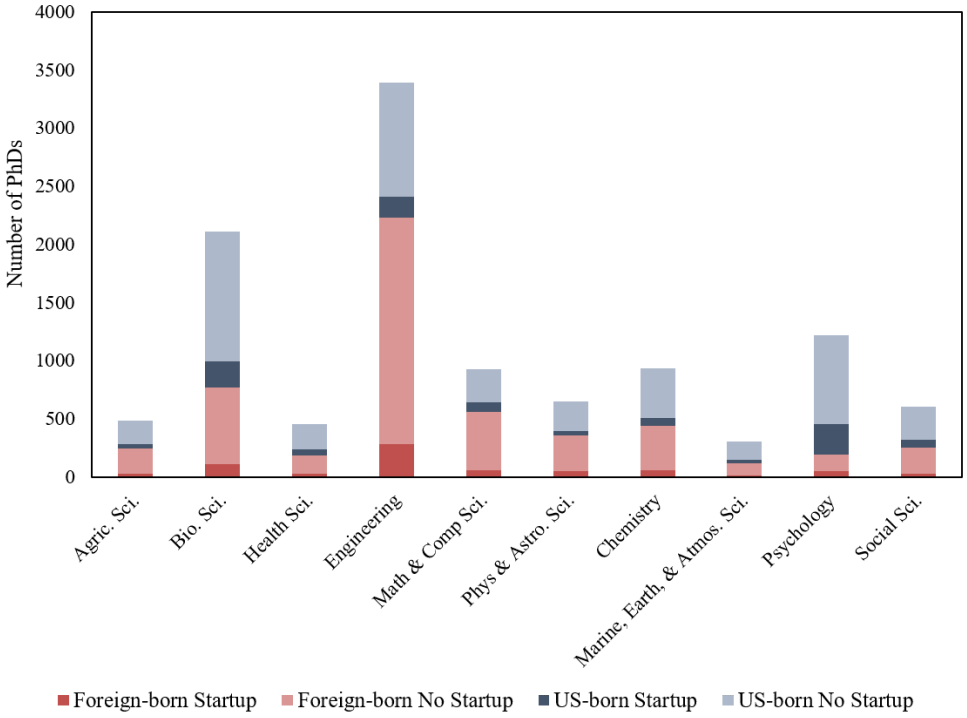
Notes: The top-left (bottom-left) panel of Figure A.1 shows the number of years between the visa bulletin date and EB-1 (EB-3) visa application priority date used as the cutoff for processing EB-1 (EB-3) visas from China and India for each month. The solid lines show triangular-weighted 3-year moving averages of these gaps for China and India, where the weights are centered at 1 year after each visa bulletin date. The dashed lines show a 12-month moving average of these gaps, centered on the visa bulletin month. The top-right (bottom-right) panel of Figure A.1 shows the number of years before a given EB-1 (EB-3) visa application priority date first becomes current, which is when Chinese or Indian doctorates with the given priority date would first be able to file Form I-485 to adjust their status to that of a permanent resident and receive their green card. As of August 2022, the most recent priority date used as a processing cutoff for EB-3 visas was January 1, 2014 for India and January 8, 2019 for China.

Figure A.2: Share of Doctorates Working in Industry within Ten Years by PhD Cohort



Notes: Figure A.2 shows the share of doctorates working in for-profit firms in industry within ten years by PhD cohort and treatment status. The treatment group contains Chinese and Indian doctorates who were temporary residents at the time of PhD graduation. The control group contains US citizen doctorates, foreign-born doctorates who were permanent residents at the time of graduation, and doctorates from other countries who were temporary residents at the time of graduation.

Figure A.3: Sample Break Down by Field



Notes: Figure A.3 breaks down the analytical sample by foreign-born status, field of degree, and whether doctorate works in a startup within 10 years of PhD graduation. Counts are unweighted. Category for "Other" fields excluded due to small cell counts. Categories are defined based on SED fine fields of study that fall within code ranges as follows: "Agricultural Science" = 000-099, "Biological Science" = 100-199, "Health Science" = 200-299, "Engineering" = 300-399, "Math and Computer Science" = 400-499, "Physical and Astronomy Sciences" = 500-509 & 560-579, "Chemistry" = 520-539, "Marine, Earth, and Atmospheric Sciences" = 510-519 & 540-559 & 580-599, "Psychology" = 600-649, "Social Sciences" = 650-699, "Other" = 700-999. SED fine fields of study are listed in the SED questionnaires at https://www.nsf.gov/statistics/srvydoctorates/#qs.

Table A.1: Regression Controls

Variable Name	Variable Definition
female	Indicator variable for if reported as a female
age_phd	Age when earned PhD
age_phd_sq	(Age when earned PhD)^2
asian	Indicator variable for if race reported as "Asian"
race_minority	Indicator variable for if race reported as non-Asian minority
foreign	Indicator variable for if reported as foreign-born
temp_res	Indicator variable for if reported being a temporary resident when earned PhD
perm_res	Indicator variable for if reported being a permanent resident when earned PhD
married_phd	Indicator variable for if reported being married when earned PhD
child_phd	Indicator variable for if reported any children living at home when earned PhD
married_child_phd	Indicator variable for if reported being married and having children at home when earned PhD
female_interactions	A set of two-way interaction terms between female and all controls listed above
phd_length	Number of years between entering PhD program and earning PhD
phd_length_miss	Indicator variable for if PhD length missing — phd_length assigned modal value
fellow	Indicator variable for if primary source of support during PhD was a fellowship or scholarship
TA	Indicator variable for if primary source of support during PhD was a teaching assistantship
RA	Indicator variable for if primary source of support during PhD was a research assistantship
edmother_ba	Indicator variable for if mother's highest level of education is Bachelor's degree
edmother_ma	Indicator variable for if mother's highest level of education is at least a Master's degree
edfather_ba	Indicator variable for if father's highest level of education is Bachelor's degree
edfather_ma	Indicator variable for if father's highest level of education is at least a Master's degree
profmd	Indicator variable for if earning or have already earned a professional degree such as MD
svy_year	A set of survey year fixed effects constructed by grouping together the first SDR wave and the last SDR wave that the doctorate is observed.
phdfy	A set of PhD cohort (i.e. graduation year) fixed effects
bthst	A set of country-of-birth fixed effects
phdfield	A set of SED fine field of study fixed effects
phdinst	A set of PhD university fixed effects

Notes: This table lists the controls used in regressions studying the impact of EB-2 visa delays on the propensity of foreign STEM doctorates to work in startups.

Table A.2: Impact of EB-2 Visa Delays on Propensity of PhDs to Work in Startup Firms within 10 Years

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A. Overall Effect						
Visa Delayed	-0.0345***	-0.0351***	-0.0300	-0.0339***	-0.0331**	-0.0304**
	(0.0133)	(0.0108)	(0.0184)	(0.0114)	(0.0132)	(0.0140)
R^2	0.005	0.074	0.074	0.083	0.113	0.142
N	26066	26066	26066	18707	10597	6845
Panel B. Country-Specific Effects						
Visa Delayed * China	-0.0479***	-0.0470***	-0.0509***	-0.0444***	-0.0465***	-0.0432***
	(0.00542)	(0.00566)	(0.00998)	(0.00661)	(0.0108)	(0.0125)
Visa Delayed * India	0.00439	-0.00163	0.0312**	-0.00385	-0.00474	0.00695
	(0.00556)	(0.00657)	(0.0129)	(0.00774)	(0.0121)	(0.0137)
R^2	0.005	0.074	0.074	0.083	0.113	0.143
N	26066	26066	26066	18707	10597	6845
Controls						
Individual-level		✓	✓	✓	✓	✓
Fixed Effects		✓	✓	✓	✓	✓
Group-specific trend			✓			
Control Group PhDs						
US-born	✓	✓	✓	✓		
Foreign-born	✓	✓	✓		✓	
Temp. Residents Only						✓

Notes: This table reports the results of individual-level regressions used to estimate the impact of EB-2 visa delays on the propensity of Chinese and Indian PhDs to work at a startup within 10 years post-PhD. The sample includes all doctorates in the SDR graduating between FY 2001 and FY 2010 and for whom I can identify whether they worked at a startup within 10 years. All regressions control for constructed survey year fixed effects based on the first and last SDR survey wave for which each doctorate is observed. "Individual-level" controls include all controls listed in Table A.1. "Fixed Effects" include cohort fixed effects, birth-country fixed effects, field of study fixed effects, and PhD university fixed effects. Robust standard errors clustered on cells constructed based on whether graduation year was before or after FY 2005, temporary resident status at time of graduation, and country-of-birth are reported in parentheses. All estimates produced using survey weights. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.3: Impact of EB-2 Visa Delays on Propensity of PhDs to Work in Industry within 10 Years

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A. Overall Effect						
Visa Delayed	-0.00731	0.00277	0.0235	0.0137	-0.0260*	-0.0363**
	(0.0180)	(0.0109)	(0.0354)	(0.0129)	(0.0150)	(0.0174)
R^2	0.038	0.218	0.218	0.222	0.274	0.309
N	26066	26066	26066	18707	10597	6845
Panel B. Country-Specific Effects						
Visa Delayed * China	-0.0143	-0.000491	-0.00618	0.0116	-0.0298*	-0.0384**
	(0.0143)	(0.0101)	(0.0189)	(0.0130)	(0.0159)	(0.0180)
Visa Delayed * India	0.00277	0.00903	0.0994***	0.0198	-0.0165	-0.0304
	(0.0147)	(0.0123)	(0.0195)	(0.0152)	(0.0177)	(0.0199)
R^2	0.038	0.218	0.218	0.222	0.274	0.309
N	26066	26066	26066	18707	10597	6845
Controls						
Individual-level		✓	✓	✓	✓	✓
Fixed Effects		✓	✓	✓	✓	✓
Group-specific trend			✓			
Control Group PhDs						
US-born	✓	✓	✓	✓		
Foreign-born	✓	✓	✓		✓	
Temp. Residents Only						✓

Notes: This table reports the results of individual-level regressions used to estimate the impact of EB-2 visa delays on the propensity of Chinese and Indian PhDs to work in industry within 10 years post-PhD. The sample includes all doctorates in the SDR graduating between FY 2001 and FY 2010 for whom I can identify whether they worked at a startup within 10 years. All regressions control for constructed survey year fixed effects based on the first and last SDR survey wave for which each doctorate is observed. "Individual-level" controls include all controls listed in Table A.1. "Fixed Effects" include cohort fixed effects, birth-country fixed effects, field of study fixed effects, and PhD university fixed effects. Robust standard errors clustered on cells constructed based on whether graduation year was before or after FY 2005, temporary resident status at time of graduation, and country-of-birth are reported in parentheses. All estimates produced using survey weights. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.4: Dynamic Impact of Visa Delays on Rest of the World

	Rest of World
Two Years Before Treatment (FY 2003)	-0.0138
	(0.0763)
One Year Before Treatment (FY 2004)	-0.0112
	(0.0773)
First Treatment Year (FY 2005)	-0.00400
	(0.0550)
Second Treatment Year (FY 2006)	-0.0918*
	(0.0538)
Third Treatment Year (FY 2007)	-0.0586
	(0.0503)
Fourth Treatment Year (FY 2008)	-0.0897*
	(0.0476)
Fifth Treatment Year (FY 2009)	-0.00314
	(0.0516)
Sixth Treatment Year (FY 2010)	-0.0761
	(0.0509)
R^2	0.179
N	7604

Notes: This table reports estimates from regressions where the impact of EB-2 visa delays is allowed to vary across cohorts and where the treatment group is made up of temporary doctorates from the rest of the world. See notes to Table 2 for details on the sample and controls. All regressions include the same controls and control group members as specification (2) in Table 2. Robust standard errors clustered on cells constructed based on whether graduation year was before or after FY 2005, temporary resident status at time of graduation, and country-of-birth are reported in parentheses. All estimates produced using survey weights. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.5: Robustness Checks with Only Temporary Resident Doctorates in the Control Group

	(1)	(2)	(3)	(4)
Panel A. Overall Effect				
Visa Delayed	-0.0300	-0.0275	-0.0397	-0.0377
	(0.0422)	(0.0430)	(0.0338)	(0.0304)
R^2	0.377	0.257	0.244	0.207
N	1819	3055	3217	3217
Panel B. Country-Specific Effects				
Visa Delayed * China	-0.0609*	-0.0598*	-0.0638*	-0.0614**
	(0.0347)	(0.0323)	(0.0341)	(0.0279)
Visa Delayed * India	0.0642	0.0690	0.0343	0.0362
	(0.0395)	(0.0452)	(0.0362)	(0.0371)
R^2	0.380	0.259	0.245	0.208
N	1819	3055	3217	3217
Robustness Checks				
Exclude PhDs graduating after FY 2007	✓			
Exclude PhDs graduating in FY 2001		✓		
Cluster S.E. at Country/State Level			✓	
Field-Cohort Fixed Effects				✓

Notes: This table reports estimates from various robustness checks of the estimates in column (6) of Table 2. In the first column, doctorates graduating after FY 2007 are excluded from the sample to reduce the chance that results are driven by the April 2008 STEM OPT extension. In the second column, doctorates graduating in FY 2001 are excluded from the sample due to the presence of short visa delays during FY 2001. In the third column, standard errors are clustered at country-of-birth level. In the fourth column, we include field-cohort fixed effects to control for possible field-specific demands shocks facing different cohorts. See notes to Table 2 for details on the sample and controls. All estimates produced using survey weights. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.6: Impact of EB-2 Visa Delays on Propensity of Industry-Employed PhDs to Work in Small Startup Firms within 10 Years

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A. Overall Effect						
Visa Delayed	-0.0225	-0.0469***	-0.0518*	-0.0534***	-0.0268	-0.0168
	(0.0145)	(0.0158)	(0.0278)	(0.0149)	(0.0200)	(0.0220)
R^2	0.022	0.187	0.187	0.214	0.237	0.243
N	9453	9453	9453	6613	4689	3217
Panel B. Country-Specific Effects						
Visa Delayed * China	-0.0333***	-0.0618***	-0.0585**	-0.0634***	-0.0460***	-0.0354**
	(0.0123)	(0.00965)	(0.0226)	(0.0114)	(0.0161)	(0.0179)
Visa Delayed * India	0.00565	-0.00501	-0.0232	-0.0252	0.0270	0.0404*
	(0.0125)	(0.0146)	(0.0294)	(0.0175)	(0.0171)	(0.0237)
R^2	0.022	0.188	0.188	0.214	0.238	0.244
N	9453	9453	9453	6613	4689	3217
Controls						
Individual-level		✓	✓	✓	✓	✓
Fixed Effects		✓	✓	✓	✓	✓
Group-specific trend			✓			
Control Group PhDs						
US-born	✓	✓	✓	✓		
Foreign-born	✓	✓	✓		✓	
Temp. Residents Only						✓

Notes: This table reports the results of individual-level regressions used to estimate the impact of EB-2 visa delays on the propensity of Chinese and Indian PhDs to work at a startup with fewer than 25 employees within 10 years post-PhD. The sample includes all doctorates in the SDR graduating between FY 2001 and FY 2010 who are employed by a US for-profit firm within 10 years post-PhD and for whom I can identify whether they worked at a startup within 10 years. All regressions control for constructed survey year fixed effects based on the first and last SDR survey wave for which each doctorate is observed. "Individual-level" controls include all controls listed in Table A.1. "Fixed Effects" include cohort fixed effects, birth-country fixed effects, field of study fixed effects, and PhD university fixed effects. Robust standard errors clustered on cells constructed based on whether graduation year was before or after FY 2005, temporary resident status at time of graduation, and country-of-birth are reported in parentheses. All estimates produced using survey weights. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

B Optional Practical Training (OPT) and H-1B Policy

This section discusses 1) F-1 Student Visa and Optional Practical Training (OPT) policy and 2) H-1B visa policy. For a discussion of permanent residency visa ("green card") policies which focuses on EB-2 permanent residency visa delays see Section 2.

B.1 Optional Practical Training (OPT)

For many foreign doctorates, the path to US permanent residency begins with the decision to study at a US university. International students in the US are typically supported by their universities under the F-1 visa program. Unlike H-1B visas and EB-2 visas, the number of F-1 visas issued in any fiscal year is not subject to a statutory cap. The F-1 visa allows international students graduating in the United States a limited period where they can use their F-1 visa to work for a US firm after graduation, which is known as the Optional Practical Training (OPT) period. The OPT period has historically lasted a maximum of 12 months, but in April 2008 the OPT period was extended an additional 17 months for foreign students receiving STEM bachelor's or graduate degrees from US universities. In May 2016, the OPT extension for STEM students was increased from 17 months to 24 months so that a foreign STEM student can now spend up to three years employed in the US while remaining in F-1 status. To remain working in the US after the OPT period has expired, foreign workers in F-1 status must typically find an employer to sponsor an H-1B visa.[83]

B.2 H-1B Visas for Temporary Residency

The H-1B visa program began in 1990 with the passage of the *Immigration and Nationality Act*. This program enables foreigners with a US bachelor's degree or its foreign-equivalent, known as "specialty workers", to obtain temporary employment in the United States. For many high-skilled immigrants, obtaining an H-1B visa represents an important steppingstone on the path towards achieving US permanent residency. Ever since its inception, the number of H-1B visas available in each fiscal year has been subject to a statutory cap. Figure B.1 shows the evolution of the H-1B cap over time. For fiscal years 1990 to 1998, the annual H-1B visa cap was set at 65,000 workers. During this period, the cap was only met in FY 1997 and 1998, precipitated by the rise of the technology sector during the dot-com boom. In response to this increased demand, the cap was temporarily increased to 115,000 for FY 1999-2000 by the *American Competitiveness and Workforce*

[83] Some exceptions exists. For example, STEM doctorates seeking employment as a postdoc may do so either through an H-1B visa or a J-1 visa. The J-1 visa is not subject to a statutory cap, has a five-year limit, and typically requires the STEM doctorate to return to their home country for at least two years after their J-1 employment. It is also possible for STEM doctorates to have their employer sponsor them for a green card while in F-1 status: according to Department of Labor data on applications for permanent employment certification, in 2017 about 10% of doctorates filing for permanent residency did so from F-1 status, while 80% file for permanent residency while holding an H-1B visa (U.S. Department of Labor).

Improvement Act (ACWIA), and then temporarily increased again to its highest level of 195,000 in FY 2001-2003 with the passage of the *American Competitiveness in the Twenty-First Century Act* (AC-21). Congress failed to renew the temporary cap of 195,000 workers put in place by AC-21 by FY 2004, and so the cap reverted to its initial level of 65,000 visas. Congress subsequently passed the *H-1B Visa Reform Act of 2004* which mandated that starting in FY 2005, 20,000 additional visas—referred to as Advanced Degree Exempt (ADE) H-1B visas—would be reserved for foreigners who had earned a master's degree or higher from a US institution of higher education, effectively setting the cap at 85,000 visas. The H-1B visa cap has been met every year since the FY 2004 drop in the cap, and since the H-1B Visa Reform Act of 2004, there have been no changes in the level of the cap.

Before applying for an H-1B visa, foreign-born workers wishing to obtain employment into specialty occupations in the US must first obtain a job offer from a US employer who then acts as a sponsor during the multi-step H-1B application process. First, the employer must file a Labor Condition Application (LCA) with the US Department of Labor that describes the occupation for which the foreign worker seeks employment, including the wage offered by the employer and the "prevailing wage" for the occupation as determined by the Department of Labor based on occupational title and location of work.[84] In an effort to prevent crowding out of native workers by cheap foreign labor, the employer is mandated to pay the higher of the actual offered wage and the prevailing wage. If the LCA is approved by the Department of Labor, then the employer can submit an H-1B visa application (Form I-129), along with the approved LCA and the $460 filing fee, to the Department of Homeland Security's US Citizenship and Immigration Services (USCIS). If the application is processed and approved by USCIS, then the foreign worker receives the H-1B visa which authorizes the worker's employment at that employer-sponsor for three years, with the possibility of a renewal for an additional three years.[85]

The first day of the H-1B application period in every fiscal year is April 1 of the previous year (e.g., April 1, 2005 was the first day of the FY 2006 H-1B application period). In "normal" years, H-1B visas are allocated on a first-come first-serve basis until the day the cap is reached. On the day that the number of H-1B applications first exceeds the visa cap, the USCIS randomly chooses which applications received on that day are approved—once they approve enough applications to

[84] An LCA for an H-1B worker is filed using Form ETA-9035 & 9035E.

[85] Section 106(b) of AC-21 (enacted in October 2000) allows for annual renewals of H-1B visas beyond the typical maximum of six years for specialty workers who have had their employer apply for a green card on their behalf but who have not yet obtained permanent residency. Section 104(c) of AC-21 allows those impacted by per-country quotas to have their H-1B status renewed until their Form I-485 form is able to be submitted and processed (https://www.govinfo.gov/content/pkg/PLAW-106publ313/pdf/PLAW-106publ313.pdf) and may renew in three-year increments (8 CFR 214.2(h)(13)(iii)(E)(1)). If a temporary worker fails to apply for permanent residency before reaching the end of their sixth year in H-1B status, they are required to leave the United States for at least one year before becoming eligible to apply for another H-1B visa, again in three-year increments for a maximum of six years (8 CFR 214.2(h)(13)(iii)(A)).

meet the cap, the rest are rejected.[86] In FY 2008-2009 and FY 2014-2020, the visa cap was met within the first week of the H-1B application period. The USCIS responded to this situation in each of these years by subjecting all H-1B visa applications received *by* the date that the cap was reached to a random lottery, instead of just those applications received *on* the day the visa cap was reached.[87]

It is important to note that not all H-1B visa applications are subject to the cap. First, applications for H-1B renewals are not subject to the cap. This includes annual H-1B visa extensions that are granted to foreign workers whose employers have already applied for permanent residency on their behalf, but who are waiting for their application to be processed.[88] Second, foreign workers from five countries—Canada, Mexico, Chile, Singapore, and Australia—with which the US has a free trade agreement are effectively exempt from the H-1B visa cap due to the existence of close H-1B visa substitutes available for foreigners from these countries.[89] Third, the passage of AC-21 made it so that starting in FY 2001, H-1B visa applications submitted by institutions of higher education and other non-profit research institutions, including government research institutions, are not subject to the visa cap.

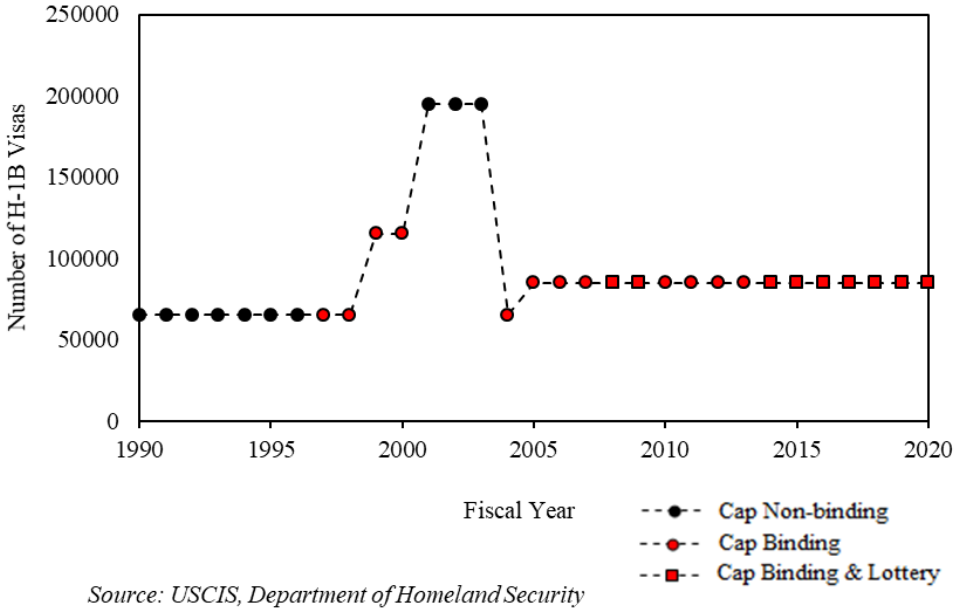
[86] For example, pooling across FY 2006 and 2007, H-1B applications on the day the cap was reached totaled 7,243, of which 4,180 applications were chosen for acceptance via random lottery (Doran, Gelber, and Isen, 2022).

[87] The two-tiered H-1B lottery has typically been conducted by the USCIS as follows: First, the USCIS allocates 20,000 Advanced Degree Exemption (ADE) H-1B visas via a random lottery to employees meeting the requirement of having received a US master's degree or above. After these 20,000 ADE H-1B visas are randomly selected for processing, any visas left over in the ADE pool are placed into the regular H-1B visa pool before the USCIS randomly selects 65,000 of these H-1B visa applications for processing. In FY 2020, USCIS reversed the order of these lotteries so that the lottery for the 20,000 ADE visas now occurs after the lottery for the other 65,000 visas. See Pathak, Rees-Jones, and Sönmez (2022) for a detailed discussion and analysis of the different H-1B visa allocation policies pursued by the USCIS since FY 2005.

[88] If a worker has applied for permanent residency, but their H-1B renewal period runs out before permanent visa delays are resolved, they are able to apply for annual H-1B visa extensions until permanent residency is achieved so long as the application for permanent residency was filed prior to the sixth year of the H-1B visa.

[89] Specialty workers from Canada and Mexico gained access to the TN visa in 1994, specialty workers in Singapore and Chile gained access to the H-1B1 visa starting in 2004, and specialty workers from Australia gained access to the E-3 visa starting in 2005. All three of these H-1B substitute visa classes were created as part of free trade agreements. The annual caps associated with the H-1B1 and E-3 visa classes have never been reached, and there exists no cap on TN visas.

Figure B.1: H-1B Visa Cap



Source: USCIS, Department of Homeland Security

Notes: Figure B.1 shows the level of the H-1B visa cap in each fiscal year.

C EB-2 Green Card Delay Warnings in FY 2005

On September 8, 2004, the US Department of State warned that the increasing number of employment-based green card applications would likely "require the establishment of cut-off dates in one or more categories during FY-2005."[90] On December 8, 2004, the US Department of State announced that they would begin delaying EB-3 visas for China, India, and the Philippines, thus ending an era of no employment-based permanent residency visa delays that spanned FY 2002 to FY 2004. Then, on May 8, 2005, the State Department issued its first warning of impending visa delays across all employment-based visas—including the EB-2 visa—stating that:

> [the] continued visa availability in the Employment-based categories cannot be guaranteed during the final quarter of FY-2005. If demand continues at the current rate, it will be necessary to oversubscribe many or all of the Employment categories on a Worldwide basis. Such oversubscription could result in the establishment of cut-off dates, retrogression of already established dates, or some categories becoming 'unavailable'.

Two months later on July 11, 2005, the State Department specifically issued a warning of impending EB-2 visa delays, stating that:

> As the end of the fiscal year approaches, it might be necessary to establish an Employment Second preference cut-off date for September to keep visa issuances within the annual numerical limits set by law. If required, such a cut-off date is likely to be limited to the China-mainland born and India chargeability areas.

Subsequently, on August 8, 2005, the US Department of State, following a warning of impending worldwide EB-3 visa delays, stated that:

> The amount of Employment demand for applicants from China and India is also likely to result in the oversubcription [*sic*] of the Employment First and Second preference categories for those chargeability areas. The establishment of such cut-off dates is expected to occur no later than December. The level of demand in the Employment categories is expected to be far in excess of the annual limits, and once established, cut-off date meovements [*sic*] are likely to be slow.

Finally, on September 8, 2005, the Department of State released the October 2005 visa bulletin which officially established new multiple-year EB-2 visa delays for India and China, and such delays have persisted ever since.

[90] The Department of State issued these warnings through their monthly Visa Bulletins available at https://travel.state.gov/content/travel/en/legal/visa-law0/visa-bulletin.html. The visa bulletin for each month is published during the preceding month (e.g., the October 2004 visa bulletin was published on September 8, 2004) and discusses the changes in the availability of permanent residency visas.