The Impacts of High-skilled Immigrants on U.S. Higher Education, Innovation and Labor Market Outcomes

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In today's increasingly globalized economy, attracting, growing and retaining high-skilled immigrants (especially STEM workers) will continue to be of great significance for a country's economic future. However, high-skilled immigrants can create multiple groups of winners and losers as they integrate into the domestic STEM workforce. When they enter U.S. undergraduate institutions, highly-skilled foreign students can potentially crowd-out domestic students, but they could also crowd-in domestic students if their tuition payments allow these institutions to hire more or better faculty or to lower fees for domestic students in need. At the Ph.D. level, foreign students could crowd-out domestic students, but they could also increase the productivity of their advisors, fomenting greater scientific advances that benefit domestic scientists and others down the road. After graduation, foreign students may compete for jobs with domestic students in STEM professions, but they may also bring about peer effects with domestic STEM workers, or even complement non-STEM workers, thereby increasing productivity in the economy as a whole.

The economics of highly-skilled immigrants in STEM areas are therefore quite subtle, and in my dissertation I aim to comprehensively analyze each of the above pathways through which highly-skilled foreign immigrants may impact domestic education and the domestic economy. Specifically, in my first paper, I analyze the impacts of highly-skilled immigrants entering at the undergraduate level; in my second paper, I analyze the impacts of those who enter at the Ph.D. level; and in the third paper, I analyze the impacts of those who graduate looking for work in the United States.

My first paper is "*The Impacts of the Influx of New Foreign Undergraduates on U.S. Higher Education*." After 2006, the United State experienced a large increase in the number of foreign students arriving at the undergraduate level. There are two important reasons that make 2006 the starting year of a sharp increase in the entry of foreign undergraduates from China (the leading sending country). The most important reason is the visa relaxation policy: in 2005, the U.S. and China achieved an agreement on relaxing visa requirements for students and scholars. After the policy change, the new agreement significantly reduced the refusal rate of Chinese student visas. For example, in 2003, the visa refusal rate for Chinese students was around 50%, but by 2013, it had declined to only 10%. In addition to the changes in visa policy, the Chinese currency (RMB) has appreciated against the U.S. dollar by more than 30% since July 21st, 2005 when the Chinese government announced changes in its official exchange rate regime, making studying in American institutions is relatively cheaper. In this paper, I make use of the foreign supply shock induced by Chinese undergraduate students after 2006 as a natural experiment. Specifically I find that institutions with many earlier foreign students experienced a larger increase in the number of new foreign students after 2006; I therefore compare institutions that were more affected by the influx of foreign undergraduates with those that were less affected, before and after the shock.

Therefore, my identification utilizes both cross-time and cross-sectional variation to identify the casual impacts of foreign undergraduates on institutional outcomes by comparing the more affected institutions versus the less affected institutions in the pre-shock and post-shock period. Below is my two stage least squares strategy:

$$E_{ut} = \delta_u + \varphi_t + \beta F_{ut} + \varepsilon_{ut} \qquad (1)$$

$$F_{ut} = \delta_u + \varphi_t + \sum_{k=1}^{8} \alpha_k (Beforeforeign_u * Post2006_{k,t}) + \varepsilon_{ut} \qquad (2)$$

where E denotes institutional outcomes of interest in school u at time t, and F denotes the respective number of full-time first foreign students. I also include school fixed effects and year fixed effects. Equation (1) is the OLS model to estimate the impacts of foreign students on institutional outcomes, and Equation (2) is the first-stage equation. *BeforeForeign* equals the number of full-time first-time foreign students in each institution between 1998 and 2000; and *Post2006* are indicator variables equal one if the year is k years relative to 2005. The omitted category is the years prior to 2005. Here, the institutional outcomes of interest

include the number of full-time first-time domestic students, tuition and fees, average institutional grant aid and average salaries for instructional staff. Unlike the standard DD model, rather than using just "treatment" and "post-treatment" dummies, using *BeforeForeign* as a continuous variable and a vector of year fixed effects could generate more variations and give us more dynamic effects.

The regression results suggest an approximate one to one crowdout effect between foreign undergraduates and native undergraduates at top-100 universities. Figure 1 and Figure 2 illustrates the raw data that underlies these regression results. Specifically, the figures clearly document that the institutions with many earlier foreign students enrolled more foreign students after 2006, and the relative decline in the number of domestic students in top-100 universities. Moreover, the results indicate that the influx of foreign students increases tuition in public schools, but it has little impact on tuition in private schools and school fees in both public and private schools. Admitting more foreign students leads to an increase in the average amount of institutional grant aid for the accepted students, as well as an increase in the average salary for instructional staff.

Education is the cornerstone for a nation's economic development. In recent years, with the large influx of foreign undergraduate students on U.S. higher education, my paper suggests that it creates both costs and benefits for domestic students and institutions in the short run.

In my second paper "*Ethnic Complementarities after the Opening of China: How Chinese Graduate Students Affected the Productivity of Their Advisors*", co-authored with George Borjas and Kirk Doran, we examine the productivity effects of a large high-skilled supply shock: the "immigration" of young graduate students in mathematics from China. We use the opening of China in late 1978 as a natural experiment. Before 1978, the Cultural Revolution both destroyed the Chinese higher education system and engendered strict isolationism, causing China to send virtually no students abroad for over a decade. After 1978, the "Open Up" policy encouraged Chinese students to acquire their graduate training in Western universities, resulting in a very large and sudden increase in the number of Chinese students sent to study in doctoral programs in the U.S.. In addition to this time dimensional difference, multiple studies have documented that people of similar ethnic background are more likely to collaborate with each other and spread technological knowledge within their ethnicity group, so the influx of Chinese graduate students should result in different impacts on pre-existing American advisors with and without Chinese heritage. Using name-matching techniques, we split the advisors into two groups: American advisors with Chinese ancestry (for simplicity, we call them Chinese-American advisors) and American advisors without Chinese ancestry (American advisors). Moreover, some departments received large numbers of Chinese students, while some were not heavily affected by the influx. We find that Chinese students gravitated towards departments that had already had Chinese-American advisors in their employ, so we further classify mathematics departments into two types, depending on whether the departments had active Chinese-American advisors before the supply shock. In short, we divide our sample into three mutually exclusive groups: Chinese- American advisors, American advisors in mixed departments and American advisors in non-mixed departments. To assess whether the supply shock had any relative productivity effects, we estimate the regression model:

$$Y_{it} = \alpha X_{it} + \phi_i + \theta_t + \gamma_c (C_i * T) + \gamma_m (A_i^m * T) + \varepsilon$$

Where Y measures the productivity of advisor i at time t; X controls for the advisor's years of work experience; C is a dummy variable indicating if the advisor is a Chinese-American; and A is a dummy variable if the advisor is an American advisor employed in a mixed department in 1988. The omitted group is the group of American advisors employed in non-mixed departments. We include advisor fixed effects and year fixed effects, so γ_c gives the difference-in-differences estimate of the impact of the supply shock on the productivity of Chinese-American advisors, while coefficient γ_m measures the corresponding impact on the productivity of American advisors in mixed departments.

Panel A and Panel B of Table 1 report the estimates of the coefficients using different two alternative definitions of a mixed department. The regression results suggest that the supply shock of Chinese graduate students sparked by the opening up of China led to: (a) an increase in the number of Chinese students mentored and an increase in the number of papers published by the pre-existing group of Chinese-American mathematics advisors employed in American universities; and (b) a decrease in the number of students, particularly American students, and a decrease in the number of papers published by the pre-existing group of American advisors in the departments that were most likely to attract the Chinese graduate students.

Furthermore, in this paper we also show that the increase in the productivity of Chinese-Americans is not only due to the increase in the number of co-authored papers with their Chinese advisees, but also driven by the relatively higher productivity in solo-authored work, suggesting that there exist sizable intra-ethnic spillovers.

Scientific knowledge is a public good and knowledge spillovers are the engine for the long--run economic growth. In this paper, we find that ethnic complementarities can be very important in knowledge production. However, if the demand for knowledge output does not shift out in those areas where a supply shock has created additional opportunities for productive interactions, the benefits of ethnic interactions may be greatly attenuated by an accompanying loss.

In addition to examining the impacts of highly-educated foreign students on both undergraduate programs and graduate programs in the U.S., my third work-in-progress project, co-authored with Kirk Doran, attempts to investigate the impacts of foreign high-skilled STEM Students on labor market outcomes in their post-graduation period. On April 4, 2008, the U.S. Department of Homeland Security released a rule extending the period of Optional Practical Training (OPT) from 12 to 29 months for qualified F-1 non-immigrant students with bachelor and higher degrees, and this additional 17-month OPT period is only possible for students who have a bachelors or higher degree in specific Science, Technology, Engineering or Mathematics (STEM) fields. Since foreign students comprise a large fraction of all students trained by US universities in STEM fields, and since the OPT period plays an important role for international students in finding a job and working in the US legally before they get an H1-B sponsorship, the OPT extension policy could have a significant influence on non-immigrant students' career choice, which may eventually generate great impacts on labor market outcomes such as employment, and wages, or impacts on knowledge generation across fields and time.

Because the OPT extension began during a specific year, and only affected STEM fields, it is possible to identify its impacts through comparing the affected and unaffected fields over time. We will use the following regression to estimate the effect of an OPT extension policy on labor market outcomes:

$$Outcomes_{itf} = \alpha_o + \alpha_1 After_t * Major_f + \alpha_2 X_{itf} + \delta_t + \varphi_f + \varepsilon_{itf}$$

In this equation, the dependent variables are the outcomes that we are interested in, such as the growth rate of wages. *X* variables represent each individual's characteristics. *After* is a dummy variable which equals 1 if the graduation year is after the OPT extension policy, and *Major* is a dummy variable which equals 1 for majors that had a larger fraction of foreign PhD students before the policy change. We also include year fixed effects and field fixed effects. The coefficient before the interaction term estimates the reduced-form effect. It thus measures the impact of an exogenous supply shock of foreign PhDs on U.S. labor market outcomes and knowledge generation.

To run the above equations, individual level data will come from two restricted-use datasets: the Survey of Earned Doctorates (SED) and the Survey of Doctorate Recipients (SDR) from 1993 and 2013. So far, we have submitted an application to access these two restricted-use datasets and the application has been approved by NSF. Aggregate measures of knowledge generation across fields and time will come from Thompson Reuters Web of Knowledge.

In sum, high-skilled immigrants have been essential for maintaining the United States' advantage in technology and innovation. The results in my dissertation suggest that from a domestic students' point of view, immigrants who enter as students take up some educational opportunities, but also lead to an expansion in aid to those in need. From an institution's perspective, admitting more foreign students might have positive effects, as foreign students usually pay a larger fraction of their education, allowing for an increase in instructional salaries. From a professor's point of view, the influx of foreign students creates both winners and losers, changing the type of knowledge that our scientists produce. Finally, once highly skilled foreign students graduate, they have the potential to greatly impact labor market outcomes and knowledge generation across fields. The NBER pre-doctoral fellowship will allow me to analyze each of these impacts in detail. I look forward to hearing from you soon!

Fig 1: Average Number of Foreign Students

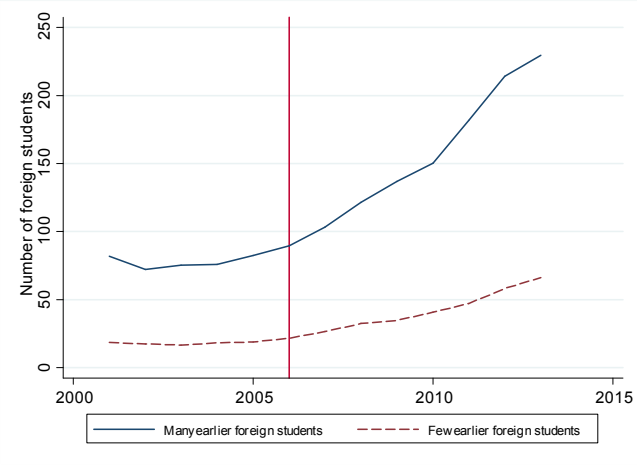


Fig 2: Average Number of Domestic Students (Top-100 Universities)

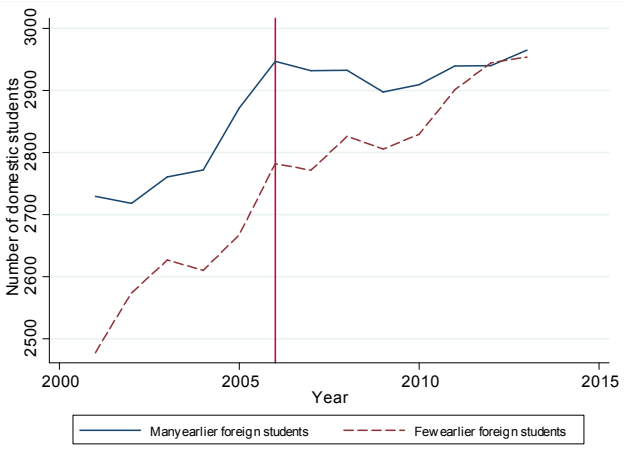


Table 1. The supply shock of foreign Ph.Ds and the productivity of pre-existing advisors

	Dependent variable				
	Number of students	Number of Chinese students	Number of American students	Number of papers published	Citations per paper published
A. Mixed department had some Chinese presence					
Chinese advisor	0.026	0.077***	-0.051***	0.144**	-0.889
	(0.022)	(0.016)	(0.015)	(0.090)	(0.764)
American advisor in	-0.005	0.005**	-0.010*	-0.088***	-0.295
mixed department	(0.008)	(0.003)	(0.007)	(0.029)	(0.411)
B. Mixed department had active Chinese presence					
Chinese advisor	0.027	0.077***	-0.050***	0.167**	-0.935
	(0.022)	(0.016)	(0.015)	(0.089)	(0.759)
American advisor in	-0.004	0.012***	-0.016**	-0.069**	-1.027
mixed department	(0.012)	(0.004)	(0.010)	(0.038)	(0.629)

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Education

Ph.D., Economics, University of Notre Dame	Expected May 2017
M.A., Economics, University of Notre Dame	2014
M.P.A., Cornell Institute for Public Affairs, Cornell University	2011
B.A., Economics, Renmin University of China	2009
Semester Study Exchange, University of Hong Kong	Spring, 2008

Fields of Specialization

Applied Econometrics, Labor Economics, Immigration Economics, Economics of Education

Working Papers

"Ethnic Complementarities after the Opening of China: How Chinese Graduate Students Affected the Productivity of Their Advisors" (with George Borjas and Kirk Doran, with equal co-authorship), *NBER Working Paper No. 21096; NBER Digest, Sept.2015*

"The Impact of the Influx of New Foreign Undergraduates on U.S. Higher Education"

"The Effect of Family Size on Children's Education: Evidence from the Fertility Control Policy in China" *Frontiers of Economics in China,* forthcoming

Work in Progress

"The Demand for STEM Graduates: Evidence from Visa Reform" (with Kirk Doran)

"An Empirical Analysis of the Effects of the United and Continental Airlines Merger"

Honors and Awards

Kellogg Institute Travel Grant	2015
Graduate Assistantship, University of Notre Dame	2012--Present
Graduate Summer Fellowship, University of Notre Dame	2013, 2014
Cornell Institute for Public Affairs Fellowship, Cornell University	2009--2011
Li & Feng Scholarship, University of Hong Kong	2008
Distinguished Student Fellowship, Renmin University of China	2007

Research Experience

Research Assistant, Professor Kirk. Doran, University of Notre Dame	2014 – Present
Research Assistant, Professor Ethan. Lieber, University of Notre Dame	2013 – 2014
Research Fellow, China Development Bank, Beijing, China	Summer, 2010
Research Intern, Samsung Economics Research Institute, Beijing, China	2008–2009

Teaching Experience

Teaching Assistant, Principle of Microeconomics	Fall, 2015
Teaching Assistant, Principle of Macroeconomics	Fall, 2015

Conferences and Presentations

The 7th International Symposium on Human Capital and Labor Markets	Scheduled
Chinese Economic Association (UK/Europe) Annual Conference, Beijing	2015
China Economist Society North America Conference, Ann Arbor, MI	2015
Applied Microeconomics Seminar, Notre Dame, IN	2013, 2014

Skills

Languages: Chinese (native), English (fluent)
Computer: Stata, SPSS, E-views, Matlab, Lyx

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To Whom It May Concern:

I am writing to give my highest recommendation for my student, Ying Shen, for the NBER Pre-Doctoral Fellowship Program on the Economics of High Skill Immigration. I believe that Ying is very likely to make an important contribution to our understanding of the economics of high-skill immigration through both her dissertation and post-dissertation work.

The economics of high-skill immigration is subtle; Ying's strength is her ability to come up with research questions and research designs which embrace that subtlety. A case in point is the first chapter of Ying's dissertation. Ying asks: what happens to American universities and American university students when high skill immigrants come as undergraduates to our universities? This is an especially pertinent question because immigration at the undergraduate level has been skyrocketing, and because anything that affects our universities has the potential to simultaneously impact the three things that we care about the most in this area: post-secondary educational attainment, labor market outcomes, and innovation in S&E fields.

In order to find out how immigration at the undergraduate level affects our universities and students, Ying needs a rather sudden shock in this type of immigration, and she needs it to hit some universities more than others. Fortunately, Ying has come up with a great example. It turns out that in 2005, the United States and China reached an agreement on relaxing their visa policies for students and scholars. This resulted in an upsurge in Chinese undergraduates at American universities starting in 2006. To get the other half of the identification, Ying makes use of the fact that foreign students are much more likely to attend a school that has already had a high presence of foreign students in the past than one that has not.

Comparing these two groups of schools before and after the shock, Ying turns to the IPUMS database to learn what happened to the institutions, as well as what happened to the students themselves. She finds that top universities experienced a decline in domestic enrollment that is roughly equal to the increase in foreign enrollment after the shock. This is an important result by itself, with ramifications for how the increased globalization of American universities will be likely to affect domestic students. But she also finds something more intriguing: the institutions respond to the increase in the supply of (probably fully-paying) foreign students by in turn increasing the average amount of grant aid for accepted students, as well as the average salaries for instructional staff.

This is a case in point of the subtlety of the impact of highly-skilled immigration on the domestic S&E sector: domestic students may be crowded out at the direct level, but indirectly, the achievement of those who are accepted may increase through better teacher salaries and improved grant aid.

Of course, to really understand the impact of highly skilled foreign students, we need to look beyond the undergraduate level to the graduate level as well. Ying does this in the second chapter of her dissertation.

The second chapter is joint work with George Borjas and myself, but, as George will attest, this was Ying's idea. Ying wanted to understand how access to more and better immigrant Ph.D. students could impact the knowledge production of advisors who were already here. Again, Ying needed a sharp increase in the supply of (not the demand for) foreign Ph.D. students, as well as variation in which advisors got them and which didn't. Ying rose to the occasion: she suggested using the opening of China in December of 1978. It turns out that advisees and advisors of the same ethnicity are more likely to work with each other than those of different ethnicities. Furthermore, it turns out that there were some advisors of Chinese ancestry already working in the United States before the opening of China. She compares these advisors to other similar advisors before and after the shock, making use of the data that George and I compiled for our work on mathematicians.

What she finds is really interesting: advisors benefitted greatly by the influx of new Ph.D. students not only through more and better coauthorships with their students, but even in their own solo-authored work as well. By looking at individual-level paper data, Ying is able to go beyond existing studies of foreign Ph.D.s as inputs and demonstrate that they can cause spillovers to their own advisors' independent production of knowledge as well.

Finally, Ying aks the question: what happens to post-graduation labor markets for S&E-trained workers when high skill immigrants are given more time to search for jobs without a visa? On April 4, 2008, the U.S. Department of Homeland Security released a rule extending the period of Optional Practical Training (OPT) from 12 to 29 months for qualified F-1 non-immigrant students with bachelor and higher degrees, and this additional 17-month OPT period is only possible for students who have a bachelors or higher degree in specific Science, Technology, Engineering or Mathematics (STEM) fields. Since foreign students comprise a large fraction of all students trained by US universities in STEM fields, and since the OPT period plays an important role for international students in finding a job and working in the US legally before they get an H1-B sponsorship, the OPT extension policy could have a significant influence on non-immigrant students' career choice, which may eventually generate impacts on labor market outcomes such as employment and wages, as well as impacts on knowledge generation across fields and time.

Because the OPT extension began during a specific year, and only affected specific STEM fields, it is possible to identify its impacts through comparing the affected and unaffected fields over time. For this chapter, individual level data will come from two restricted-use datasets: the Survey of Earned Doctorates (SED) and the Survey of Doctorate Recipients (SDR) from 1993 and 2013. So far, we have submitted an application to access these two restricted-use datasets and the application has been approved by NSF. Aggregate measures of knowledge generation across fields and time will come from Thompson Reuters.

As you can see, Ying is applying creative identification strategies to study multiple pathways through which high skill immigration may impact the S&E economy. She is taking the data seriously, the identification seriously, and most of all she is asking the right questions. I believe that the results of this research will help us better understand the winners, losers, and likely outcomes of this fascinating aspect of the globalization of education and knowledge production. Ying Shen is one of the brightest and most creative graduate students in the country working on these issues, and you couldn't pick a better person for your fellowship.

Sincerely,

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