The Effects of Green Cards on the Wages and Innovations of New PhDs

Xiaohuan Lan[1]

Cheung Kong Graduate School of Business

This is a preprint of an article published in Journal of Policy Analysis and Management, 32(4),807–834. http://onlinelibrary.wiley.com/doi/10.1002/pam.21713/abstract

Abstract

Visa policies restrict job opportunities and job mobility for U.S.-trained PhDs who hold a temporary visa, a group that accounts for 40% of new PhDs in science and engineering. The Chinese Student Protection Act of 1992 unexpectedly granted Chinese students a green card. Many CSPA-beneficiaries did not pursue postdoctoral training and instead entered the public or private sectors, which increased the relative wage of native postdocs to non-postdocs. Four to eight years after graduation, CSPA-beneficiaries earned 9% more than the comparison group, were less likely to work in academia, published fewer research articles, and produced more patents.

[1] This paper is based on my PhD dissertation, and all empirical results in this paper are based on my data analysis completed at the University of Virginia before graduation. I gratefully acknowledge Leora Friedberg, William Johnson, and Sarah Turner for advice and encouragement. I thank the editor, three anonymous referees, Henry Cao, Kirk Doran, Roger Gordon, William Kerr, Xiaoyang Li, Wei Li, Robert Olson, Michelle White, and seminar participants at Abt Associates, Central University of Finance and Economics, Cheung Kong Graduate School of Business, Renmin University of China, and University of Virginia for helpful comments and suggestions. The use of NSF data does not imply NSF endorsement of the research methods or conclusions contained in this paper. This paper was previously circulated under the titles "Green Card, Wage, and Innovation of PhDs" and "Foreign PhDs and the Wage of Postdocs in the U.S.". All errors are mine.

INTRODUCTION

A long-standing policy debate exists on whether to grant green cards (or permanent legal resident status) to international students who earned advanced degrees in science and engineering (S&E) in American universitie.[2] For these immigrants, green cards potentially provide greater job opportunities, remove restrictions related to temporary work visas, and improve the quality of job match. Ultimately, green cards may encourage these students to remain in the U.S. after graduation and contribute to scientific innovation in the country.[3] The influx of foreign talents into the U.S., however, could reduce the income and productivity of comparably-trained natives (Borjas, 2006; Borjas & Doran, 2012). Visa reforms, like the recently proposed bill known as the Immigration Innovation Act of 2013, must carefully weigh all of these effects.[4]

This paper evaluates multiple effects of green cards on both their holders and comparable natives, among the group of U.S.-trained PhDs in S&E. This group leads American scientific innovation and is composed of greater number of immigrants than other disciplines. From 1980 to 2005, the percentage of non-citizens among S&E PhDs trained in the U.S. increased from 26% to 48%; 82% of these held a temporary visa (hereafter

---

[2] In this paper, S&E does not include the social sciences and psychology. One of the most recent policy debates involved the hearing of the U.S. House of Representatives on October 5, 2011, entitled "STEM the Tide: Should America Try to Prevent an Exodus of Foreign Graduates of U.S. Universities with Advanced Science Degrees?" The record is available online: http://judiciary.house.gov/hearings/printers/112th/112-64_70576.PDF. For the debate on the current H1B temporary work visa for high-skilled immigrants, see, for example, Lowell (2001), Matloff (2003), and Kerr and Lincoln (2010).

[3] A large literature has documented significant contributions of high-skilled immigrants to scientific innovation in the U.S. Some of the most recent examples include Stephan and Levin (2007), Chellaraj, Maskus, and Mattoo (2005), Stuen, Mobarak, and Maskus (2007), Black and Stephan (2008), Kerr and Lincoln (2010), Hunt and Gauthier-Loiselle (2010), and Hunt (2011). For those who have to leave the U.S. when their temporary visa expires, especially for those moving to a developing country, Kahn and MacGarvie (2012) report that their research productivity is lower due to loss of access to a high-quality research environment.

[4]For a summary of the bill, see http://www.hatch.senate.gov/public/index.cfm/releases?ID=f9331d41-1577-4475-934d-a38ce592d987 .

referred to as temporary immigrants), and 75% of these temporary immigrants planned to work in the U.S. after graduation (NSF, 2005). Due to limited job opportunities restricted by work visa, temporary immigrants are more likely to take a low-paid postdoctoral position than citizens or permanent residents (Lan, 2012a).

I examine a unique visa shock from the Chinese Student Protection Act of 1992 (CSPA). In order to protect Chinese students and scholars in the U.S. from political persecution following the Tian'an Men Square Incident in 1989, the CSPA unexpectedly granted green cards to thousands of Chinese PhDs. Holding a green card at the time of graduation eliminated all restrictions imposed by a temporary work visa and made available increased job opportunities in the U.S. I evaluate the effects of this shock on income and productivity of PhDs by using the data from two surveys: the Survey of Earned Doctorates, a unique annual individual-level census of new doctorate recipients in U.S. institutions; and the Survey of Doctorate Recipients, a biannual longitudinal individual-level employment survey.

Since Chinese students comprised the largest group of immigrants among S&E PhDs in the 1990s, 12% of all new PhDs and 16% of all postdocs, the CSPA and more job opportunities associated with a green card created a large flow from low-paid postdoctoral sector to other public or private sectors. The *relative supply* of postdocs to non-postdocs on the market decreased, and the *relative wage* of native postdocs to native non-postdocs increased. This paper estimates that a 10% decrease in the percentage of temporary immigrants among all new PhDs, driven by more Chinese green card holders, increases the *relative wage* of native postdocs to non-postdocs by about 6%, operating through a higher *wage level* of native postdocs.

Holding a green card at the time of graduation affects the long-term career outcomes of its holder. A green card creates more job opportunities outside of academia and enhances job mobility, while a temporary work visa is tied to a specific employer. In 2001, four to eight years after graduation, the difference-in-difference estimate shows that CSPA-beneficiaries earned 9% more than the comparison group, were less likely to work in academia, published fewer research articles, and produced more patents.

This paper contributes to the large literature on the wage effect of immigrants on natives in several important aspects. First, I use a foreign political shock, exogenous to the U.S. economy and labor market conditions, to identify the effect of the inflow of temporary immigrants. In this vein, Card (1990) uses the immigration flow into Miami after the Mariel Boatlift in Cuba, and Friedberg (2001) uses the flow into Israel around the collapse of the Soviet Union. In contrast, many others use an instrument based on historical enclaves of immigrants as a determinant of geographic location within the U.S. (Card, 2001 and 2009). Second, I focus on the national labor market for PhDs within 38 research fields, while much of the literature focuses on local labor markets. As a response to immigrant inflows, endogenous movement of natives across markets is a typical concern in the research based on local markets (Borjas, 1999; Card, 2001). For PhDs, the labor market is certainly national, while mobility across research fields is rare. Third, I only use new PhDs with little work experience, which differs from studies that exploit variation across education-experience groups, such as Borjas (2003). Fourth, I highlight different job choices between foreigners and natives caused by work visa restrictions, not by comparative advantage as in Peri and Sparber (2009). Finally, my results complement the results of Borjas (2006). He shows that a 10% increase in immigrant PhDs lowers the wage of all PhDs by 3% to 4%, and about half of this negative effect can be attributed to the prevalence of low-paid postdoctoral positions.[5] However, he does not deal with the endogeneity of immigrant inflow. Using data on only new PhDs and an instrumental variable, I show that a 10% increase in the percentage of temporary immigrants lowers the relative wage of native postdocs to non-postdocs by about 6%.

For immigrant groups, this paper adds to the estimates of wage premium from holding a green card. Both an employment-based and a marriage-based green card could boost wages (Chi & Drewianka, 2010; Mukhopadhyay & Oxborrow, 2012), as could a green card granted by policy changes. Examining the largest amnesty program in the U.S., the 1986 Immigration Reform and Control Act, Kossoudji and Cobb-Clark (2002) estimate that the act increases the wage of its beneficiaries by 6%. For the second largest amnesty

[5] He includes both naturalized citizens and permanent residents as immigrants, but I only focus on temporary immigrants. He also includes PhDs in the fields of psychology and the social sciences.

program in the U.S., the 1997 Nicaraguan Adjustment and Central American Relief Act, Kaushal (2006) estimates that the act increases the wage of its beneficiaries by 3%-4%. This line of research generally suggests that skilled immigrants benefit more from a green card than unskilled immigrants, since skilled immigrants are more capable of taking advantage of new opportunities. For immigrants with the highest skill level, S&E PhDs, this paper shows that a green card increases their annual earnings by 9%-10%. This result complements the results of Orrenius, Zavodny, and Kerr (2012). Using census data, they show that the CSPA increases employment and earnings of college-educated Chinese. In addition to controlling for a greater number of individual characteristics that could affect wage than were included in their study, such as research fields and quality of PhD programs, I also relate higher earnings of CSPA-beneficiaries with their career change: they are less likely to work in academia which pays less than other sectors.

This paper links the career choices of high-skilled workers with their innovative output, which helps explain the mechanism of innovation and talent allocation. Zucker, Darby, and Toreto (2002) show that the career change of star scientists from academia to firms is related to the research productivity of their own and their colleagues who have moved to a firm. Shu (2012), on the other hand, estimates that labor market conditions and job choice at the time of college graduation affect the future patent production of MIT alumni. This paper shows that holding a green card and benefiting from the greater job opportunities it affords attracts immigrant PhDs from academia into industry. This career change discourages academic publications but encourages patent production, since industry generally rewards patents over research articles.[6]

This paper also suggests that visa policies can help explain the prevalence of low-paid postdoctoral positions, which has become a major issue in science policy but its reasons and consequences are still unclear (NSB, 2008). Despite the crucial contributions of postdocs to scientific research, the prolonged low-paid training and the fast expansion of this population has raised concerns about the negative impact on the careers of young

[6] Many papers have documented that patent production increases firms' market value and productivity, for example, see Bloom and Van Reenen (2002) and Hall, Jaffe, and Trajtenberg (2005).

scientists.[7] Freeman et al. (2001) describe the competition between research labs as a tournament, in which principal investigators (PIs) have strong incentives to hire a large number of postdocs and PhD students at low cost. Stephan and Ma (2005) show that the large number of postdoctoral positions is related to a lower demand for faculty positions in universities. Besides these factors involving labor demand, I show that visa policies create an extra labor supply of postdocs from the pool of temporary immigrants and decrease the relative wage of postdocs to non-postdocs.

DATA

I use two surveys of S&E PhDs trained in U.S. universities: the Survey of Earned Doctorates (SED) and the Survey of Doctorate Recipients (SDR). Both surveys are jointly conducted by multiple federal agencies, including the National Science Foundation (NSF), the National Institutes of Health (NIH), and the U.S. Department of Education (DOE).[8] The NSF maintains the data and provides a version for public use.[9] I

[7] Postdocs are key inputs in research production. 87% of papers in *Science* have either a current postdoc or graduate student as one of the authors (Black & Stephan, 2008). Many principal investigators (PIs) apply for grants based on research conducted by postdocs in their labs (Freeman et al., 2001), and the work of postdocs also allows PIs to spend time managing labs (Decker et al., 2007). Postdocs routinely help train undergraduate and graduate students (NAS, 2000). Meanwhile, the median length of time spent in postdoc positions grew from 24 months for pre-1972 graduates to 46 months for 1992–1996 graduates in the life sciences, from 21 to 30 months in the physical sciences, and from 12 to 19 months in other S&E research fields (NSB, 2008). From 1985 to 2005, the number of postdocs in U.S. academia almost tripled, while full-time faculty positions only increased by 26% (NSB, 2008). Postdocs accounted for 63% of all full-time non-faculty positions in academia in 2006 and have become the largest part of the workforce in biomedical science (Garrison, Stith, & Gerbi, 2005). The expansion of the postdoctoral population significantly reduces the probability of landing a faculty position after completion of the postdoctoral training (Freeman, 2005)

[8] The SED is jointly sponsored by the NSF, the NIH, the DOE, the U.S. Department of Agriculture, the National Endowment for the Humanities, and the National Aeronautics and Space Administration. The SDR is jointly conducted by the NSF and the NIH.

[9] The SED data are available at WebCASPAR: https://webcaspar.nsf.gov/; and the SDR data are available at SESTAT: http://sestat.nsf.gov/datadownload/.

use the restricted data with a license, which includes additional information necessary for this research, such as visa status.

The SED is a unique annual individual-level census of doctorate recipients in U.S. institutions from 1957 onwards. The survey is given to each individual PhD at the time of graduation. As a part of the graduation process, response rates are high, at around 92%. It records detailed information on post-graduation employment status, visa status, country of citizenship, research fields, and demographic variables (such as gender and marital status). The SED does not report wage or follow respondents beyond the time of graduation.

The SDR is a longitudinal individual-level survey based on the S&E population obtained in the SED. The survey records post-graduation employment status, wage, research productivity such as the number of publications and patents, visa status, and a number of demographic variables. For U.S. citizens, the survey covers S&E doctorates under 76 years of age; and for non-citizens, it covers those who plan to remain in the U.S. after receiving their degree. The survey has been conducted biannually since 1973, and each wave includes about 30,000 PhDs in S&E. The survey was redesigned in 1993 in order to increase the response rate, and the rate has been stable at around 82% ever since.

I use all S&E PhDs who received doctoral degrees between 1991 and 2000, and the selected period includes an exogenous visa shock from the Chinese Student Protection Act in 1992.[10] In order to measure the number of temporary immigrants among new PhDs, I use the SED since it is a census and offers more accurate measure of the size of the

[10] The pre-1991 SDR data are not strictly comparable with the later data, after a major redesign of the survey in 1993. For example, since 1993, the SDR has included more than 90 questions, compared to 20 to 37 questions in the 1980s and in 1991 (Cox, Mitchell, & Moonesinghe, 1998). In the late 1980s, the response rate of the SDR dropped to about 50%, which may not be an unrepresentative national sample. Borjas (2006) mentions the similar reasons and drops data from the pre-1993 SDR. More importantly, the visa policies discussed in this paper are based on the *1990 Immigration Act* (effective in 1991). This act was the most significant reform in legal immigration since the *1965 Immigration and Nationality Act*. The 1990 Act created the present employment-based green card categories (EB visas). Thus, for all pre-1991 graduates with a temporary visa, their visa restrictions might not be the same as PhDs graduated after the 1990 Act. Greenwood and Ziel (1997) discuss the details of the 1990 Act and its effects.

population. To measure wages of postdocs and non-postdocs for new PhDs, I use the 1993 SDR for 1991-1992 graduates, the 1995 SDR survey for 1993-1994 graduates, and so forth. Altogether, I compile the five waves of the biannual SDR from 1993 to 2001, and I divide these new PhDs who graduated between 1991 and 2000 into five groups. This construction avoids repeated observations across the survey waves.[11] To measure long-term wage and research outputs, I use the 2001 SDR.

********** Insert table 1 here **********

Panel A of Table 1 summarizes the SED data. At the time of graduation, the mean age of PhDs is about 33, 27% of them are female, and 60% are married. About half of these PhDs are immigrants. Temporary immigrants account for 35% and permanent immigrants (green card holders or naturalized citizens) account for 14%. 48% of these PhDs take or plan to take a postdoctoral position.[12] The Chinese comprise the largest group of immigrants, accounting for 12% of all PhDs and 16% of all postdocs.

Panel B of Table 1 summarizes the five waves of SDR data on new PhDs from 1993 to 2001, divided by postdocs and non-postdocs. 77% of postdocs work in academia whereas 62% of non-postdocs work in government or industry. The mean annual salary of postdocs is only slightly above half that of non-postdocs. In both the postdoctoral and non-postdoctoral sectors, the mean salary of temporary immigrants is not significantly different from natives or permanent immigrants.[13]

---

[11] I restrict my sample to PhDs who were younger than 50 and in the labor force when surveyed. In my SDR sample, only 1.6% are unemployed and 2.6% are not in the labor force. I exclude them from my sample.

[12] The denominator here is all PhDs. I do not differentiate between "definitely taking a postdoctoral position" and "planning to take a postdoctoral position" in the SED survey. Lan (2012a) shows that it seems more accurate to combine the two categories together to measure postdoctoral participation immediately after receiving a PhD degree. I do not use the number of postdocs calculated from the SED in following regressions, hence different measures do not generate measurement errors in estimation.

[13] In both the postdoctoral and non-postdoctoral sectors, the mean salary of natives is slightly lower than immigrants. This difference mainly reflects the different distribution in research fields. After controlling for fixed effects of research fields, regression analysis

INSTITUTIONAL BACKGROUND

Visa Policy and Job Choice of New PhDs

Work visa policies restrict job opportunities for immigrants who hold a temporary student visa at the time of graduation. To work in the U.S., these temporary visa holders must have an H1B working visa, which is required for immigrants who have a bachelor's degree or its equivalent in their specialty field. The H1B visa imposes several constraints. First, many companies, government agencies, and high-security labs and programs only employ citizens or green card holders and do not sponsor temporary work visas (NRC, 2005). The Department of Labor also requires that employers pay their H1B employees at least as much as that paid to other employees for the same type of job. Due to the extra legal costs incurred in the process of employing H1B workers, the requirement further discourages employers, particularly in small companies, from employing temporary immigrants. Second, the H1B visa is tied to a specific employer. The potential risks and costs related to switching job also restrict opportunities for temporary immigrants. Third, the annual cap of the H1B visa, initially set at 65,000 in the *1990 Immigration Act*, restricted opportunities for PhDs who graduated between 1997 and 2001.[14] Fourth, H1B visa holders are not allowed to start their own businesses, and the spouse of an H1B visa holder, who holds an H4 visa, is not allowed employment.[15]

---

shows that the salary difference across groups is neither economically nor statistically significant.

[14] The cap was reached for the first time in 1997; thus, it did not restrict those who graduated earlier. Since 2001, many potential employers of PhDs, including higher education institutions and non-profit or government research institutions, have been exempt from the cap. Also, the *American Competitiveness and Workforce Improvement Act of 1998* raised the cap to 115,000 for the fiscal years 1999 and 2000, to 107,500 for 2001, and to 195,000 for 2002 and 2003. In 2001 and 2002, the cap was not binding due to the slowdown of the economy. The *H1B Visa Reform Act of 2004* further issued an annual 20,000 new H1B visas limited solely to aliens who had received a master's or higher degree from a U.S. institution of higher education.

[15] The webpage of the U.S. Citizenship and Immigration Services provides institutional details of the H1B visa: http://1.usa.gov/8VIT7E.

These restrictions are much less binding for postdoctoral positions, since postdocs are able to work with either a H1B work visa or a J1 visa for foreign scholars.[16] A postdoctoral position is usually temporary and research-oriented, and is supported by research grants obtained by the PIs of a research lab. It may not be attractive for PhDs who have many job opportunities due to its low wage, but it provides extra opportunities for temporary immigrants whose options are more limited. Among those who graduated between 1997 and 2001, 33% of postdocs who were temporary immigrants reported taking a postdoctoral position only because other employment was not available, which was 7 percentage points higher than for citizens (NSF, 2001).

As a result of work visa restrictions in non-postdoctoral sectors, temporary immigrants are more likely to take a postdoctoral position. For new PhDs who graduated in the 1990s, Table 2 shows that the percentage of postdocs is higher among temporary immigrants than among citizens or permanent residents in each research subfield. Even in the bio-medical sciences, where postdoctoral training is standard, the percentage of postdocs is still much higher among temporary immigrants. For example, 92% of temporary immigrants in physiology are postdocs compared to only 73% of citizens. In all S&E PhDs, 56% of temporary immigrants and 45% of citizens are postdocs.

********** Insert table 2 here **********

The visa restriction at the time of graduation may also have long-term effects on the income and career path of temporary immigrants. First, having to undertake prolonged low-paid postdoctoral training could reduce a PhD's life-time income. Although postdoctoral training is a prerequisite for a tenure-track position in many research fields, the probability of landing a faculty position after the training diminishes because of the rapid growth of the postdoctoral population (Freeman, 2005). Outside of academia, work experience earned as a postdoc may be substantially devalued. Second, even for those temporary immigrants who manage to find a job in non-postdoctoral sectors, their job

[16] J1 visas are for foreign visiting students, professors, or other scholars. The application procedure is more like student F visas rather than H1B work visas, and it has been a routine for U.S. universities to obtain these visas. In fact, many foreign students study in U.S. PhD programs with a J1 visa (Kahn & MacGarvie, 2012)

mobility is very limited before obtaining a green card. Both a temporary H1B work visa and an application for a green card are tied to a specific employer. If a H1B visa holder loses the sponsorship from her employer, she loses her legal status in the U.S. immediately. Even if she finds a new employer who is willing to sponsor a H1B work visa, her application for a green card also has to start over. The limited job mobility and bargaining power of H1B visa holders with their employer could diminish their payment and opportunities (Matloff, 2003).

A green card eliminates these institutional barriers and expands job opportunities for temporary immigrants. The effect of a green card on job choice or wage, however, cannot be estimated correctly from a comparison between green card holders and temporary visa holders. The U.S. government only grants green cards to applicants who meet certain conditions, such as close relatives of U.S. citizens or those who had worked in the U.S. and been sponsored by their employers before the PhD graduation.[17] The different family background and work experience related to observed visa status could also affect job choice and wage. In order to identify the causal effects of visa adjustment, I use a unique shock of the Chinese Student Protection Act, which unexpectedly granted Chinese nationals a green card.

The Chinese Student Protection Act

In the spring of 1989, Chinese college students protested against corruption among the Communist Party elite in Beijing. The protest eventually evolved into a mass movement for political reform, including hunger strikes and occupation of the Tian'an Men Square at the center of Beijing. On June 4, 1989, the event led to a military crackdown. The exact number of civilian death is still unknown.

In order to protect Chinese students and scholars in the U.S. from possible political persecution following the Tian'an Men Square Incident, President Bush issued Executive

[17] The webpage of the U.S. Citizenship and Immigration Service provides more institutional details of obtaining a green card: http://www.uscis.gov/greencard.

Order 12711 (EO12711) on April 11, 1990. For Chinese nationals who were in the U.S. on or after June 5, 1989, the EO12711 waived their two-year home country residence requirement if they held a J-1 visa, deferred their deportation if their visa expired, and authorized their employment in the U.S., through January 1, 1994.[18]

In the summer of 1992, the Chinese Student Protect Act of 1992 (CSPA) was first introduced in Congress, sponsored by U.S. Representative Nancy Pelosi. The bill was passed by the end of 1992 and became effective on July 1, 1993. For Chinese nationals who were in the U.S. sometime between June 5, 1989 and April 11, 1990, and their qualified family members, regardless of their location during the time, the act allowed them to adjust their temporary visa to a permanent visa. More than 80,000 Chinese nationals benefited from the act and obtained a green card (Qian & Chu, 2002). Most of these were illegal immigrants who were not students (Poston & Luo, 2007).

********** Insert figure 1 here **********

Figure 1A shows the large impact of the CSPA on the visa status of Chinese PhDs. Before the act, more than 90% of Chinese students held a temporary visa; after the act, the percentage drastically decreased to around 25% in 1994 and 1995, when most CSPA-beneficiaries graduated. The impact faded over time since most CSPA-eligible students graduated by 1997. As a comparison, Figure 1A also shows a stable percentage of temporary immigrants among other non-Chinese immigrant groups over this period, at around 84%.

By the time of the CSPA, Chinese PhDs had become the largest group of foreign PhDs in the U.S. Figure 1B shows that the CSPA reversed the upward trend in the percentage of temporary immigrants among PhDs before 1992; the percentage decreased from 38% in 1992 to 30% in 1995. The percentage rose again after the peak of the CSPA-impact in 1995, but it did not reach the pre-CSPA level until 2001. To confirm that the reversed trend was driven by the CSPA, Figure 1B also shows the trend was stable in the 1990s without the Chinese.

[18] A J-1 visa for visiting scholars requires a mandatory two-year home-country physical residence following the expiration of the visa.

Both the EO12711 and the CSPA were unexpected to their beneficiaries, since both acts were announced on or after April 11, 1990, but eligible Chinese must have been in the U.S. prior to that date. The CSPA was not even discussed until the summer of 1992, two years after its eligibility period. Thus, it was impossible for someone to enter the U.S. in order to take the advantage of the act.

Compared to the CSPA, the temporary EO12711 was not very effective in reducing uncertainty and employment costs for employers since it was expected to expire soon. Before the introduction of the CSPA, both employers and beneficiaries of the EO12711 still had to confront most restrictions related to a temporary work visa. Appendix shows that the EO12711-beneficiaries did not reduce their postdoctoral participation, but the CSPA-beneficiaries reduced their postdoctoral participation significantly. This result is similar to Lan (2012a), who uses eligibility for the CSPA as the instrumental variable of visa status and shows that a green card reduces the postdoctoral participation of Chinese students by 24%. Thus, the following sections focus on the effect of the CSPA.

TEMPORARY IMMIGRANTS AND WAGE OF NATIVES

Empirical Framework

New PhDs can work in either the postdoctoral sector or the non-postdoctoral sector. As shown in Table 2, temporary immigrants are more likely to work in the postdoctoral sector due to visa restrictions. Thus, the relative supply of postdocs to non-postdocs is increasing with the percentage of temporary immigrants on the market. Figure 2 shows a simple supply-demand analysis of the wage effect under a supply shock in temporary immigrants. Given the labor demand and visa restrictions, the relative supply of postdocs to non-postdocs is higher among temporary immigrants than among citizens. The aggregate market supply curve lies between the two supply curves, and the position of the aggregate supply is determined by the share of each group in the whole population.[19] The

[19] Let P_{temp} be the probability of taking a postdoctoral position among temporary visa holders, and $P_{citizen}$ the probability among citizens. Since there are only two sectors, these probabilities also measure the relative supply of postdocs to non-postdocs in the two groups. It is easy to show that the aggregate relative supply of postdocs to non-postdocs

original market equilibrium is E0. When the share of temporary immigrants among all PhDs increases, the aggregate relative supply of postdocs to non-postdocs increases. The relative wage of postdocs decreases, both among all PhDs (from E0 to E1) and among citizens (from C0 to C1).

********** Insert figure 2 here **********

With the influx of foreign students on a temporary visa in U.S. PhD programs, a postdoctoral position has become the most popular postgraduate plan of new S&E PhDs. From 1985 to 2005, the percentage of temporary immigrants among new S&E PhDs increased from 26% to 44%, while postdoctoral participation increased from 44% to 54% (NSF, 2005). The increase in the relative supply of postdocs to non-postdocs could decrease the relative earnings of postdocs to non-postdocs. Figure 3 shows that the mean annual salary of postdocs relative to that of non-postdocs decreased from 63% in 1993 to 53% in 2001, and the relative mean annual total earnings decreased from 59% in 1995 to 53% in 2001.[20] On the other hand, if the U.S. government grants all foreign PhDs a green card, the percentage of temporary immigrants would become zero. Even though these immigrant PhDs are still in the U.S., now as green card holders, such a policy would generate a large flow from the postdoctoral sector to the non-postdoctoral sector, which would raise the relative wage of postdocs.

********** Insert figure 3 here **********

---

on the market, P_{total}, is:

$$P_{total} = (\frac{citizens}{all\,PhDs}) * P_{citizen} + (\frac{tempvisaholders}{all\,PhDs}) * P_{temp} = P_{citizen} + (\frac{tempvisaholders}{all\,PhDs})(P_{temp} - P_{citizen})$$

Since $P_{temp} > P_{citizen}$, P_{total} increases with $(\frac{tempvisaholders}{all\,PhDs})$, the percentage of temporary immigrants among all PhDs.

[20] The salary is the annual salary of the principal job, and the total earnings include income from all jobs including summer teaching and research.

The above analysis suggests that the percentage of temporary immigrants among all PhDs is a supply shifter , which could be changed by visa policies. To estimate the effect of this supply shifter on the relative wage of postdocs to non-postdocs among new S&E PhDs, I use the following specification:

$$log(\frac{salaryof\ postdoc}{salaryof\ nonpostdoc})_{ft} = \beta_1 * (\frac{tempvisaPhDs}{all\ PhDs})_{ft} + \alpha_f + \gamma_t + \varepsilon_{ft1} \qquad (1)$$

I define the market by 38 research subfields, f , as listed in Table 2. PhDs are highly specialized workers and movement across research fields is rare, particularly for fresh PhDs. Thus, the market division based on research field reduces the bias caused by labor flow across research field as a response to the influx of temporary immigrants. For each research field f in year t, I calculate the mean salary both for postdocs and for non-postdocs from the SDR, and I use the difference of their logs as the dependent variable. Since a typical postdoctoral position lasts for two years and the SDR is conducted biannually, I use the wage in the 1993 SDR for 1991-1992 graduates, and the 1995 SDR for 1993-1994 graduates, and so forth. Together, I divide PhDs who graduated from 1991 to 2000 into five groups. I use the SED to calculate the number of all new PhDs and temporary immigrants, $(\frac{tempvisaPhDs}{all\ PhDs})_{ft}$. Consistent with the SDR, I group PhDs who graduated from 1991 to 2000 into five groups. α_f is a set of field fixed effects and γ_t is a set of year fixed effects, which control for field and time specific demand shocks, such as shocks in research funding and secular trends in the U.S. economy. ε_{ft1} is a mean-zero error.

I estimate the wage effect among all PhDs and among native-borns. Since all new PhDs have the same educational attainment and work experience, it seems reasonable to assume that immigrants are perfectly substitutable to natives.[21] As shown in Table 1 and

[21] With the same educational attainment and work experience, Borjas (2003, 2006) assumes that immigrants are perfectly substitutable to natives. Ottaviano and Peri (2006) suggest adding age as another category, besides education and work experience. Card (2009) summarizes this branch of literature.

Footnote 12, in both the postdoctoral sector and the non-postdoctoral sector, the mean salary of natives is not significantly different from that of immigrants. The estimated β_1 among all PhDs should be the same among natives.

The estimated β_1 should be negative. The OLS estimate, however, could be biased for three reasons. First, the number of temporary immigrants could be related to the U.S. labor demand in either the postdoctoral or the non-postdoctoral sector. A field-time specific demand shock could affect both the number of temporary immigrants and wage. For example, American universities could enroll more foreign students in PhD programs when federal R&D spending increases, and this higher spending could also boost the demand for postdocs. Or, more immigrants could come to study computer science in the U.S. during the IT boom, when the demand for related skills in the non-postdoctoral sector was high. Including interaction terms of α_f and γ_t would have controlled for these shocks, but β_1 would not be identified. Second, salaries (or labor demand) in both the sectors could affect the PhD completion rate, and in turn the number of PhD recipients. After all, only about 59% of PhD students in S&E earn their degrees in 10 years (King, 2008). Those who study computer science and IT may leave their PhD program with a master's degree during the IT boom, and those who study biology may quit after they learn of the low wage associated with prolonged postdoctoral training. Third, the inflow of temporary immigrants into U.S. PhD programs may be positively related to the inflow of foreign-trained PhDs into U.S. postdoctoral positions. Although foreign-trained PhDs may not be perfect substitutable to American PhDs because of quality differences in their PhD training, a large pool of foreign applicants for U.S. postdoctoral positions may also decrease the wage of postdocs. I cannot control for this factor by including a field-year specific number of American postdocs trained in foreign PhD programs, because there are no such data.[22]

[22] Even the total number of U.S. postdocs who obtained their PhD degree in foreign countries is unknown. Based on different sources of data, Freeman (2005) estimates that about half of postdocs in academia have non-U.S. PhD degrees. Garrison, Stith, and Gerbi (2005) report that growth in the number of postdocs in biomedical sciences is mainly driven by the recruitment of foreign-trained PhDs.

The Instrumental Variable

As shown in Figure 1B, the CSPA exogenously reduces $(\frac{number of\ tempvisa}{number of\ all})_{ft}$ by granting a green card to thousands of Chinese PhDs. The percentage of temporary immigrants among new PhDs decreased from 38% in 1992 to 30% in 1995, and it did not reach the pre-CSPA level until 2001. I calculate the number of CSPA-eligible PhDs according to their entry year in the U.S., $(CSPAeligibles)_{ft}$, from the SED as the instrumental variable. The entry year in the U.S. is based on individual educational history recorded in the SED. For Chinese PhDs who obtained their bachelor degree outside of the U.S. (in China or in other countries), the entry year is the year that they attended an U.S. graduate school, either for a PhD or for a Master degree. For those who attended an U.S. college, the entry year is their college entry year.[23]

Eligibility for the CSPA was determined by presence in the U.S. during the eligibility period, unrelated to U.S. labor demand. Also, the number of CSPA-eligible students is unlikely to be related to the number of China-trained PhDs who apply for American postdoctoral positions. The number of China-trained PhDs follows an upward trend due to the reform and the fast growth of Chinese PhD programs (Freeman, 2009), but Figure 1A clearly shows that the number of CSPA-eligible students does not follow such a trend. Lan (2012a) shows that the CSPA did not change other characteristics of Chinese PhDs that could affect postdoctoral participation either, such as gender, intention of staying in the U.S. after graduation, or quality of PhD programs.

A green card may encourage its holder to leave a PhD program in order to gain employment work, and thus the CSPA could reduce the observed number of PhD recipients in a way that depends on labor market conditions, which could violate the

[23] For Chinese PhD students in the 1990s, non-educational channels of entering the U.S. were rare. "Chinese PhDs" only include those who were a Chinese citizen at the time of the SED survey. Those who migrated to the U.S. with their family and were naturalized citizens are not counted as a Chinese. Appendix of Lan (2012a) provides more details on the construction of the CSPA eligibility based on entry years.

exclusion restriction for the instrumental variable. This effect, however, seems insignificant. The CSPA-eligible PhDs must have been in the U.S. prior to April 11, 1990, so 83% of them had been in their PhD programs for at least four years by the time they received their CSPA green card, starting on July 1, 1993.[24] King (2008) shows that the PhD attrition rate in S&E after the fourth year was only about 4% in the 1990s, much lower than the rate of 27% in the first four years. Even if the CSPA could somehow affect the PhD attrition rate among non-Chinese students who were in their first four years when the act was effective, it would most likely affect PhDs who entered their programs between 1993 and 1996, since the act was not in effect until 1993 and 92% of CSPA-eligible green card holders had graduated by the end of 1996. King (2008) shows that the four-year cumulative attrition rate among those who entered S&E PhD programs between 1993 and 1995 was essentially identical to the attrition rate among the 1996-1998 graduates. Furthermore, it shows a similar pattern in the social sciences in which the number of Chinese students was too small to affect others.[25] These observations suggest that the CSPA was unlikely to affect the PhD attrition rate either among Chinese or among non-Chinese students.

Results

Table 3 reports the estimates of β_1 in equation (1), the effects of the percentage of temporary immigrants among all new PhDs who graduated in the 1990s on the relative wage of postdocs to non-postdocs. I weight all regressions with the number of observations in calculating the dependent variable in each field and year in the SDR. I use the number of CSPA-eligible PhDs as the instrument and report the 2SLS results too. The

[24] In the late 1980s and early 1990s, Chinese undergraduates in American universities were rare.

[25] The four-year cumulative attrition rate among the 1993-1995 graduates was 23% in engineering, 21% in life sciences, and 31% in math and physical sciences. The rates among the 1996-1998 graduates were 23%, 22%, and 31%, respectively. The rates in the social sciences were 20% in both groups (King, 2008).

first-stage results show that an increase of 100 in the number of CSPA-eligible students decreases the percentage of temporary immigrants by two percentage points.

********** Insert table 3 here **********

The 2SLS estimate in Column 2 shows that a one percentage point decrease in the percentage of temporary immigrants among all PhDs increases the relative wage of postdocs to non-postdocs among all PhDs by about 1.7%. The CSPA reduced the percentage of temporary immigrants among all PhDs by 8 percentage points, from 38% in 1992 to 30% in 1995, which would increase the relative wage of native postdocs to non-postdocs by 13.6%. Around the mean of $(\frac{tempvisaPhDs}{all\,PhDs})$, 0.35, this estimate also suggests that a 10% decrease in the percentage of temporary immigrants reduces the wage gap between postdocs and non-postdocs by 6%. As a robustness check, Columns 3 and 4 report the similar results without including students who graduated in 1991 and 1992 who were under the influence of the EO12711 but not the CSPA. Columns 5 and 6 show the similar results without including students who graduated in 1999 and 2000.

The OLS estimates are biased toward zero and insignificant, which suggests that temporary immigrants are more likely to enter the market in which the relative wage of postdocs to non-postdocs is higher. This is consistent with the labor demand in scientific research. As shown in Table 1, 77% of postdocs work in academia. When research funding and the demand for research assistants increase, professors tend to hire more postdocs and enroll more PhD students as well. As a result, foreign students are more likely to be enrolled in those research fields with a high demand for postdocs.

********** Insert table 4 here **********

Columns 1 and 2 in Table 4 repeat the estimates on the relative wage of native postdocs to non-postdocs. The results are very close to the results in Table 3. A one percentage point decrease in the share of temporary immigrants among all PhDs increases the relative wage of native postdocs to non-postdocs by about 1.7%.

The log relative wage of postdocs and non-postdocs is simply the difference of the two wage levels. In order to investigate which sector drives the negative effect on the relative wage, I also estimate the effects on wage levels separately in each sector. Columns 3 and 4 in Table 4 show that the influx of temporary immigrants significantly decreases the wage level of native postdocs. I use individual-level data to estimate the effects more efficiently by controlling for demographic variables that could affect wages, such as age, gender, and marital status. I also use dummies for PhD programs to control for ability differences, and I use a set of state dummies for work locations to control for geographic differences in salaries.[26] I cluster standard errors at the field-year level.[27] Both the OLS and the 2SLS estimates are negative and significant, and the OLS estimate is still biased towards zero. The 2SLS estimate in column 4 suggests that a one percentage point decrease in the percentage of temporary immigrants among all new PhDs increases the wage level of native postdocs by 0.8%. In contrast, columns 5 and 6 show that neither the OLS nor the 2SLS estimates suggest a significant effect of temporary immigrants on the wage level of native non-postdocs. Older, male, and married PhDs earn more in both sectors. Men earn 8% more than women in the non-postdoctoral sector, but only 2% more in the postdoctoral sector. In sum, Table 4 shows that the decrease in the percentage of temporary immigrants among new PhDs increases the relative wage of native postdocs to non-postdocs, operating through a higher wage level of native postdocs.

INCOME AND INNOVATION OF CSPA-BENEFICIARIES

Difference-in-Difference Strategy

[26] The SDR only reports the state of PhD-awarding universities and their Carnegie Classification (Research University Type 1 and 2, Doctoral Granting University Type 1 and 2, Medical Schools, etc.). I use the interaction of the state and the Carnegie classification to approximate specific PhD programs, which results in 169 different S&E PhD programs in my sample. All the reported results are robust without including dummies for work locations.

[27] Standard errors increase slightly when clustered at the field level, and all significant results are still significant at the 5% level. The field-level clusters allow for serial correlation in the error term within each field; however, it may introduce bias because the number of fields is small (only 38).

Between 1993 and 1996, the influence of the CSPA was at its peak and 66% of Chinese held a green card at graduation. I compare them with Chinese students who graduated between 1997 and 2000, after the effect of the CSPA faded and only 29% of Chinese graduates held a green card. I include 1993 Chinese graduates into the treatment group though the percentage of green card holders among them was low. Almost all 1993 graduates were eligible for the CSPA but many of them had not adjusted their visa status when the SED was conducted in March and April of 1993, because the CSPA was not effective until July of 1993. However, they all knew that they would obtain a green card very soon, since the act had been passed in 1992. They were allowed to work with a 12-month certificate of Optional Practical Training and wait for a green card, and employers did not have to sponsor a H1B work visa and pay extra employment costs. I also drop the 1991-1992 graduates to highlight the effect of holding a green card *at the time of graduation*. In 1991 and 1992, graduates did not benefit from the CSPA since the act had not been introduced yet. However, almost all of them were eligible and obtained a green card after the act became effective in 1993. Appendix Table 2 shows that the estimates are robust by adding 1991-1992 Chinese graduates into the group of beneficiaries.

I use the 2001 wave of the SDR to estimate the effect of holding a green card on five outcomes: salary in 2001, total earnings in 2000, the probability of working in academia in 2001, number of published articles in a refereed professional journal since 1995, and the probability of being granted at least one U.S. patent since 1995.[28] I can use either natives or other immigrants as the control group, and the results are similar.

[28] A complementary approach is to use the 2001 SDR for 1993-1996 graduates (the treatment group) and the 2006 SDR for 1997-2000 graduates (the control group). In this exercise, both groups are evaluated at the same post-PhD experience (5-9 years). However, after the 9/11 attack in 2001, student visa policies became much more restrictive, which may significantly reduce the labor supply of PhDs, particularly in those "sensitive fields" such as biology, biological engineering, chemistry, and nuclear physics. Due to the high probability of visa denial after the 9/11 attack, both foreign applications for U.S. graduate programs and the enrollment of foreign students in those programs declined (Bhattacharjee, 2005; Thurgood, 2004). Since postdoctoral positions concentrate on those "sensitive fields", more restrictive visa policies also blocked a large number of foreign PhDs who applied for U.S. postdoctoral positions (Editorial, 2004). These policies particularly affected Chinese students, along with students from Muslim countries (Hindrawan, 2003; Neuschatz & Mulvey, 2003). In addition, the 2006 SDR

The DID specification is:

$$Outcome_{ictf} = \beta_2 Year9396_t + \beta_3 Chinese_c + \beta_4 (Year9396_t * Chinese_c) + Field_f + \beta_5 X_{ictf} + \varepsilon_{ft2} \quad (2)$$

For a PhD i who is from country c and graduated in period t and research field f, $Year9396_t$ is 1 if she graduated between 1993 and 1996 and 0 if between 1997 and 2000. $Chinese_c$ is 1 for Chinese and 0 for natives or other non-Chinese immigrants. The interaction term $Year9396_t * Chinese_c$ captures the DID effect. $Field_f$ includes dummies for 38 research subfields, as listed in Table 2. X_{ictf} are demographic variables, including age, gender, marital status, years of work experience since PhD graduation, and dummies for PhD programs to approximate the abilities of PhDs.

********** Insert table 5 here **********

Panel A of Table 5 summarizes sample means and differences from the SDR 2001, by Chinese, natives, and other immigrants. In 2001, those who graduated between 1993-1996 generally earned more than those who graduated between 1997-2000 since they had worked for more years. This income gap, however, was larger among Chinese, which suggests an income premium related to a green card at their time of graduation. 1993-1996 graduates were less likely to work in academia since some 1997-2000 graduates had not finished their academic postdoctoral training by 2001. The larger difference among Chinese, however, may reflect that many 1993-1996 Chinese graduates did not pursue a career in academia since their green card generated more job opportunities. 1993-1996 Chinese graduates also published fewer research articles and were more likely to be granted a patent, which could be related to their career choice. Over this period, PhDs who worked in academia published about three more articles than those who worked in government or industry, but they were 12 percentage points less likely to be granted a patent (NSF, 2001).

---

does not record the number of academic publications and patents, the two important measures of innovation.

Panel B of Table 5 summarizes background information at the time of graduation from the SED.[29] Thanks to the CSPA, 1993-1996 Chinese graduates were 37 percentage points more likely to hold a green card at graduation than 1997-2000 Chinese graduates. There was no such difference among other immigrant groups. Among all the three groups, the percentage of females increased over time, but there was no significant difference in their age and ranking of PhD programs between 1993-1996 and 1997-2000 graduates.[30] Nearly all Chinese and native PhDs stayed in the U.S. after graduation and there was no significant change over time. Among other immigrants, however, the percentage of those who stayed in the U.S. was much lower and variable over time.[31]

One threat to identification is the problem of sample selection. Chinese PhDs can work either in the U.S. or in China, but the SDR only surveys those who remain in the U.S. at the time of the survey. The Chinese economy has been very dynamic in the past two decades, and it is possible that the percentage of Chinese PhDs who work in the U.S. after graduation changes over time. As a result, the comparison between Chinese who stay in the U.S. but graduate in different years could be biased, since abilities or other characteristics of those Chinese who stay in the U.S. may change over time. In the 1990s, however, Chinese PhDs rarely left the U.S. As shown in Panel B of Table 5, 97% of 1993-1996 Chinese graduates and 96% of 1997-2000 Chinese graduates stayed in the U.S. at the time of graduation.

---

[29] Note that Panel B of Table 5 is different from Panel A of Table 1. Table 1 pools all students together from the SED, while Panel B of Table 5 separates all SED PhDs into three groups. Panel A of Table 1 includes all graduates from 1991 to 2000, while Table 5 only includes graduates from 1993 to 2000.

[30] I divide all S&E PhDs into eight broad research fields and define "Top 20" programs for six fields based on the ranking from the National Research Council (1995). The six fields are biology, computer science and information technology, mathematics, physics and astronomy, chemistry, and engineering. For agriculture and natural resources, I combine the top 10 programs in food science and soil science (the largest two subfields in the field) listed on this website: http://bit.ly/mFTT9b. For health science, I use the top 20 pharmacy programs (the largest subfield in the field) listed in the *U.S. News and World Report 2009* ranking: http://bit.ly/HVN9I.

[31] Grogger and Hanson (2013) relate the stay pattern of U.S. trained foreign PhDs with their academic ability, relative GDP growth rate in the U.S. and in their birth country, and average income level and political regime in the birth country.

Another aspect of sample selection is the selection over different stages of a career. Even though nearly all Chinese stay in the U.S. at the time of graduation, those 1993-1996 Chinese graduates might be more likely to leave the U.S. by 2001 than 1997-2000 graduates. Particularly, if only higher-ability Chinese can manage to remain in the U.S. in the long run, the estimated better average outcomes of 1993-1996 graduates could simply reflect that their "weaker members" had left the U.S. However, Finn (2003, 2005) finds that even in the long run, U.S.-trained Chinese S&E PhDs still rarely leave the U.S. By using the income and Social Security tax records, Finn has been tracking the long-run stay-rate of U.S.-trained foreign PhDs and publishing his results every two years since 1997. In 2001, 96% of 1996 Chinese graduates were still in the U.S., as were 92% of 1998 Chinese graduates and 95% of 2000 Chinese graduates. Most Chinese who graduated between 1993 and 1995 had a green card because of the CSPA, but Finn only tracks those PhDs who hold a temporary visa at graduation. In general, green card holders rarely leave the U.S. since they usually work in the country. They must stay in the country for a certain amount of time in each year to keep their green card valid, and for 36 months in five years to be qualified for naturalization. About 93% of green card holders stayed in the U.S. after their graduation in the 1990s (NSF, 2005)

Due to the sample selection problem related to non-Chinese immigrants, as shown in Panel B of Table 5, I use natives as the main control group since they rarely work abroad. Natives are not affected by a green card and they help control for secular changes on the U.S. market. They also help control for the effect of career stage on income and research output, which may not be fully captured by years of work experience. The concern of using natives as the control group is that they might also be affected by the CSPA in the long run, which could bias the DID estimates. By increasing the short-term relative wage of native postdocs to non-postdocs, the CSPA could also attract more natives into the postdoctoral sector and change their long-term career path. An earlier version of this paper shows that the CSPA shock did not change postdoctoral participation among natives (Lan, 2012b).[32] This is consistent with the inelastic postdoctoral participation of

[32] The CSPA-shock might not change the relative wage of native postdocs to non-postdocs sufficient to attract natives into the postdoctoral sector. Table 4 shows that one percentage point decrease in the percentage of temporary immigrants among all PhDs

natives observed in Freeman (2005): when the NIH doubled its research budget in the late 1990s and the demand for postdocs increased drastically, the number of natives accepting postdoctoral positions in the biological sciences barely changed. Since the CSPA did not change the rate of PhD completion among natives either, as discussed before, it seems reasonable to assume that the CSPA does not have a long-term impact on natives. As a robustness check, I also use non-Chinese immigrants as another control group.

Results

********** Insert table 6 here **********

Table 6 reports the estimates of equation (2), using natives as the control group. The results are robust with or without controlling for individual characteristics. In 2001, Columns 1-4 show that the CSPA increased annual salaries of its beneficiaries (1993-1996 Chinese graduates) by 9% and total earnings by 10%. Columns 7-10 show that the CSPA reduced the number of published research articles among its beneficiaries by about 1.1, but increased the probability of being granted a patent by eight percentage points. These results are related to different career paths. Columns 5 and 6 show that the CSPA reduced the percentage of individuals working in academia by seven percentage points. On average, PhDs working in academia earn less than in non-academic sectors, publish more research articles, and are less likely to be granted a patent (NSF, 2001). As expected, older, male, married, and more experienced PhDs earn more. Male and more experienced PhDs also produce more research articles and patents. After controlling for PhD programs

---

increases the relative wage of native postdocs to non-postdocs by about 1.7%. The CSPA reduced the percentage of temporary immigrants among all PhDs by 8 percentage points, from 38% in 1992 to 30% in 1995, which would increase the relative wage of native postdocs to non-postdocs by 13.6%. Since postdocs only earn about half as much as non-postdocs, an increase of 13.6% means the relative wage of postdocs to non-postdocs would increase from 50% to about 57%, which is still very low.

and research fields, these demographic variables do not affect the probability of working in academia.[33]

********** Insert table 7 here **********

As a robustness check, Table 7 uses non-Chinese immigrants as the control group and reports the estimates of equation (2). Most results are similar to Table 6: the CSPA increases the annual salaries of its beneficiaries by 8% and total earnings by 12%, reduces the number of published research articles by 0.8, and increases the probability of being granted a patent by seven percentage points. There is no significant difference in the probability of working in academia. These results, however, could be biased by the different sample selection between Chinese and non-Chinese immigrants. With the improvement of research environments in home countries, especially in other developed countries such as Japan and Germany, immigrants who would have worked in academia in the U.S. are likely to be attracted back home. As shown in Panel B of Table 5, compared to 1993-1996 non-Chinese immigrant graduates, 1997-2000 non-Chinese graduates were more likely to stay in the U.S. At least two factors contributed to the change among 1997-2000 non-Chinese immigrants: the collapse of the USSR in 1991 and the financial crisis of 1997 in East Asia. After the collapse of the USSR, the number of students from Russia and Eastern Europe in U.S. PhD programs drastically increased, particularly in the fields of math and physics. They graduated in the late 1990s and rarely left the U.S. after graduation (NSF, 2005). Also, after the financial crisis of 1997 in East Asia, more PhDs from Taiwan, South Korea, and Japan stayed in the U.S. than before (NSF, 2005).

[33] Fixed effects of PhD programs may also help (at least partially) control for effects of English proficiency, considering different standards for the scores in TOEFL and GRE at the time of PhD enrollment. Generally, it is difficult to compare English proficiency between the two groups of Chinese. In 2001, 1993-1996 Chinese graduates had stayed in the U.S. for a longer time than 1997-2000 graduates, which may help improve their English. However, considering the fast development in Chinese education system, 1997-2000 graduates might have an earlier and better English education back in China than 1993-1996 Chinese graduates.

CONCLUSIONS

A green card can eliminate job restrictions imposed by a temporary work visa, open up more job opportunities, and enhance job mobility. Using a unique visa shock from the Chinese Student Protection Act of 1992, this paper estimates the effect of a green card on its holder and on natives, among U.S. trained S&E PhDs who graduated in the 1990s. At the time of graduation, green cards attract temporary immigrants from the low-paid postdoctoral sector to other sectors and raise the relative wage of native postdocs to non-postdocs. Four to eight years after graduation, a green card holder earns more, is less likely to work in academia, publishes fewer research papers, and produces more patents.

Although fewer labor market restrictions are likely to improve efficiency of talent allocation in the U.S. labor market, there are at least three important caveats to interpret the results of this paper in the debate of a more general visa policy reform. First, the long-run impact on the wage of native postdocs is uncertain. As more U.S.-trained immigrant PhDs obtain a green card and leave the low-paid postdoctoral sector, the resulting higher wage of postdocs raises the cost of research for PIs. Given a limited budget, PIs may hire more foreign-trained PhDs even when they are somewhat less well-trained. In the long run, the competition from foreign-trained PhDs may still keep the wage of native postdocs at a low level. There is little data about postdocs in the U.S. who obtained their PhD degree abroad, and the size of this population and their productivity remain unclear.

Second, the difference-in-difference results only estimate the effects of holding a green card *at the time of graduation.* A general visa reform, however, is likely to target all high-skilled immigrants with an advanced S&E degree from an U.S. university. For those who have been working in the U.S. for several years after graduation, the effects of a green card on their career change are unclear. A green card can still eliminate the reliance on the employer for a temporary work visa and facilitate job change, but job-specific human capital accumulation may make the change more costly. Also, for a green card at the time of graduation, I only estimate its effects in four to eight years after graduation. Over a longer time period, the effects may eventually fade because those temporary immigrants who graduated without a green card could obtain one after several years of working in the U.S.

Third, although a one-time and unexpected visa shock is a key to identify the causal effects of a green card, the CSPA shock may not capture the long-run market adjustments to an established new visa regime. If the U.S. grants a green card to all U.S.-trained PhDs in selected S&E fields, it is likely that the application for related PhD programs would become more competitive. These programs would attract more and better foreign talents, especially those from developing countries, which could contribute more to the U.S. scientific and technological innovation. However, natives could be crowded out from these PhD programs, and the competition on the U.S. labor market of PhDs would also become more intense.

XIAOHUAN LAN is a Research Fellow at the Cheung Kong Graduate School of Business, 2F, Tower E2, Oriental Plaza, 1 East Chang An Avenue, Beijing 100738, China

ACKNOWLEDGEMENTS

REFERENCES

Bhattacharjee, Y. (2005). Drop in foreign applications slows. Science, 307(5716), 1706.

Black, G. C., & Stephan, P. E. (2008). The economics of university lab sciences and the role of foreign graduate students and postdoctoral scholars. Andrew Young School of Policy Studies Research Paper Series No.09-02.

Bloom, N., & Van Reenen, J. (2002). Patents, real options and firm performance. Economic Journal, 112, 97-116.

Borjas, G. J. (1999). The economic analysis of immigration. In O. Ashenfelter & D.Card (Eds.), Handbook of labor economics volumn 3 (pp. 1697-1760), North-Holland.

Borjas, G.J. (2003). The labor demand curve is downward sloping: reexamining the impact of immigration on the labor market. Quarterly Journal of Economics, 118, 1335-1374.

Borjas, G. J. (2006). Immigration in high-skill labor markets: the impact of foreign students on the earnings of doctorates. NBER Working Paper No. 12085. Cambridge, MA: National Bureau of Economic Research.

Borjas, G. J., & Doran, K. B. (2012). The collapse of the Soviet Union and the

productivity of American mathematicians. NBER Working Paper No. 17800. Cambridge, MA: National Bureau of Economic Research.

Card, D. (1990). The impact of the Mariel Boatlift on the Miami labor market. Industrial and Labor Relation Review, 43, 245–257.

Card, D. (2001). Immigrant inflows, native outflows, and the local labor market impacts of higher immigration. Journal of Labor Economics, 19, 22-64.

Card, D. (2009). Immigration and inequality. American Economic Review Papers and Proceedings, 99, 1–21.

Chellaraj, G., Maskus, K. E., & Mattoo, A. (2005). The contribution of skilled immigration and international graduate students to U.S. innovation. Policy Research Working Paper Series No. 3588. Washington, DC: The World Bank.

Chi, M., & Drewianka, S. (2010). How much is a green card worth? Evidence from Mexican and Puerto Rican men who marry women born in the U.S. Unpublished manuscript, University of Wisconsin-Milwaukee.

Cox, B. G., Mitchell, S.B., & Moonesinghe, R. (1998). Current and alternative designs for the Survey of Doctorate Recipients, A Report to the National Science Foundation. Retrieved Feburary 16, 2013, from: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.201.5768&rep=rep1&type=pdf

Decker, R. S., Wimsatt, L., Trice, A. G., & Konstan, J. A. (2007). A profile of federal-grant administrative burden among federal demonstration partnership faculty. A report of the faculty standing committee of the Federal Demonstration Partnership. Retrieved May 20, 2010, from: http://www.txstate.edu/research/avpr/fdp_updates/contentParagraph/00/content_files/file0/Faculty_burden_survey_report.pdf.

Editorial. (2004). US visas: postdocs in peril. Nature Materials, 3, 75.

Finn, M. (2003). Stay rates of foreign doctorate recipients from US universities, 2001, Oak Ridge Institute for Science and Education, Oak Ridge, TN.

Finn, M. (2005). Stay rates of foreign doctorate recipients from US universities, 2003, Oak Ridge Institute for Science and Education, Oak Ridge, TN.

Freeman, R. B. (2005). Does globalization of the scientific/engineering workforce threaten

U.S. economic leadership? NBER Working Paper No. 11457. Cambridge, MA: National Bureau of Economic Research.

Freeman, R. B. (2009). What does global expansion of higher education mean for the U.S.? NBER Working Paper No. 14962. Cambridge, MA: National Bureau of Economic Research.

Freeman, R. B., Weinstein, E., Marincolm, E., Rosenbaum, J., & Solomon, F. (2001). Careers and rewards in bio-sciences: the disconnect between scientific progress and career progression. A report to the American Society of Cell Biology. Bethesda, Maryland.

Friedberg, R. (2001). The impact of mass migration on the Israeli labor market. Quarterly Journal of Economics, 116, 1373–1408.

Garrison, H. H., Stith, A. A., & Gerbi, S. A. (2005). Foreign postdocs: the changing face of biomedical science in the U.S. Federation of American Societies for Experimental Biology Journal, 19,1938-1942.

Greenwood, M., & Ziel, F. A. (1997). The impact of the Immigration Act of 1990 on US immigration. Washington, DC: US Commission on Immigration Reform. Retrieved Feburary 16, 2013, from: http://migration.ucdavis.edu/mn/cir/Greenwood/combined.htm

Grogger, J., & Hanson, G. H. (2013). Attracting talent: location choices of foreign-born PhDs in the US. NBER Working Paper No. 18780. Cambridge, MA: National Bureau of Economic Research.

Hall, B., Jaffe, A., & Trajtenberg, M. (2005). Market value and patent citations. The RAND Journal of Economics, 36, 16-38.

Hindrawan, J. J. (2003). International student recruitment since 9/11, part I: what is the fallout from the war on terrorism. World Education News & Reviews, 16. Retrieved Feburary 16, 2013, from: http://www.wes.org/eWENR/03March/Feature.htm

Hunt, J. (2011). Which immigrants are most innovative and entrepreneurial? Distinctions by entry visa. Journal of Labor Economics, 29, 417-457.

Hunt, J., & Gauthier-Loiselle, M. (2008). How much does immigration boost innovation? NBER Working Paper No. 14312. Cambridge, MA: National Bureau of Economic Research.

Kahn, S., & MacGarvie, M. (2012) The effects of the foreign Fulbright program on

knowledge creation in science and engineering. In J. Lerner & P. Stern (Eds.), The Rate and direction of inventive Activity Revisited (pp. 161-197). Chicago, Illinois: University of Chicago Press.

Kaushal, N. (2006). Amnesty programs and the labor market outcomes of undocumented workers. Journal of Human Resources, 41, 631-647.

Kerr, W. R., & Lincoln, W.F. (2010). The supply side of innovation: H-1B visa reforms and US ethnic invention. Journal of Labor Economics, 28, 473-508.

King, M. (2008). Ph.D. completion and attrition: analysis of baseline demographic data from the Ph.D. completion project, Council of Graduate Schools, Washington D.C. Retrieved June 15, 2010, from http://www.phdcompletion.org/information/book2.asp.

Kossoudji, S. A., & Cobb-Clark, D. A. (2002). Coming out of the shadows: Learning about legal status and wages from the legalized population. Journal of Labor Economics, 20, 598-628.

Lan, X. (2012a). Permanent visas and temporary jobs: Evidence from postdoctoral participation of foreign PhDs in the United States. Journal of Policy Analysis and Management, 31,623–640.

Lan, X. (2012b). Foreign PhDs and the Wage of Postdocs in the U.S. PhD dissertation, Department of Economics, University of Virginia.

Lowell, L. (2001). Skilled temporary and permanent immigrants in the United States. Population Research and Policy Review, 20, 33-58.

Matloff, N. (2003). On the need for reform of the H-1B non-immigrant work visa in computer-related occupations. University of Michigan Journal of Law Reform, 36, 815-915.

Mukhopadhyay, S., & Oxborrow, D. (2012). The value of an employment-based green card. Demography, 49, 219-237.

National Academy of Sciences, Committee on Science, Engineering, and Public Policy. (2000). Enhancing the postdoctoral experience for scientists and engineers: a guide for postdoctoral scholars, advisers, institutions, funding organizations, and disciplinary societies. Washington D.C.: National Academy Press.

National Research Council. (1995). Research doctorate programs in the United States: continuity and change. Washington D.C.: National Academy Press.

National Research Council. (2005). Policy implications of international graduate students and postdoctoral scholars in the United States. Washington D.C.: National Academy Press.

National Science Board. (2008). Science and engineering indicators. Arlington, VA. Retrieved September 15, 2009, from: http://www.nsf.gov/statistics/seind08/pdfstart.htm

National Science Foundation. (2001). The survey of doctoral recipients. Unpublished dataset.

National Science Foundation. (2005). The survey of earned doctorates. Unpublished dataset.

Neuschatz, M., & Mulvey, P. J. (2003). Physics students from abroad in the post-9/11 era. A Report of the American Institute of Physics. Retrieved Feburary 16, 2013, from: http://www.aip.org/statistics/trends/highlite/intvisa/intvisa.htm

Orrenius, P., Zavodny, M., & Kerr, E. (2012). Chinese immigrants in the US labor market: effects of post-Tiananmen immigration policy. Unpublished manuscript, Federal Reserve Bank of Dallas

Ottaviano, G., & Peri, G. (2006). Rethinking the effects of immigration on wages. NBER Working Paper No. 12497. Cambridge, MA: National Bureau of Economic Research.

Peri, G., & Sparber, C. (2009). Task specialization, immigration, and wages. American Economic Journal: Applied Economics, 1, 135-169.

Poston, D. L., & Luo, H. (2006, March). Chinese student and labor migration to the United States: trend and politics since the 1980s. Paper for the Conference on Global Competition for International Students, Georgetown University, Washington, DC.

Qian, N., & Chu, T. K. (2003). Chinese students encounter America. Seattle, Washington: University of Washington Press.

Shu, P. (2012). The long-run impact of business cycles on innovation: evidence from the MIT. Unpublished manuscript, Harvard Business School.

Stephan, P. E., & Levin, S. (2007). Foreign scholars in U.S. science: Contributions and costs. In R. Ehrenberg & P. Stephan (Eds.), Science and the university (pp. 150-176). Madison, Wisconsin: University of Wisconsin Press.

Stephan, P. E., & Ma, J. (2005). The increased frequency and duration of the postdoctorate career stage. American Economic Review Papers and Proceedings, 95, 71-75.

Stuen, E., Mobarak, A., & Maskus, K. (2007). Foreign PhD students and knowledge creation at U.S. universities: Evidence from enrollment fluctuations. Unpublished manuscript, University of Colorado.

Thurgood, L. (2004). Graduate enrollment in science and engineering fields reaches new peak: first-time enrollment of foreign students declines. InfoBrief NSF, 04, 326.

Zucker, L. G., Darby, M. R., & Toreto, M. (2002). Labor mobility from academe to commerce. Journal of Labor Economics, 20, 629-660.

APPENDIX: THE EXECUTIVE ORDER 12711 AND THE CSPA

For Chinese nationals who were in the U.S. on or after June 5, 1989, the EO12711, made effective on April 11, 1990, extended their legal stay if their visa expired and authorized their employment in the U.S. through January 1, 1994. The CSPA, which became effective on July 1, 1993, granted a green card to all Chinese nationals who were in the U.S. sometime between June 5, 1989 and April 11, 1990. Thus, the EO12711 affected 1990-1992 Chinese graduates *at the time of graduation*, while the CSPA affected 1993-1996 graduates after it became effective in 1993. Between 1990 and 1992, graduates were unlikely to anticipate the CSPA, since it was not introduced and discussed until the summer of 1992. Beneficiaries of the EO12711 were also eligible and benefited from the CSPA, but only after the CSPA became effective in 1993.

Compared to the CSPA, the temporary EO12711 was not very effective in reducing uncertainty and employment costs for employers since it was expected to expire after 1993. Using data from the SED, this section shows that the EO12711 beneficiaries did not reduce their postdoctoral participation, compared to Chinese who graduated in 1986-1989 and were not affected by either the EO12711 or the CSPA at the time of graduation. The other control group is temporary immigrants from all other countries who were subject to the same work restrictions. Unlike the SDR that only surveys immigrants who stay in the U.S., the SED surveys all PhDs at the time of graduation. Thus, there is no sample selection problem in the SED.

The difference-in-difference specification is:

$$postdoc_{ictf} = Year9092_t + Chinese_c + \beta_a(Year9092_t * Chinese_c) + Field_f + X_{ictf} + \varepsilon_{ft}$$

For a PhD i who is from country c and graduates in year t and research field f, $postdoc_{ictf}$ is 1 if she takes a postdoctoral position in the U.S. and 0 for other jobs. $Year9092_t$ is 1 if she graduated between 1990 and 1992 and 0 if between 1986 and 1989. $Chinese_c$ is 1 for Chinese and 0 for non-Chinese temporary immigrants. The interaction term $Year9092_t * Chinese_c$ captures the DID effect of the EO12711 but not the CSPA. $Field_f$ includes dummies for 38 research subfields, as listed in Table 2. X_{ictf} includes gender and dummies for PhD programs to approximate the abilities of PhDs. The regressions do not include more demographic variables such as age and marital status, because there are too many missing values in these variables. Panel A of Appendix Table 1 reports that β_a is neither economically nor statistically significant from zero, with or without controlling for PhD programs.

By the same specification, I use the 1993-1996 Chinese graduates as the treatment group to estimate the effect of the CSPA. Panel B of Appendix Table 1 reports the results. At the time of graduation, the 1993-1996 Chinese were eight percentage points less likely to take a postdoctoral position. Instead of using Chinese who graduated in the late 1980s, Lan (2012a) uses Chinese who entered the U.S. too late to be eligible for the CSPA as the control group. Using eligibility for the CSPA as the instrumental variable for visa status, he shows that a green card reduces postdoctoral participation by about 12 percentage points.

Figure 1A: The CSPA and Percentage of Temporary Visa Holders Among Immigrants

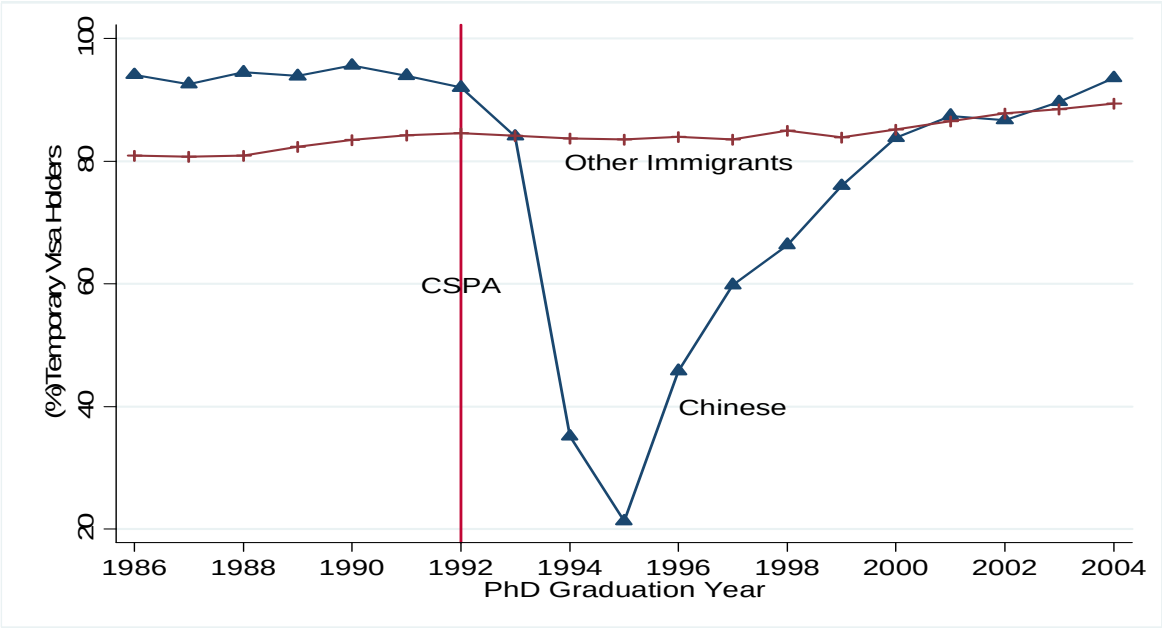
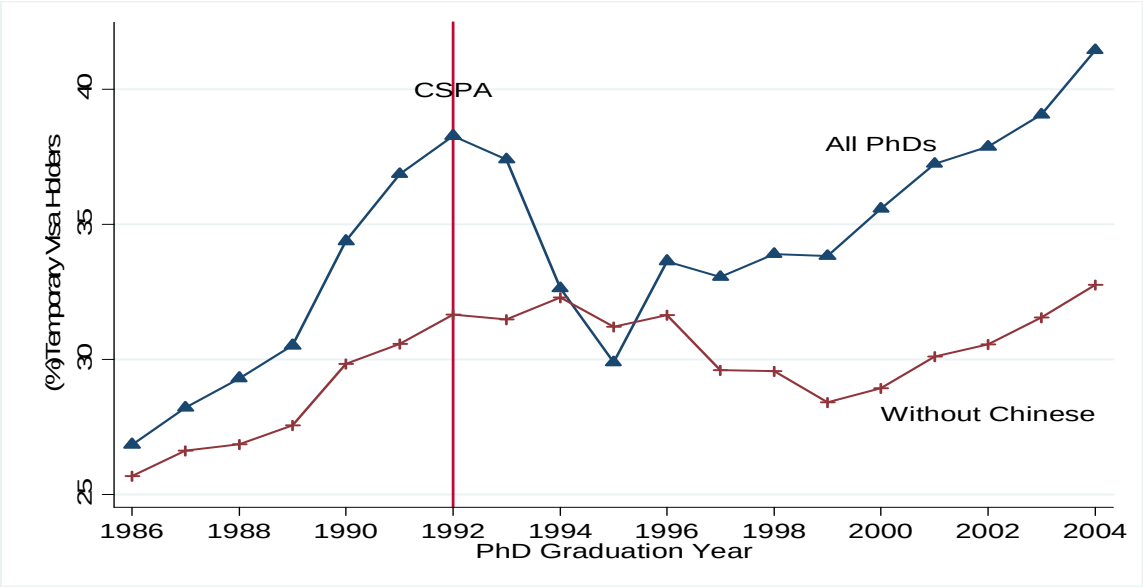


Figure 1B: The CSPA and Percentage of Temporary Visa Holders Among All S&E PhDs



Source: *Author's Tabulation from the Survey of Earned Doctorates.*

Figure 2: Postdocs/Non-postdocs, Relative Supply and Demand

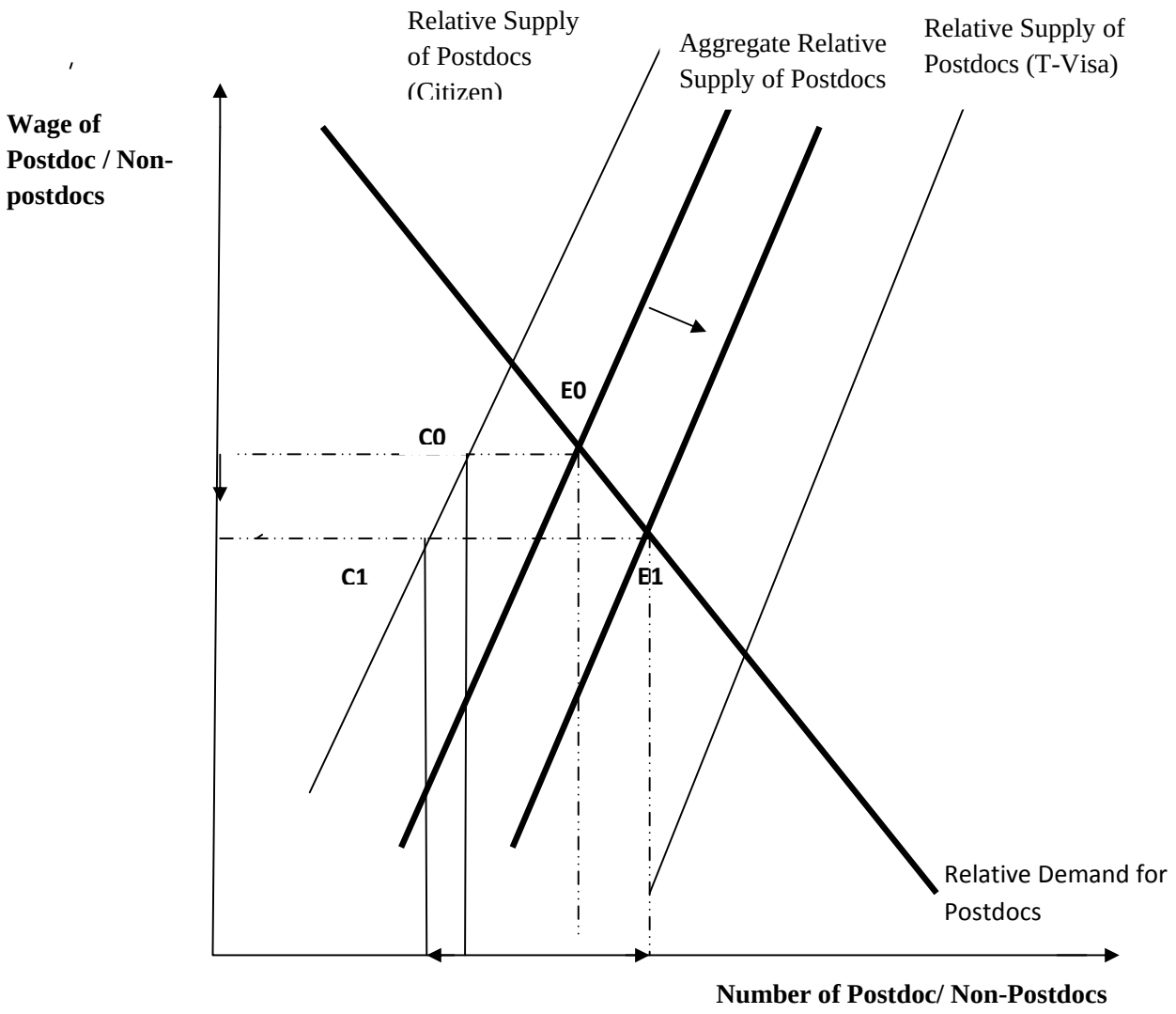


Figure 3A: Mean Annual Salary of New S&E PhDs

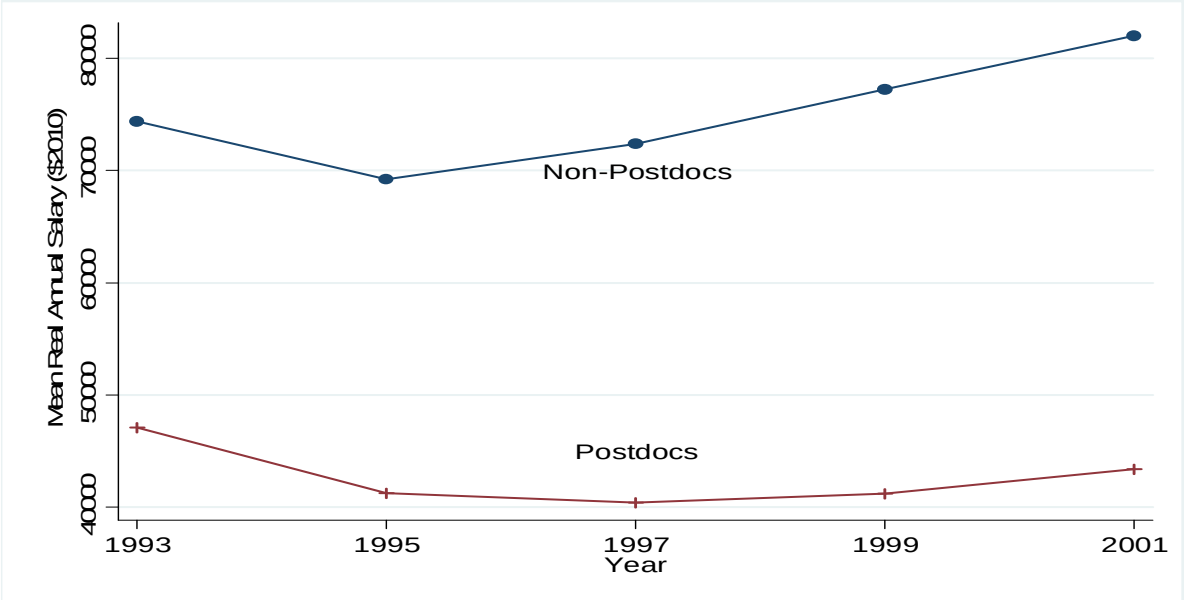
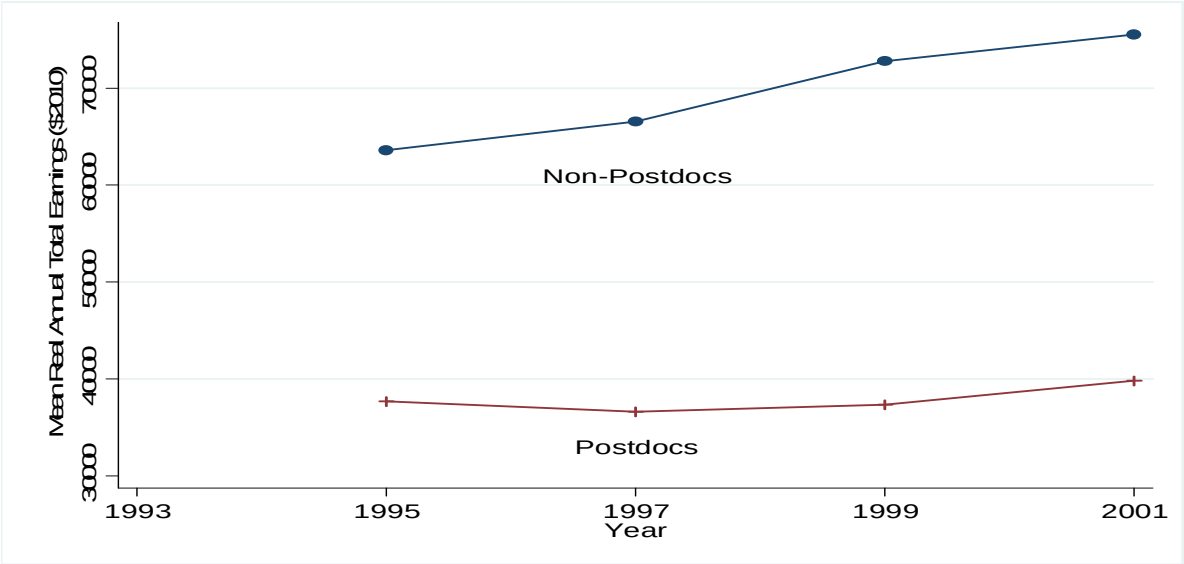


Figure 3B: Mean Annual Total Earning of New S&E PhDs



Notes: Data on annual total earnings were not collected in 1993. Annual salary consists of salary from the principal job in the survey year. Annual total earnings include all resources, such as overtime and summer teaching, in the year before the survey year. For example, the 2001 survey records the salary in 2001 and the total earnings in 2000.

Source: *Author's Tabulation from the Survey of Doctorate Recipients (1993-2001).*

Table 1 Summary Statistics for S&E PhDs Graduated from 1991 to 2000

Panel A: SED Sample Means (Number of Observations = 197,356)		
Age	32.6	
(%) Female	27.0	
(%) Married	60.3	
(%)Native-born	51.6	
(%)Naturalized Citizens/Green Card Holders	13.6	
(%)Temporary Immigrant	34.8	
(%) Postdocs in the U.S.	47.7	
(%) Chinese among All	11.6	
(%) Chinese among Postdocs	15.9	
Panel B: SDR Sample Means (Number of Observations = 13,543)		
	Postdocs (4,678)	**Non-Postdocs (8,865)**
(%) Working in 4-Year University or Medical Institution	77.1	35.5
(%) 2-Year College or Other School System	1.1	2.5
(%) Government/Industry	21.8	62.0
Salary (natives)	42,476 (13,124)	72,198 (23,818)
Salary (naturalized citizens/green card holders)	43,596 (14,613)	78,020 (24,031)
Salary (temporary immigrants)	43,681 (14,532)	78,923 (22,253)

Notes: Both samples include PhDs in S&E age 50 or younger. Salaries are reported in 2010 dollars.

Source: *Author's Tabulation from the Survey of Earned Doctorates and Survey of Doctorate Recipients 1993-2001.*

Table 2: Percentage of Postdocs, New S&E PhDs Graduated from 1991 to 2000

Research Fields	Temporary Immigrants	Citizens/Permanent Residents	Differences
Computer and IT	19.3	12.6	6.7***
Applied Math	38.8	25.5	13.3***
Statistics	21.3	13.1	8.2***
Other Math	45.8	22.7	23.1***
Animal Science	71.9	32.7	39.2***
Plant Science	81.6	38.2	43.3***
Food & Other Agriculture Science	64.1	27.8	36.3***
Biochemistry and Biophysics	90.0	79.9	10.2***
Cell and Molecular Biology	93.8	83.1	10.7***
Microbiology	90.9	78.8	12.0***
Pharmacology	91.2	80.8	10.4***
Botany	83.1	52.0	31.1***
Physiology	91.6	72.5	19.0***
Zoology	85.7	52.9	32.9***
Ecology	79.5	50.5	29.0***
Genetics	91.2	80.3	10.8***
Biology, General	93.2	75.8	17.4***
Nutrition Science	81.3	50.2	31.0***
Other Biology	85.2	69.9	15.3***
Environmental Life Science	60.7	25.0	35.7***
Public Health	53.4	19.6	33.8***
Pharmacy and Medicine	38.5	22.8	15.7***
Other Health & Related Science	50.6	18.4	32.2***
Chemistry	74.1	49.5	24.6***
Geology	59.5	37.9	21.6***
Atmospheric Sci. & Oceanography	76.6	51.6	24.9***
Astronomy & Physics	71.9	54.9	17.0***
Aerospace Engineering	48.0	20.1	27.9***
Chemical Engineering	40.0	20.7	19.3***
Civil Engineering	35.2	16.5	18.8***
Electrical and Electronics Engi.	22.1	12.6	9.4***
Computer and System Engi.	14.2	9.1	5.2***
Material Science	51.0	29.2	21.8***
Mechanical Engineering	35.6	20.4	15.2***
Bioengineering	49.5	45.9	3.6
Industrial Engineering	15.1	8.4	6.7***
Engineering Sci., Physics & Mechanics	47.0	25.1	21.9***
Other Engineering	43.8	19.7	24.0***
All	55.6	44.8	10.8***

Source: *Author's Tabulation from the Survey of Earned Doctorates* **** p<0.01*

Table 3 Effects on the Relative Wage between Postdocs and Non-postdocs among All New PhDs

	1991-2000 Graduates		1993-2000 Graduates		1991-1998 Graduates	
	OLS	**2SLS**	**OLS**	**2SLS**	**OLS**	**2SLS**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Percentage of Temporary Immigrants among All PhDs	**-.027**	**-1.652****	**-.699**	**-1.650****	**.371**	**-2.175****
	(.457)	(.830)	(.569)	(.776)	(.480)	(1.100)
First-stage Coefficient		**-.020*****		**-.020*****		**-.017*****
		(.004)		(.004)		(.005)
First-stage t-statistic		-5.07		-5.46		-3.63
R-Square	.587	.540	.628	.526	.620	.517
Number of Observations	187	187	149	149	149	149

Robust standard errors in parentheses **** p<0.01, ** p<0.05*

Notes: Estimates are weighted OLS or 2SLS. The weight is the number of PhDs in calculating the dependent variable in each field and year. The dependent variable is the difference between the log mean annual salary of postdocs and the log mean annual salary of non-postdocs, from the SDR. The instrumental variable is the number of CSPA-eligible PhDs (unit=100). Both the percentage of temporary immigrants and the instrumental variable are calculated from the SED. All regressions include field and year dummies.

Table 4 Effects of the Percentage of Temporary Immigrants on the Wage of Native PhDs Graduated in 1991-2000

	Relative Wage		Wage Level of Postdocs		Wage Level of Non-postdocs	
	OLS	2SLS	OLS	2SLS	OLS	2SLS
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Percentage of Temporary	**-0.417**	**-1.736****	**-0.459****	**-0.838****	**-0.082**	**0.818**
Immigrants among All PhDs	(0.536)	(0.787)	(0.223)	(0.390)	(0.165)	(0.642)
Age			0.005***	0.005***	0.005***	0.005***
			(0.002)	(0.002)	(0.001)	(0.001)
Male			0.024**	0.024***	0.078***	0.078***
			(0.010)	(0.009)	(0.011)	(0.011)
Married			0.018**	0.017**	0.029***	0.028***
			(0.008)	(0.007)	(0.009)	(0.009)
First-stage		**-0.020*****		**-0.019*****		**-0.020*****
Coefficient		(0.004)		(0.003)		(0.004)
First-stage t-statistic		-5.04		-5.32		-5.47
R-squared	0.465	0.435	0.343	0.343	0.293	0.290
Observations	175	175	2,922	2,922	5,710	5,710

**** p<0.01, ** p<0.05*

Notes: Estimates in Column 1 and 2 use the same method described under Table 3, but dependent variables are measured by only using native PhDs. Dependent variables in Columns 3-6 are individual salaries, from the SDR. Both the percentage of temporary immigrants and the instrumental variable, the number of CSPA-eligible PhDs (unit=100), are calculated from the SED. All regressions include field and year dummies. Regressions in Columns 3-6 also include dummies for work locations and PhD programs. In columns 1 and 2, robust standard errors are in parentheses; in columns 3-6, standard errors are clustered at the field-year level.

Table 5: Differences of Sample Means, for PhDs Who Graduated under the CSPA (93-96) and after the CSPA(97-00)

	Chinese			Natives			Other Immigrants		
	93-96 Graduates (1)	97-00 Graduates (2)	(3)=(1)-(2)	93-96 Graduates (4)	97-00 Graduates (5)	(6)=(4)-(5)	93-96 Graduates (7)	97-00 Graduates (8)	(9)=(7)-(8)
Panel A: Outcomes in 2001, Survey of Doctorate Recipients									
Salary in 2001	**79,910**	**63,637**	**16,273*** **	**69,124**	**59,001**	**10,123*** **	**77,736**	**65,855**	**11,880*** **
	(1,349)	(1,205)	(1,803)	(605)	(490)	(770)	(1,139)	(833)	(1,382)
Total Income in 2000	**80,286**	**59,987**	**20,299*** **	**70,154**	**56,532**	**13,622*** **	**77,372**	**62,937**	**14,435*** **
	(1,570)	(1,416)	(2,108)	(653)	(526)	(829)	(1,277)	(935)	(1,551)
Work in Academia (%)	**22.3**	**33.3**	**-11.0*** **	**44.4**	**47.9**	**-3.4** **	**30.3**	**37.1**	**-6.7*** **
	(2.2)	(2.3)	(3.2)	(1.1)	(1.0)	(1.5)	(1.8)	(1.5)	(2.4)
Number of Published Articles since 1995	**3.87**	**4.82**	**-0.95** **	**4.84**	**4.44**	**0.40** **	**4.56**	**4.39**	**0.17**
	(.29)	(.24)	(.37)	(.13)	(.10)	(.16)	(.23)	(.15)	(.26)
Granted a Patent since 1995 (%)	**22.1**	**10.6**	**11.4*** **	**12.8**	**7.5**	**5.3*** **	**19.3**	**10.2**	**9.0*** **
	(2.2)	(1.5)	(2.6)	(.8)	(.5)	(.8)	(1.5)	(.9)	(1.7)
Observations	367	414	781	1,958	2,519	4,477	670	1,037	1,707
Panel B: Demographic Variables at Graduation, Survey of Earned Doctorates									
Green Card (%)	**65.5**	**28.5**	**37.0*** **	**N/A**	**N/A**	**N/A**	**16.1**	**15.5**	**0.6* **
	(.5)	(.5)	(.7)				(.2)	(.2)	(.3)
Age	**33.2**	**33.2**	**0.0**	**32.4**	**32.3**	**0.2*** **	**32.7**	**32.7**	**0.1** **
	(.0)	(.0)	(.1)	(.0)	(.0)	(.0)	(.0)	(.0)	(.0)
Male (%)	**75.6**	**72.9**	**2.7*** **	**68.2**	**66.3**	**2.0*** **	**80.9**	**75.7**	**5.2*** **
	(.4)	(.5)	(.6)	(.2)	(.2)	(.3)	(.2)	(.2)	(.3)
Top 20 Programs (%)	**23.2**	**23.9**	**-.7**	**34.2**	**33.7**	**0.5**	**34.6**	**33.3**	**1.3*** **
	(.4)	(.4)	(.6)	(.2)	(.2)	(.3)	(.3)	(.3)	(.4)
Stay in the U.S.	**97.0**	**96.2**	**.8*** **	**95.9**	**96.5**	**-0.7*** **	**67.5**	**75.3**	**-7.8*** **
	(.2)	(.2)	(.3)	(.1)	(.1)	(.1)	(.3)	(.3)	(.4)
Observations	9,988	9,049	19,037	39,143	39,950	79,093	30,877	30,605	61,482

Standard errors in parentheses *** *p<0.01*, ** *p<0.05*

Table 6: Difference-in-Difference Estimates on Outcomes in 2001: Chinese and Native PhDs

VARIABLES	Log(salary in 2001)		Log(income in 2000)		Probability of Working in Academia		Number of Published Articles since 1995		Probability of Being Granted a Patent since 1995	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Chinese*(93_96 Graduate)	**0.075*** **	**0.089*** **	**0.081*** **	**0.101*** **	**-0.076** **	**-0.072** **	**-1.393*** **	**-1.137*** **	**0.069** **	**0.082*** **
	(0.027)	(0.025)	(0.030)	(0.029)	(0.033)	(0.033)	(0.403)	(0.408)	(0.027)	(0.028)
Chinese	**0.047** **	**0.004**	**0.017**	**-0.024**	**-0.106*** **	**-0.100*** **	**0.628** **	**0.823*** **	**0.008**	**0.001**
	(0.019)	(0.019)	(0.022)	(0.022)	(0.023)	(0.024)	(0.258)	(0.269)	(0.016)	(0.017)
93_96 Graduates	**0.167*** **	**-0.041** **	**0.239*** **	**-0.072*** **	**-0.030** **	**-0.009**	**0.436*** **	**-0.459**	**0.050*** **	**-0.008**
	(0.011)	(0.020)	(0.012)	(0.021)	(0.014)	(0.028)	(0.161)	(0.302)	(0.009)	(0.018)
age		**0.002***		**0.004*** **		**-0.002**		**-0.139*** **		**-0.000**
		(0.001)		(0.001)		(0.002)		(0.016)		(0.001)
male		**0.088*** **		**0.088*** **		**0.002**		**1.142*** **		**0.035*** **
		(0.011)		(0.012)		(0.015)		(0.151)		(0.009)
married		**0.058*** **		**0.070*** **		**-0.021**		**0.115**		**0.010**
		(0.012)		(0.012)		(0.015)		(0.159)		(0.009)
work experience		**0.048*** **		**0.071*** **		**-0.004**		**0.341*** **		**0.014*** **
		(0.005)		(0.005)		(0.006)		(0.068)		(0.004)
PhD Programs	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES
Employer Location	NO	YES	NO	YES	NO	NO	NO	NO	NO	NO
R-squared	0.269	0.366	0.301	0.392	0.127	0.162	0.053	0.106	0.090	0.122

Robust standard errors in parentheses *** *p<0.01, ** p<0.05, * p<0.1*

Notes: All regressions include 5,258 observations and dummies for 38 research subfields as listed in Table 2. "Work experience" is the number of years between the year of PhD graduation and 2001. "Academia" includes four-year colleges and medical institutions.

Table 7: Difference-in-Difference Estimates on Outcomes in 2001: Chinese and Other Immigrants

VARIABLES	Log(salary in 2001)		Log(income in 2000)		Probability of Working in Academia		Number of Published Articles since 1995		Probability of Being Granted a Patent since 1995	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Chinese*(93_96 Graduate)	**0.080*** **	**0.084*** **	**0.109*** **	**0.124*** **	**-0.038**	**-0.020**	**-1.120** **	**-0.813* **	**0.039**	**0.065** **
	(0.030)	(0.030)	(0.034)	(0.034)	(0.036)	(0.038)	(0.454)	(0.467)	(0.031)	(0.033)
Chinese	**0.026**	**0.032**	**0.015**	**0.019**	**-0.063** **	**-0.068*** **	**0.245**	**0.286**	**0.003**	**0.002**
	(0.021)	(0.021)	(0.024)	(0.024)	(0.025)	(0.026)	(0.287)	(0.305)	(0.018)	(0.019)
93_96 Graduates	**0.160*** **	**-0.038**	**0.214*** **	**-0.082** **	**-0.060*** **	**-0.012**	**0.188**	**-0.041**	**0.079*** **	**0.035**
	(0.018)	(0.029)	(0.021)	(0.032)	(0.022)	(0.037)	(0.269)	(0.450)	(0.017)	(0.032)
age		**-0.006*** **		**-0.006*** **		**0.005** **		**-0.103*** **		**-0.006*** **
		(0.002)		(0.002)		(0.002)		(0.025)		(0.002)
male		**0.105*** **		**0.100*** **		**-0.012**		**1.236*** **		**0.050*** **
		(0.017)		(0.018)		(0.021)		(0.235)		(0.015)
married		**0.071*** **		**0.072*** **		**-0.100*** **		**-0.402**		**0.014**
		(0.019)		(0.022)		(0.025)		(0.273)		(0.018)
work experience		**0.053*** **		**0.079*** **		**-0.016* **		**0.122**		**0.015** **
		(0.006)		(0.007)		(0.008)		(0.102)		(0.007)
PhD Programs	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES
Employer Location	NO	YES	NO	YES	NO	NO	NO	NO	NO	NO
R-squared	0.340	0.460	0.343	0.464	0.169	0.234	0.063	0.126	0.097	0.153

Robust standard errors in parentheses **** p<0.01, ** p<0.05, * p<0.1*

Notes: All regressions include 2,488 observations and dummies for 38 research subfields as listed in Table 2. "Work experience" is the number of years between the year of PhD graduation and 2001. "Academia" includes four-year colleges or medical institutions.

Appendix Table 1: Executive Order 12711 and Chinese Student Protection Act: on the Probability of Postdoctoral Participation

Panel A: Executive Order 12711			Panel B: Chinese Student Protection Act		
Chinese*(90_92 Graduates)	**-0.017**	**-0.014**	Chinese*(93_96 Graduates)	**-0.080*** **	**-0.075*** **
	(0.014)	(0.014)		(0.013)	(0.013)
Chinese	**0.238*** **	**0.230*** **	Chinese	**0.248*** **	**0.240*** **
	(0.012)	(0.012)		(0.011)	(0.012)
90_92 Graduates	**-0.065*** **	**-0.065*** **	93_96 Graduates	**-0.054*** **	**-0.054*** **
	(0.005)	(0.005)		(0.005)	(0.005)
female	**-0.010**	**-0.010**	female	**0.007**	**0.008**
	(0.007)	(0.007)		(0.006)	(0.006)
Dummies for PhD Programs	NO	YES	Dummies for PhD Programs	NO	YES
Number of Observations	34,022	34,022	Number of Observations	45,783	45,783

Robust standard errors in parentheses *** *p<0.01*

Notes: All regressions include dummies for 38 research subfields as listed in Table 2. The dependent variable is the probability of postdoctoral participation. The control group includes all non-Chinese temporary immigrants and 1986-89 Chinese graduates.

Appendix Table 2: DID Estimates on Outcomes in 2001: Including 91-92 Chinese Graduates in the Treatment Group

	Log(salary in 2001)	Log(income in 2000)	Probability of Working in Academia	Number of Published Articles since 1995	Probability of Being Granted a Patent since 1995
			Panel A: Chinese and Natives, Number of Observations=6,225		
Chinese*(91_	**0.078*** **	**0.097*** **	**-0.057* **	**-1.193*** **	**0.073*** **
96 Graduate)	-0.001	-0.029	(0.031)	(0.397)	(0.025)
Chinese	**-0.001**	**-0.029**	**-0.098*** **	**0.670*** **	**-0.001**
	(0.019)	(0.022)	(0.024)	(0.258)	(0.017)
91_96	**-0.008**	**-0.012**	**-0.021**	**0.692*** **	**-0.003**
Graduates	(0.018)	(0.019)	(0.024)	(0.150)	(0.016)
			Panel B: Chinese and Other Immigrants, Number of Observations=2,882		
Chinese*(91_	**0.079*** **	**0.113*** **	**-0.034**	**-0.771* **	**0.063** **
96 Graduate)	(0.027)	(0.031)	(0.035)	(0.437)	(0.030)
Chinese	**0.029**	**0.017**	**-0.060** **	**0.329**	**-0.002**
	(0.021)	(0.024)	(0.026)	(0.287)	(0.019)
91_96	**0.009**	**-0.012**	**-0.046**	**0.275**	**0.046**
Graduates	(0.026)	(0.029)	(0.033)	(0.249)	(0.029)
Employer Location	YES	YES	NO	NO	NO

Robust standard errors in parentheses *** *p<0.01, ** p<0.05, * p<0.1*

Notes: All regressions include age, gender, marital status, work experience, dummies for PhD programs, and dummies for 38 research subfields as listed in Table 2. "Work experience" is the number of years between the year of PhD graduation and 2001. "Academia" includes four-year colleges or medical institutions.