Quotas and Quality: The Effect of H-1B Visa Restrictions on the Pool of Prospective Undergraduate Students from Abroad[*]

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Abstract

In deliberating whether to pursue an undergraduate education in the US, a foreign student takes into consideration the expected probability of securing US employment after graduation. The H-1B visa provides a primary means of legal employment for college-educated foreign-nationals. In October 2003, the government drastically reduced the number of available H-1B visas, hence lowering the probability of a college-educated foreign-national finding employment and possibly discouraging highly qualified international students from attending US colleges and universities. However, citizens from five countries are *de facto* exempt from the 2003 H-1B visa restrictions. Using international students from these five exempt nations as the control and other international students as the treatment group, we study the effects of the 2003 H-1B policy change on the pool of international applicants to US schools. We use two datasets: (i) College Board SAT score data on prospective international applicants; and (ii) SAT and high-school GPA data on international applicants to a single highly selective university. Our difference-in-difference estimates show that the restrictive immigration policy has had an adverse impact on the quality of prospective international applicants, reducing their SAT scores by about 1.5%. This effect is driven mostly by a decline in the number of SAT score reports sent by international students at the top-quintile of the SAT score distribution, suggesting that the restrictive immigration policy disproportionately discourages high-ability international students from attending US schools. Our results are robust to alternative specifications, including the use of high-school GPA as a measure of applicant ability.

Key Words: Skilled Immigration, H-1B Visa, College Education, SAT Scores

JEL Classification Codes: F22, I20, O15, I28, J61

1 Introduction

Foreign students often study in the United States hoping that an American undergraduate education will serve as a gateway to longer-term US employment. Rosenzweig (2006) provides strong empirical support for this phenomenon. Borjas (2002) notes that the probability of ultimately receiving a green card (permanent residency) was 26 times higher for foreign students than for those applying through the random green card lottery. Bhagwati and Rao (1999) and Chiswick (1999) are among other authors to claim that student visas are often used in hopes of securing permanent employment. It follows that a foreign student considering higher education in the US will be affected by any significant exogenous change in the probability of securing US employment upon graduation. Such a change did occur in October 2003 when Congressionally-imposed limits on new H-1B visa issuances per annum were reduced dramatically from 195,000 to 65,000 for fiscal year 2004.

The H-1B visa offers many foreign-nationals with a college degree a legal, though temporary, permit to work in the United States. It is granted for a three-year period, renewable for a total of six years, and is only available to individuals in professional occupations requiring "the theoretical and practical application of a body of highly specialized knowledge requiring completion of a specific course of higher education."[1] As noted, the drastic cut in the H-1B quota beginning in fiscal year 2004 represented a marked exogenous change in US job market prospects for college-educated foreign citizens. The H-1B visa cap was never binding in the years immediately preceding the policy change. Thus, foreign citizens with undergraduate degrees faced no legal impediment to working in the US so long as they had received a job offer from an employer upon graduation. After the H-1B visa cap became binding, legal employment became more difficult to secure. The US government began denying H-1B petitions, which generated an incentive for employers to withdraw (or decide against) job offers to foreign candidates and avoid the uncertainty of the visa process. That visa quotas in general reduce US immigrant flows is an already well-established phenomena in the literature.[2] This paper instead assesses how restrictive H-1B policy has affected the average academic quality (or ability) of prospective international students who face reduced US employment opportunity after graduation, including an analysis of how the number of students at each quintile of the ability distribution has changed.

Section 2 begins with a discussion of past literature and motivation. Section 3 turns to our empirical strategy. It provides a simple theory to motivate the empirical analysis, a brief history of H-1B policy and legislation, a discussion of data measurement, and our main regression specification.

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[1]See the US State Department website, http://travel.state.gov/visa/temp/types/types_1271.html
[2]See Mayda (2009) and Clark, Hatton, and Williamson (2007) for recent evidence.

Importantly, college-educated citizens of five key control countries – Australia, Canada, Chile, Mexico, and Singapore – can acquire work permits that are close substitutes for the H-1B visa. Thus, workers from those countries are less bound by H-1B restrictions. This allows us to employ difference-in-difference estimation to identify the effect of current policy on the selection of foreign-student interest in US education.

Section 4 gives the results. We begin with a College Board dataset measuring the SAT scores of international test takers. We find that visa restrictions have reduced SAT scores of prospective students by about 20 points. Log-regressions suggest a loss of 1.5%. The College Board dataset presents a few limitations, however. First, SAT scores are not the only relevant gauge of academic quality used by US college admission offices, and some researchers argue that high school GPAs are a superior measure (Geiser and Santelices 2005, Rask and Tiefenthaler 2009). Though we believe that the use of SAT scores may be more justifiable for international applicants, it is of significant value to test the robustness of our key results to the use of an alternative quality measure. Second, although the College Board provides data on prospective international students, we cannot be sure that all of them actually become college applicants. Finally, the dataset is complicated by timing issues. We cannot precisely identify dates in which students sent SAT score reports, which may be a problem for individuals taking the exam near policy change dates.

We turn to an alternative dataset that allows us to conduct a case-study of applicants to a highly-selective university to address these issues. This dataset provides a measure of standardized high school GPA, includes international applicants only, and is less encumbered by timing issues. Our case study analysis uncovers ability losses comparable in magnitude to those found using College Board data, pointing to the robustness of our findings.

2   Literature and Motivation

In political debate over immigration policy, Americans maintain more favorable attitudes toward highly-educated immigrants compared to less-educated ones. For example, a *CBS News / New York Times* Poll (2007) revealed that 51% of respondents believe US immigration policy should favor people based upon education and job skills – results echoed in a recent paper by Hainmueller and Hiscox (2010). US politicians are now considering a shift in immigration policy toward prioritizing skilled immigrants as evidenced by recent Congressional measures introduced by Senators Lindsey Graham and Charles Schumer.[3] Despite these views, however, immigration among highly-educated workers

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[3] See Preston (2010).

remains controversial. The 2003 policy change regarding the H-1B visa for skilled workers increased restrictions,[4] while economists have highlighted the potential for both positive and negative effects. The economics of highly-educated immigration thus warrants additional attention.

Researchers who focus on the costs of skilled immigration emphasize distributional concerns. Hira (2007), Miano (2007), Stephan and Levin (2007), Borjas (2006), and Borjas (1999) all warn that highly-educated immigrants could reduce employment and wage opportunities for similarly-educated natives. This includes, for example, the proliferation of low-paying postdoc positions now expected of recent science Ph.D. graduates before finding permanent employment. Similarly, Borjas (2007) and Borjas (2002) worry that immigrants alter the educational plans of natives and crowd them out of science and engineering programs within universities.[5]

Even if immigrants are not explicitly crowding-out natives, it is clear that foreign-workers are becoming more prominent in US maths and sciences. Stephan and Levin (2007) quote an American Mathematical Society statistic that 40% of US mathematics jobs in 1995 were awarded to immigrants. Levin et. al. (2004, p. 359) note that while the number of citizen science and engineering doctoral recipients living in the US rose three-fold between 1973-97, the number of non-citizen recipients had grown eight-fold. By 1997, 20% of US scientists were non-citizens at the time of doctoral degree receipt.[6]

More sanguine views of highly-educated immigration focus on the far-reaching macroeconomic effects. Hunt (2009) demonstrates that immigrants are particularly innovative and entrepreneurial. Compared to natives, immigrants are more adept at patenting, licensing their patents, and publishing. This advantage of immigrants over natives is largely explained by educational differences between the two groups (degree and field of study). However, immigrants are more likely to start new companies than natives are, even after controlling for education. Kerr and Lincoln (2008) provide concurring evidence for the innovative gains of highly-educated immigration by focusing specifically on the H-1B program. They argue that H-1B admissions increase Indian, Chinese, and total patenting in cities and firms that are dependent upon highly-educated foreign-born workers. Further evidence for the technology and productivity enhancing effects of highly-educated immigration can be found in Hunt and Gauthier-Loiselle (2009), Stephan and Levin (2007), Chellaraj, Maskus, and Mattoo (2005), and

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[4]The history of H-1B legislation will be detailed in Section 3.2.

[5]Peri and Sparber (2008), in contrast, suggest that comparative advantages among highly-educated native and foreign-born workers should protect natives from competition, and mitigate potential wage losses. Similarly, results in Kerr and Lincoln (2008) suggest that highly-educated workers on H-1B visas do not crowd out natives.

[6]Another concern might be one of brain-drain: origin countries suffer when skilled workers leave. However, recent empirical evidence in Rosenzweig (2006) and simulation results in Mayr and Peri (2009) suggest that origin countries actually benefit from emigration, since emigrants often return home with improved skill sets.

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Borjas (1999).

Freeman (2009) argues that the US's comparative advantage in science and technology is severely threatened by educational trends in the US and abroad. He reports that 29% of the world's college students were enrolled in US schools in 1970, but that figure declined to just 12% in 2006. In the mid 1980s, 37.8% of the world's students studying abroad chose to matriculate in US universities. That number declined to 20% in 2006-07. These declines will hit science and engineering fields particularly hard. Foreigners represented 15% of science and engineering workers with a bachelors degree and a third of those with a doctorate. Of those foreign-born workers, most were educated in the US.[7] Freeman predicts that these trends together imply that wages of skilled US workers will decline, as will the price of US high-tech exports.

A key question surrounding immigration in general and unskilled immigration in particular is what determines the quantity of immigrant flow. Hence, determinants of the quantity of immigrant flows have been relatively well-researched at least since Sjaastad (1962), and gaining popularity after Borjas (1987). Most research employs a cross-section or panel of countries to assess the macroeconomic determinants of the quantity of aggregate migration flows. Mayda (2009), for example, employs a panel of 14 OECD destination countries and shows that pull factors (e.g., high GDP in destination countries) are more important than push factors (low GDP in origin countries) in driving migration decisions. As immigration policy in host countries becomes less restrictive, both push and pull factors become more important. Clark, Hatton, and Williamson (2007) provide a more direct test of the consequences of US immigration policy over 1971-1998. Using a panel of 81 source countries over 28 years, they report (p. 365), "The effects of immigration policy are discernible and have the expected effects... An increase in 10% in the family quota raises immigration from a country by 0.3%. The same proportionate increase in employment visas raise it by 1.4%. A 10% increase in the refugee allowance raises immigration by 0.5%, while the effect of the diversity quota is minimal."

Less work has been done on policy's effect on the quality (as opposed to quantity) of immigrants. For research on skilled immigrants, however, quality issues may be even more important than quantity. Rosenzweig (2006) focuses on the determinants of foreign student flows. To him, students make an interesting case for analysis because student flows are considerably larger than other skill-based flows, while there is no country-specific or total ceiling on student visas. He proposes that students are likely to be particularly motivated by economics – other immigrant groups are often driven by family ties, or in the case of refugees, by political forces. His empirical results support this view. He finds that students immigrate not due to a lack of educational opportunity at home, but rather due to the lure

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[7]See Freeman (2009) Exhibits 1, 7, and 10.

of greater economic prosperity in the US. He concludes by arguing that foreign students go to the US in hopes of permanent employment, even though only a fraction actually remains after graduation.

Chiswick (2000) surveys the empirical literature and offers a theoretical model of migrant selectivity. He argues that migrants are favorably self-selected. If the direct costs of migration rise, or if ability is negatively correlated with the costs of migration, this favorable self-selectivity grows stronger. Chen (2005) provides a short case-study of the quality of masters degree students in a Chinese university and their interest in migrating to the US to continue their education. He finds that potential emigrants were negatively self-selected during a less-restrictive policy regime, but positively selected during a more-restrictive regime. However, he is vague about which policies were in question, and it is not clear that they would have targeted and/or restricted highly-educated workers.

In short, there is little if any disagreement among researchers about whether immigration quotas affect the quantity of immigration flows. On the other hand, researchers are much less unanimous about the effects on the quality of immigrants. For highly-educated immigration, the skills of those who decide to migrate is at least as important as how many workers choose to do so. Sanguine views of immigration are discounted if the quality of the immigrant pool declines, while US higher education might also suffer. We aim to fill this important gap in the literature by providing rigorous evidence on the effects of restrictive immigration policy (reductions in H1-B quotas) on the quality of (potential) skilled immigrants.

3   Empirical Strategy

3.1   Simple Theoretical Model of a Student's Migration Decision

We develop a highly simplified theoretical model of a student's migration decision to better motivate the empirics. Specifically, the model illustrates a possible relationship between H-1B visa policy and the average abilities of foreign applicants to US colleges that ultimately points to a need for rigorous empirical analysis. The intuition of the model is straightforward: Low ability foreign students are unlikely to find attractive US employment even in the absence of visa quotas. Labor policy is irrelevant to their schooling location decisions. Quotas only affect foreign labor that US firms want to hire. Thus, high ability students may be deterred from US education by the decreased probability of finding legal employment after graduating.

Let us assume that a foreign student applies to a US school based solely upon perceived labor market prospects upon graduation. Individual i will apply only if the expected net-benefit (NB_i) of US employment exceeds her reservation wage (R_i) of either studying at home or pursuing her education

in a foreign country other than the US (whichever yields a higher net benefit). Let us further suppose that both the net benefit and reservation wage experience positive but diminishing returns to ability (a_i) – the probability of graduation, the probability of finding employment, and the earnings from employment are all increasing in ability, whereas the costs of migrating decrease in ability.

Next we allow the government to institute a random lottery to allocate a fixed number of work permits $(\bar{v})$ akin to the US government's distribution of H-1B visas. The probability of receiving a visa equals exogenous ρ – we are abstracting away from an endogenous determination of ρ in this highly simplified model.[8]

Finally, if we assume zero migration costs so that net benefit and gross benefit are equal, then foreign student i applies to (or attends) a US university only if $\rho \cdot NB(a_i) > R(a_i)$.[9] Changes in quotas disproportionately affect high ability individuals. Mathematically, this arises because $\frac{d(\rho \cdot NB(a_i))}{d(\rho)d(a_i)} = \frac{d(NB(a_i))}{d(a_i)} > 0$. More intuitively, this might occur for two reasons. First, low-ability immigrants may be unlikely to secure desirable US employment even in the absence of visa restrictions – employment quotas are largely irrelevant. High-ability immigrants, in contrast, have no worry in finding attractive options under free mobility. They face substantially higher risk of unemployment when required to subject themselves to a random lottery, however. Second, high-ability foreign-nationals might simply be more aware of US policy changes. They would alter their college application decisions accordingly, whereas those ignorant of policy developments would exhibit no response.

Figure 1 illustrates the effects of a restrictive policy that shifts $\rho_0 \cdot NB(a_i)$ down to $\rho_1 \cdot NB(a_i)$. The equilibrium and skill-level effects are determined by the relative concavity of $NB(a_i)$ and $R(a_i)$. In Panel A, the net benefit function is more concave than the reservation wage is. Immigrants come from the middle of the ability distribution. Restrictive policy discourages both the highest and lowest ability workers from immigrating. In Panel B, the net benefit function is less concave. Here, immigrants come from the ability tails. Visa limits discourage the weakest of the still very good students from immigrating. It also deters the best of the lower ability students. In both cases, the theoretical effect on the average quality of international applicants to US higher education would require additional assumptions regarding the distribution of individuals across the ability spectrum – Figure 1 simply

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[8] In practice, individuals can enter the H-1B lottery only after receiving a job offer from an employer willing to sponsor an application. If firms are hesitant to subject themselves to a lottery for low ability workers, restrictions could disproportionately affect low ability immigrants. Our empirics uncover no such result, however, so we omit this possibility from the theoretical model.

[9] Though we have assumed that ρ does not affect $R(a_i)$, a relationship could be possible. H-1B statutes offer no preference for individuals who have obtained their undergraduate degrees in the United States versus other countries, and foreign students outside the US might also be hoping to secure US employment. Incorporation of this possibility into the model would not alter its predictions insofar as the probability of obtaining an H-1B visa matters more for foreign students who attend US colleges than for other foreign students, a plausible assumption.

illustrates potential changes in the ability thresholds determining migration decisions.

Though our model is highly stylized, it shows that restrictive immigration policy can affect the average ability of foreign applicants to US higher education, and that the direction of the effect is generally ambiguous. As such, rigorous empirical analysis is needed to better understand the direction and size of the effect of policy.

3.2 History of H-1B Policy

The Immigration Act of 1990 (implemented in 1992) created the H-1B visa for professional foreign nationals seeking temporary employment in the United States. Kapur and McHale (2005) report that 98% of H-1B approvals go to individuals with a bachelors degree or more education. Though government statistics do not record the location of an H-1B recipient's undergraduate degree, Figure 2 offers descriptive cross-country evidence that a 1% rise in undergraduate enrollment is associated with an equivalent rise in H-1B visas issued four years later, controlling for country population size.[10] Given that foreign students study in the US hoping to secure longer-term employment (as evidenced by Rosenzweig (2006), Borjas (2002), Bhagwati and Rao (1999), Chiswick (1999), and others), prospective students should be sensitive to H-1B policy changes.

At the time of its creation, 65,000 H-1B visas became available for new applicants each year. The cap was not reached until fiscal year 1997 and again in 1998. In October of 1998, Congress enacted the American Competitiveness and Workforce Improvement Act (ACWIA), which temporarily raised the cap to 115,000 for fiscal years 1999 and 2000, and to 107,000 for 2001. The 1999 limit was accidentally exceeded by 22,000, an oversight for which the Immigration and Naturalization Service (INS) was ultimately forgiven.[11] The 2000 limit was reached six months prior to the end of the fiscal year. Congress responded to the increase in demand for H-1B visas with the American Competitiveness in the 21st Century Act (AC21) – signed by then-President Clinton in October 2000. The act had two effects. First, it reduced the number of H-1B visas that counted toward the quota by exempting employees of universities, nonprofit research organizations, and governmental research organizations. Second, it raised the cap to 195,000 for each of 2001, 2002, and 2003. Those limits were never reached;

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[10] A simple log-regression of H-1B issuances (in fiscal year 2006) on undergraduate enrollment (in academic year 2001/02) and Population (2002) reveals an elasticity estimate of 1.10 that is significantly different from zero but not from one. More formal results are available upon request. H-1B data is from "Non-immigrant visa issuances by visa class and by nationality" at the US Department of State, http://www.travel.state.gov/visa/frvi/statistics/statistics_4396.html. Enrollment data is from the Institute of International Education Data, "All Places of Origin and By Place of Origin and Academic Level," http://opendoors.iienetwork.org/?p=28633. The World Bank's "World Development Indicators" provides population data.

[11] That is, the US did not revoke visas awarded to individuals in 1999, nor did the 22,000 additional visas count toward the 2000 limit. See US Department of Justice (2000).

only about 78,000 visas counted toward the cap in 2003. AC21 clearly stipulated that without further legislation, the H-1B cap would revert to 65,000 for fiscal year 2004 and beyond. Despite a trend for progressively less restrictive labor laws, Congress did not enact wide-ranging legislation to maintain the high quota. As a result, the H-1B cap has been binding every year since 2004.[12]

We assume that even though high caps were temporary, there was a reasonable expectation of permanence – the trend had been for a rising cap, and the Immigration and Naturalization Service was even forgiven for exceeding the cap in 1999. By Fall 2003, however, it was clear that there would be no renewal. Most international students considering matriculation after that date (i.e., beginning in Fall 2004) would expect limited access to the US labor market. In our research design, potential foreign applicants to US colleges can be seen as having received a "treatment" in Fall of 2003 (that is, an exogenous decline in the expected probability of securing employment in the US upon graduation).

Potential foreign applicants from five key countries were unaffected by this treatment and the H-1B visa cap reduction, however. Specifically free trade agreements have created close H-1B substitutes for citizens from Canada, Mexico, Chile, Singapore, and Australia. First, the North American Free Trade Agreement created the TN visa for professionals from Canada and Mexico.[13] Although the approved list of occupations[14] is more restrictive than the H-1B, each occupation is associated with college-degree holders. There is no limit to the number of TN visas that can be issued. Second, two free trade agreements signed by then-President Bush on September 3, 2003 set aside 1,400 and 5,400 of the annual H-1B visas (called H-1B1) for citizens of Chile and Singapore, respectively. Another bill signed on May 11, 2005 created 10,500 annual E-3 visas for Australian professionals. The caps on H-1B1 and E-3 visas have never been reached. Figure 3 demonstrates that workers from these countries indeed choose alternative routes of entry. TN, H-1B1, and E-3 visas have become more popular throughout the period of binding H-1B limits. Moreover, the percentage of H-1B visas issued to citizens of these countries peaked at 4.7% in fiscal year 2003 and has steadily declined to 2.8% in 2008.[15]

Since workers from Canada, Mexico, Chile, Singapore, and Australia have viable alternatives to

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[12]As we explained above, all we need for our difference-in-difference analysis is the fact that the H-1B cap was not binding prior to 2004 and became binding after 2004. However, it would be of additional interest to gauge the magnitude of excess demand for H-1B visas. Unfortunately it is not possible to measure the quantity of visas demanded after 2004 – the US Citizenship and Immigration Service (USCIS) simply returns applications received after the date on which it has obtained enough petitions to meet the cap.

[13]Canadians do not have to apply for TN or H-1B visas, but must instead simply meet the criteria to qualify as a TN or H-1B type of worker. Hence, only a nominal number of professional visas are issued to Canadians, despite their significant presence in the US labor force.

[14]See NAFTA appendix 1603.D.1, available at http://www.consular.canada.usembassy.gov/nafta_professions.asp.

[15]Data is from "Non-immigrant visa issuances by visa class and by nationality" at the US Department of State, http://www.travel.state.gov/visa/frvi/statistics/statistics_4396.html.

the H-1B visa and face much lesser constraints in entering the US labor force, college-educated workers from those five control countries seeking US employment should be largely unaffected by H-1B policy changes. In terms of research design, foreign applicants from these five countries form a control group, while all other foreign applicants comprise the treatment group. We can therefore use a difference-in-difference approach to estimate the causal effect of the skilled immigration policy change on the pool of foreign students interested in undergraduate US education.

3.3 Student Ability Data

We use SAT scores as a measure of applicant ability despite the recent controversy in doing so. Many university admissions offices stress the importance of alternative criteria to standardized test scores. Rask and Tiefenthaler (2009, p. 1) note that "The chief complaint against the SAT is that it is not the best predictor of college success but is highly correlated with parental education and income." For example, high income students might achieve high scores not through ability, but rather by enrolling in private test preparation classes or through repeated exam attempts. Though Rask and Tiefenthaler find that SAT scores are better able to predict college performance for some demographic groups, the magnitude of the effects is not meaningful.

Geiser and Santelices (2007), like Rask and Tiefenthaler (2009), advocate high school grade point average (GPA) as a preferred measure of ability. They use University of California data to perform a multivariate regression of cumulative four-year college GPA on high school GPA, verbal SAT score, and math SAT score. They find that a one standard deviation increase in high school GPA correlates with a 0.36 standard deviation increase in college GPA. A one standard deviation increase in verbal SAT scores correlates with a 0.23 standard deviation increase in college GPA. Math scores were insignificant. Bound, Hershbein, and Long (2009), Rothstein (2004), and Vigdor and Clotfelter (2003) provide additional SAT critiques.

Nonetheless, most SAT critiques focus on its ability to predict domestic student success (or they choose not to distinguish between domestic and international students in the analysis). The SAT for international students is offered less frequently and in more geographically dispersed areas, which should deter strategic test-taking and multiple testing attempts. Many schools that choose not to require the SAT for domestic applicants still require them for international students, pointing to the college admission offices' continued faith in the exam as a primary tool for assessing and comparing the ability of applicants from diverse countries and grading systems. Thus, we argue that the use of the SAT as a measure of applicant quality is probably more justifiable for international students.

Our primary data source is the College Board, which owns and administers the SAT. This dataset provides a sample of foreign-nationals sending SAT score reports to US colleges and universities. These students might ultimately decide against applying to these schools officially. Hence, score reports provide a measure of the quality of *prospective students* as opposed to actual applicants.[16] This dataset includes a sample of high-school seniors who took the exam outside the United States between November 2000 and March 2008, dropping those who have dual US citizenship or are permanent US residents.[17] A student may take the SAT multiple times, but the data only records the math and verbal scores from the last exam that the student has completed. It also includes demographic information about the student that he/she supplied to the College Board. We do not know the date in which a student requested the exam scores be sent to particular universities, and we assume that they did so at the latest exam date. Each available observation represents a unique score report. Since individual students are likely to send multiple reports from a single exam, the dataset records several observations per student.

We are interested in whether the academic qualifications (SAT scores) of foreign-nationals interested in US education have changed in response to more restrictive H-1B policy. The appropriate methodology is to compare the average scores of reports received by US schools before and after the policy change. Unfortunately, information identifying specific schools is not available since the College Board wishes to preserve institutional privacy. Instead, they attached user-defined school characteristics to the dataset. We know four characteristics: The region of the country in which the school is located (as defined by the Bureau of Economic Analysis); the school's funding source (public or private); school type (e.g., research, liberal arts, etc.); and school tier (or quality). We then define "pseudo-schools" by their type, tier, funding, and region. We aggregate individual score-report information accordingly.

School type and tier characteristics are determined by the *2009 US News and World Report Guide to America's Best Colleges* (*USNWR*). *USNWR* provides a single rank of US colleges and universities that is determined by several criteria including enrollee SAT scores, student/faculty ratio, and academic reputation among peer institutions. It is widely-used by perspective students when choosing a school to attend.[18] The guide ranks institutions within four types: national research universities, national liberal arts colleges, masters-granting universities, and four-year baccalaureate schools. The

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[16]Thomas (2004b, p. 1375) argues that by "Identifying the set of institutions where college-bound students sent their SAT scores remains the most accurate form of revealed preference at the initial stage of the college-decision path."

[17]99% of score reports come from October, November, December, and January exams. The remaining few come from March and April exams that are only available only in select countries.

[18]See Griffith and Rask (2007), Webster (2001), and Monks and Ehrenberg (1999) for studies using *USNWR* and further details about the guide.

ranking structure varies by school type in that the guide ranks masters-granting universities and baccalaureate schools within four geographic regions, whereas research universities and liberal arts colleges are compared nationally. The College Board supplied us with the type and general ranking of schools receiving SAT score reports. For research and liberal arts schools, we know whether a recipient school was ranked in the top 25, between numbers 26-50, between 51-100, other tier 1, tier 3, or tier 4 (there is no explicit tier 2). For the other institutions, we know if they were among the top 10, 11-25, other tier 1, tier 3, or tier 4 within their region. We use this to create a harmonized tier structure. We label research and liberal arts schools in the top 50 as "Top Tier," 51-100 and other tier 1 as "Middle Tier," while tier 3 and 4 schools are "Bottom Tier." For masters and baccalaureate schools, we place the 40 top 10 schools in the Top Tier, the 11-25 and other tier 1 institutions in the Middle Tier, and the remaining schools in the Bottom Tier.[19]

Summary statistics for individual SAT score reports by type and tier of school are provided in Table 1. Table 2 gives aggregate statistics. Average math, verbal, and total SAT scores were 638, 552, and 1190. Higher quality schools receive better SAT score reports, with the best scores generally going to liberal arts colleges.

For reasons discussed in the Introduction, we supplement our analysis of College Board data with a case study of a highly selective college. Specifically, we were given full access to detailed information on each international applicant to this school, including SAT scores, high school GPA, and other personal characteristics. The data are available from 2001 through 2008. As discussed before, the key advantages of this dataset are the use of standardized high school GPAs as an alternative to SAT scores and the focus on actual applicants as opposed to potential applicants.

3.4   Main Regression Specification

Though the theory in Section 3.1 modeled the effects of H-1B visa restrictions on individual decision-making, data limitations do not allow direct empirical estimation of individual behavior. The natural experiment methodology would require observation of an individual's interest in US education both before and after the policy change – information that is clearly unavailable. Instead, we can learn about the collective outcomes of individual decisions by measuring the characteristics of the pool of individuals interested in US education before and after the policy. That is, aggregate regressions are more consistent with the natural experiment methodology than individual-level regressions given the

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[19]Students can and do elect to send reports to non-ranked institutions, such as community colleges and proprietary schools. We choose to focus upon the four school categories ranked in the annual *US News and World Report* survey of colleges.

available data.

To identify the effects of H-1B policy on the abilities of prospective students from abroad, we estimate the simple difference-in-difference model in Equation (1).

$$Score_{s,c,t} = \alpha + \beta \cdot H1B\_Restriction_{s,c,t} + \delta_s + \delta_c + \delta_t + \varepsilon_{s,c,t} \tag{1}$$

The variable *Score* is our primary measure of the academic quality of international applicants, measured by the average math, verbal, or combined SAT score of reports received by pseudo-school s from students who last took the exam in country c at date t. The main coefficient of interest, β, measures the effect of the restrictive H-1B visa policy on the quality of foreign students interested in US education. In our baseline regressions, we assume that students taking the SAT in the month following a policy change are aware of that change, and hence take the immigration policy change into consideration when deciding whether to take the SAT and send their scores to a US school. The variable $H1B\_Restriction$ equals zero for individuals taking the exam on or before October 2003, those from Canada, Chile, Mexico, and Singapore for any year, and those from Australia at all dates except November 2003 through May 2005. The variable equals one for all other observations. This implies that β will be negative if current visa policy has reduced the academic qualifications of foreign students interested in US education.

The vector δ_s controls for time-invariant fixed effects and idiosyncratic features specific to particular schools while δ_c does the same for countries. Also, δ_t represents year effects for the most recent year in which the student took the exam. This controls for global macroeconomic conditions, time-variant fluctuations in the costs and benefits of enrolling in a US college, common trends in test-taking behavior, and possible changes in College Board testing procedures or score-release policy. The error term is represented by $\varepsilon_{s,c,t}$, and regressions weight cells by their inferred number of population score reports.[20]

There are two common threats to the validity of our difference-in-difference methodology. The first concerns the exogeneity of our policy (or treatment) variable. If the ability of foreign students from our five control countries somehow motivated their preferential visa consideration, or if some omitted variable is correlated with the variation of both policy and scores across these two groups, the estimated β cannot be interpreted as causal. These scenarios seem unlikely. The return to a restrictive H-1B visa regime was likely motivated by macroeconomic forces that are accounted for by

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[20]The College Board data is an unweighted sample within academic year, but is weighted across years. Each report in the sample corresponds to between 1.4 and 5.3 reports in the population, depending upon the academic year of observation.

the regression's time dummies. The US experienced a recession between March and November 2001. The unemployment rate of native workers with a bachelor degree rose over 75% from 1.8% in 2000 to 3.2% in 2003 – the minimum and maximum values between 1994 and 2008.[21] Alternative visas set aside for the five control countries were a result of pre-existing or concurrently-negotiated free trade agreements. It is unlikely that removal of these special visas would have been politically feasible. Moreover, we see no plausible story to suggest that free trade agreements and the ability of foreign high school students are related.

A second threat to identification would arise if our treatment and five control countries had experienced differential trends in SAT performance prior to the change in H-1B policy. This would cause our regression to erroneously identify a policy effect that was instead due to differences in pre-policy trend behavior. Fortunately, this limitation does not appear to afflict our model. Between academic years 2000-01 and 2002-03 average SAT scores rose 4% (from 1122 to 1167) for treatment countries that would later face H-1B restrictions. Scores rose a qualitatively equal 3.9% (from 1181 to 1226) for our five control countries. Pre-policy regressions (available upon request) reveal no relationship between the trend in scores received by pseudo-schools and whether scores are coming from treatment or control countries. Altogether, we believe our difference-in-difference strategy remains valid.

4   Results

4.1   Main Results from College Board Data

Baseline results are in Table 3. Results for math scores are in columns (1)-(3), verbal scores are in (4)-(6), and total scores are in (7)-(9). Each regression uses year fixed effects. The first specification for each dependent variable includes origin country plus receiving school fixed effects. Standard errors are clustered by country. The second and third instead use school*country fixed effects with standard errors clustered by this unique identifier.

The estimated coefficients on $H1B\_Restriction_{s,c,t}$ when applicant characteristics are not controlled for are negative and statistically significant at least at the 5% level except when the average SAT verbal score is used as the dependent variable. The size of the estimated coefficients suggests that recent H-1B visa restrictions have reduced the average math SAT score of foreign prospective students by about 8.5 points, verbal scores by about 10 points, and combined scores by 18.5 points.

To see if the results change when we account for applicant characteristics that might be correlated with their academic quality, we add a variety of applicant characteristics as controls. The results are

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[21]Figures are based upon our own calculations from the Current Population Survey, available at King et. al. (2010).

shown in Columns (3), (6), and (9). Added controls include a school's share of applicants who are sure to apply for financial aid, intend to play intercollegiate sports, and who plan to eventually earn an advanced degree. We also include demographic controls for gender, race, and parental education.[22] Reassuringly, the sign and size of the estimated coefficients on $H1B\_Restriction_{s,c,t}$ change little and they continue to be statistically significant (in fact, even more significant than without these controls). The only meaningful change in the size of the coefficients concerns the average verbal score, which rises a bit when the additional controls are used.

Webster (1999) argues that SAT scores of enrolled students were the most important determinant of research universities' *USNWR* rankings in 1999. From his published results, we can infer that a one-point increase in SAT score corresponded to a 0.20 improvement in the rankings.[23] Using the 2009 *USNWR* rankings of national research and liberal arts universities, we find that a one-point rise in SAT scores is associated with a 0.29 improvement in the ranking.[24] If the average score among enrollees were to drop by the same amount as the decline among international prospective students (roughly 20 points), it would be associated with a 4 to 6 place loss in *USNWR* ranking.

Table 4 presents the OLS estimates of Equation (1) but with log-scores as the dependent variables. The results are robust to this alternative specification, suggesting that restrictive H-1B policy caused prospective student scores to drop by a significant 1.4-1.5%.

4.2   Timing Issues in Identifying Average Score Effects

The baseline results of Tables 3 and 4 suggest that US colleges are receiving lower average quality score reports from foreign students as a result of restrictive H-1B visa policy. However, those effects could be subject to a number of timing issues that we consider in this section.

First, we explore potential seasonality in the data. Seasonality could occur, for example, if repeated test attempts result in higher averages than first attempts and are disproportionately represented in particular months. Since our dataset does not identify the number of times an individual has taken the exam, we cannot control for repeated attempts, but we can account for seasonality by controlling for the month and year in which an exam was taken.

The first row of results in columns (1)-(3) of Table 5 repeat the regressions in columns (2), (5), and

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[22]See Thomas (2004a) and (2004b) for variables that predict SAT scores for domestic test-takers.

[23]Webster (1999) uses a sample of 114 research universities. He reports a standard deviation of average SAT scores among enrolled students equal to 129.55. The correlation between scores and school rank is -0.78. If schools are ranked from 1 to 114, the standard deviation of rank would be 33, and the slope coefficient would be -0.20.

[24]As in Webster (1999), this estimate comes from a simple bivariate regression of college rank on the average of first and third quartile SAT scores of enrolled students among institutions reporting SAT scores to *USNWR*. Our regression produces a coefficient of -0.293, standard error of 0.013, and R^2 of 0.74. See Figure 4 for a scatterplot of the data.

(8) of Table 3, but replace year indicators with year-by-month exam date fixed effects. The second row of results does this for the natural log regressions of Table 4. One limitation of this approach is that the SAT is not offered to all countries on all potential exam dates. This approach will also reduce variation in the data and decrease the efficiency of estimates. Nonetheless, this robustness check could be important if visa policy changes were correlated with SAT seasonality.

The results for math SAT scores are strikingly similar to those of baseline regressions. Without seasonality controls (Table 3, Column 2), binding visa policy reduced math scores by 8.5 points. With seasonality controls, the estimate increases to a 9.9 point loss. Both methodologies suggest a 1.2-1.4% decline in math scores when measuring the dependent variable in logs. The effect of policy on verbal scores, by contrast, disappears. This mitigates the total SAT score effect so that restrictive policy reduces scores by 9.8 points (or 0.6%).

The robustness of the results for math scores is especially encouraging. One might argue that math scores are a better measure of foreign student ability, while English verbal scores are likely to be a noisier measure of general intellectual ability. For example, those who happen to grow up in an English speaking environment will probably score high.

Another potential timing issue involves difficulty in identifying the date at which foreign students respond to policy. Baseline results assume that test-takers respond in the *month following* the policy change. Column (4) of Table 5 instead assumes that test-takers respond in the *month of* the policy change, whereas column (5) assumes that people respond *two months after* the policy change. The results do not change much across assumptions, pointing to the robustness of our key result.

Finally, the College Board dataset unfortunately does not measure the date in which a student elects to send a score report to a given school. This is a problem for our results if students who had taken the exam before the policy change then respond to it by selecting a new group of schools to receive reports. Column (6) addresses this issue by assuming that people apply to matriculate to universities in the fall of the year following their SAT date. For example, consider individuals taking the SAT in the 2002-03 academic year. Those taking the exam between September and December of 2002 will be applying for Fall 2003 matriculation, while those taking it from January to June 2003 will be applying for Fall 2004. Policy changes will affect those who have not yet matriculated. Thus, a policy change in October 2003 will affect those who took the exam anytime in 2003, as students who tested in the early part of the year can still respond by sending their score reports to alternative schools. Column (6) indicates that the SAT quality response to H-1B policy is again robust to this timing assumption. The combined score drops by more than 13 points.

4.3   Country Exclusions

Our theoretical and empirical models implicitly assume that US immigration policy does not affect an individual's reservation wage. Estimation of (1) could be biased if US policy dates are correlated with country-specific events or trends. Table 6 explores these potential biases by excluding countries that pose particular concern. The empirical specification is as Column 3 of Table 5 – Regressions are weighted, cluster-robust, and include exam date fixed effects.

Column 1 considers countries bound by H-1B constraints that experienced unique changes during our period of analysis. First, China and India are undergoing rapid economic development. Second, Bulgaria and Romania signed the Treat of Accession to the European Union in April 2005 and formally joined the EU in January 2007. These developments could possibly deter students from considering US education. For China and India, domestic schooling and employment options may be becoming more attractive. For Bulgaria and Romania, the EU now provides less expensive schooling and greater labor market access. Eliminating these four countries from regressions, however, does not affect qualitative results – coefficient estimates are nearly identical to those of Column 3 in Table 5.

Our results are identified by a natural experiment in which the immigration policy change affects all but five key countries. Roughly two-thirds of score reports among control countries come from Canadians, and another quarter come from Singaporeans. Columns 2 and 3 omit score reports sent from citizens of these respective countries. Though this affects magnitudes of the estimated coefficients, the qualitative conclusions remain intact.

South Korea and Australia are among countries that have actively tried to increase recruitment of foreign undergraduate students.[25] Time fixed effects control for increases in competitiveness of world education, and there is little reason to expect that changes in competitiveness should attract students from our control group countries more or less than students from treatment countries. Nonetheless, the regression in Column 4 explores the possibility by omitting Asian and Oceanic countries – that is, countries near South Korea and Australia that could serve as the primary source of their foreign student body. The regressions again continue to confirm that restrictive H-1B policy reduced the quality of potential applicants to US universities.

4.4   Compositional and Demographic Effects

The College Board dataset is rich enough that we can explore a number of additional issues surrounding the effects of the restrictive H-1B policy. First, Table 7 assesses whether the effects differ across type

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[25]See Palmer and Cho (In Press) and Kremmer (2010a and 2010b). Foreign enrollment in Australia has been relatively constant over this period.

and quality of institution. First, policy seems to have been least harmful for research schools, which saw an SAT point drop of just 7.5 points. Liberal Arts and Masters Granting schools, in contrast, saw declines about double that effect. Baccalaureate losses were even larger, though we caution that only 1.6% of score reports are sent to Baccalaureate institutions. Not surprisingly, elite schools are less harmed by policy than middle and bottom tier institutions. In the final set of results, we differentiate top research schools from all others. The general effect of restrictive policy was to reduce SAT scores of potential students by 14 points. Top Research schools mitigated this decline by a significant 8.4, but still suffered losses.

Table 8 explores policy's effect on the demographic composition of potential applicants. These results might be particularly relevant for institutions who use international students to enhance the diversity of their student body. Column (1) considers gender composition – visa restrictions have had no effect. The next four columns explore racial composition. Restrictive H-1B policy has come at the expense of Asian applicants. The share of score reports from international Asian students has decreased by 7.6 percentage points. Whites, in contrast, saw a 5.9 percentage-point increase in applicant share.[26]

Column (6) shows that those intending to continue their education after obtaining a bachelors degree have not been deterred by restrictive H-1B policy. This is not at all surprising, given that their motive for US study is not to enter the US labor force, but rather to pursue an advanced degree. These students would not want or need an H-1B visa to matriculate at a graduate school. Moreover, those with advanced graduate degrees (such as a Ph.D.) who find eventual employment at academic institutions are exempt from H-1B quotas.[27] Finally, column (7) suggests that the policy change has caused foreign demand for financial aid to increase. Foreign applicants, facing a decline in the expected benefit of graduating from US colleges, now find US education relatively more costly. One response has been to demand a price discount in the form of financial aid.

While baseline results effectively established that average ability has declined in response to visa policy restrictions, they are not informative about the parts of the ability distribution most affected. For example, it is of considerable interest to colleges and policy makers whether the observed drop in average ability comes mostly from reduced interest among high-ability students or a rise in applications from low-ability students. To analyze this issue we first divide score reports into quintiles of the ability distribution of the pre-binding policy period (exams taken on or before Spring 2003).[28] We then

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[26]In interpreting these coefficients, recall that regressions already control for country of origin (by school) fixed effects. Thus, racial composition effects are driven by variation of application rates of students within countries.

[27]In addition, professors and researchers sometimes qualify for H-1B alternatives, including the EB-1 visa.

[28]For simplicity, we drop reports for the 1% of exams taken during March and April.

calculate the share (r) of a pseudo-school's reports (R) from country c at time t belonging to each quintile q. That is, $r_{s,c,t,q} = \frac{R_{s,c,t,q}}{R_{s,c,t}}$, where $R_{s,c,t} = \sum_{q=1}^{5} R_{s,c,t,q}$.

The first row of Table 9 displays the results for a regression of $r_{s,c,t,q}$ on the policy variable and our usual array of fixed effects for each quintile.[29] The effects are particularly severe at the tails of the ability distribution – restrictive immigration policy deters the weakest and strongest students from sending score reports to US schools. The proportion of lowest-ability score reports declined 3.2 percentage points, while the proportion of highest-ability reports dropped 1.8 percentage points. Both results are consistent with the theory illustrated in Figure 1a. Most importantly, our finding that the policy change caused the proportion of lowest-ability score reports to fall rather than to rise rejects the hypothesis that the observed drop in average ability comes mostly from the proliferation of weak applications. The falling average appears to be attributable to the decline in interest among high-ability students – a result that is especially worrisome from a policy-maker point of view.

We check the robustness of this result by considering an alternative specification. We replace the denominator of our dependent variable $(r_{s,c,t,q})$ with $\bar{R}_{s,c}$ – the average number of score reports received by school s from country c in a given time period. Since this value is fixed across time, it is robust to any possible effect of restrictive policy on the total number of score reports sent. All estimated effects of the policy change would occur through the number of reports sent at a given quintile. The second row of results in Table 9 reports the effects of this alternative specification. They confirm that restrictive policy is deterring both the lowest and highest-ability foreign students from applying to US universities.

We interpret our results as evidence that restrictive policy is decreasing the average quality of potential international applicants to US colleges and universities. Since students can send score reports to multiple schools, however, an alternative interpretation is possible – policy might be affecting the number of reports that students send (the intensive margin), not their interest in studying in the US per se (the extensive margin). If policy's effect on the intensive margin differs between high-ability and low-ability applicants, then this heterogeneity can generate our results.

To study the plausibility of this alternative interpretation, we first examined the average number of reports sent by international students over time. We found that international students send an average of about four reports to US schools and that this number is quite stable over time. More importantly, we found no evidence that the distribution of the average number of SAT score submissions changed significantly for the treatment group when compared to the control group following the policy change.

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[29]Regressions continue to cluster on school*country cells, but are not weighted by the total number of score reports received since this value now appears in the dependent variable.

As such, we believe that our regression results are picking up the policy effect on the extensive rather than the intensive margin.

4.5 Case Study

The College Board data presents three problems. First, it provides only one measure of ability – SAT scores – which some researchers consider an inferior measure of applicant ability as compared to high school GPA (though these critiques are usually aimed at evaluations of domestic applicants). Second, the College Board data cannot be strictly interpreted as a sample of foreign *applicants*, but is rather a sample of foreign *prospective* applicants. This is because it includes both applicants and those who sent SAT scores to US schools but later declined to submit a formal and complete application. We cannot distinguish between these two groups of individuals in the College Board data. Third, results may be confounded by remaining timing issues including the challenge of precisely identifying the dates in which individual behavior would respond to a policy change.

Our second dataset is assembled to account for these three problems. It includes every foreign-national officially applying to matriculate at a particular highly-selective university between Fall 2001 and Fall 2008.[30] The use of the applicant data (as opposed to the College Board's prospective student data) reduces ambiguity surrounding the timing of international applicants' awareness of H-1B policy changes since students should be aware of the current policy at the time of application submission.[31] Finally, the dataset also includes a measure of high school GPA. Raw GPAs would be greatly confounded by grading system differences across countries. Fortunately, this university's admissions office – using their long experience with overseas high schools – resolved this issue by converting raw values into an internationally comparable GPA measured on a four point scale. Values therefore represent GPAs that this university uses to evaluate international applicants.

Our regression methodology is similar to the specification in (1). The dependent variables now reflect the average abilities of applicants to this particular university. Observations vary by country of origin (c) and year of application (t). The model includes both country and year fixed effects but obviously omits institutional controls. Regressions weight observations by the total number of applicants from country c at year t, and standard errors are clustered by country. For the policy variable, we now assume that students perceived H-1B policy to be non-binding if they applied to

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[30] As in the case of the College Board data, we drop individuals who have dual US citizenship or are permanent US residents.

[31] For example, we assume that all international students applying to matriculate in Fall 2004 did so with awareness of the H-1B policy change in October 2003. Although some applications were received in late summer 2003, the application deadline was in January 2004.

enter college before 2004, if they applied from Canada, Chile, Mexico, and Singapore in any year, or if they were Australian applying to enter college in any year except 2004.

Table 10 provides results for dependent variables measured in both levels and logs. As in the prospective applicant regressions controlling for seasonality, the policy effects are again most prominent for math scores. Column (1) demonstrates that the math SAT scores of applicants from countries subject to binding H-1B constraints have declined by 13 points relative to the scores among applicants from countries who have H-1B alternatives. Measured in logs, this suggests a 2.2% decline in average ability of international applicants. For overall SAT scores, in contrast, the estimate is negative but not statistically different from zero. This may be due to sample size, which is much smaller than with the College Board dataset. It is worth emphasizing that the point estimates of the total score penalty in percentage terms is quite similar in the two samples. For prospective international applicants, H-1B restrictions reduced total scores by about 1.5%. For this university's actual applicants, scores reduced by 1.2%.

Perhaps most importantly, Column (4) presents the results using high school GPA. We again see evidence that restrictive H-1B policy is reducing the quality of international applicants. The average GPA of international applicants at this university declined by 0.09 points, or 2.8% when measured in logs – a magnitude higher than that of any of the SAT regressions. The estimated effects on average GPA of restrictive H-1B policy are statistically significant at the 5% level.

5   Conclusion

To our knowledge, this paper is the first to provide rigorous evidence on the effects of restrictive immigration policy on the quality of international applicants to US tertiary education. The analysis employed two datasets: (i) College Board data on the SAT scores of prospective students; and (ii) SAT and GPA data on a highly-selective university's foreign-applicants. Both cases generate robust evidence that restrictive skilled-immigration policy has had an unintended adverse effect on US higher education by reducing the average ability (or quality) of potential foreign students.

Unfortunately, the lack of adequate data on foreign-born matriculates prevents us from further investigating to what extent the weakened pool of foreign applicants will translate into lower quality foreign-born graduates, but the potential costs to the US economy may be non-trivial. Many US colleges and universities benefit from the presence of high-quality international students directly and indirectly. For example, classroom experience for domestic students is often enriched by the presence of well-motivated and well-prepared international students who provide diversity. Universities and

their students therefore suffer an immediate welfare loss due to restrictive immigration policy.

The US could face even more important macroeconomic consequences. Many international students continue to work in the US after graduation. Such individuals have proven to be especially effective in innovative and entrepreneurial activity, boosting aggregate productivity. With lower ability individuals seeking entry into the US, the country may ultimately sacrifice those aggregate gains.

Given recent political developments in public opinion regarding highly-educated immigrants, it is increasingly important to design policy to maximize the benefit of skill-based immigration. By providing evidence on a potentially serious adverse effect of current H-1B immigration restrictions, this paper points to a need for reassessment of current policy.

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Table 1: Average SAT Scores of Potential International Applicants by Type and Tier of School

Harmonized Tier		Top Tier			Middle Tier			Bottom Tier	
Within-Type Tier		Top 10	Top 25	26 to 50	11 to 25	51 to 100	Other Tier 1	Tier 3	Tier 4
Research	Mean		1280	1200		1128	1084	1055	1010
	Std Dev		161	162		163	172	175	176
	Obs		38061	17404		13638	3696	3452	2909
Liberal Arts	Mean		1260	1216		1143	1129	1081	970
	Std Dev		157	157		164	167	172	201
	Obs		7940	3603		2027	628	769	363
Masters	Mean	1099			1054		1034	1002	1012
	Std Dev	160			174		178	182	193
	Obs	2694			1359		3014	1821	1133
Baccalaureate	Mean	1076			1016		966	1017	952
	Std Dev	196			179		194	188	209
	Obs	491			302		338	232	317

Note: Summary statistics of individual score reports sent by international SAT test-takers in academic years 2000-01 through 2007-08. Source: College Board sample data.

Table2: Descriptive Statistics, College Board SAT Data

Variable	Obsservations	Mean	Std. Dev.	Min	Max
SAT Math Score	106191	638	110	200	800
SAT Verbal Score	106191	552	106	200	800
SAT Total Score	106191	1190	189	410	1600
Female	106180	0.466	0.499	0	1
Intends to Play Intercollegiate Sports	106191	0.289	0.453	0	1
Sure to Apply for Aid	96293	0.601	0.490	0	1
Ultimately Wants Advanced Degree	95410	0.735	0.442	0	1
Bound by H-1B Visa Cap	106191	0.526	0.499	0	1
Asian	100924	0.490	0.500	0	1
Black	100924	0.097	0.295	0	1
Hispanic	100924	0.074	0.262	0	1
Other Non-White Race	100924	0.118	0.323	0	1
White	100924	0.221	0.415	0	1
Mother's Edu: Less than High School Degree	91777	0.062	0.241	0	1
Mother's Edu: HS Diploma	91777	0.121	0.326	0	1
Mother's Edu: Business School	91777	0.025	0.158	0	1
Mother's Edu: Some College or Assoc. Degree	91777	0.141	0.348	0	1
Mother's Edu: Bachelor's Degree	91777	0.356	0.479	0	1
Mother's Edu: Graduate Degree	91777	0.295	0.456	0	1
Father's Edu: Less than High School Degree	91652	0.046	0.209	0	1
Father's Edu: HS Diploma	91652	0.065	0.246	0	1
Father's Edu: Business School	91652	0.031	0.173	0	1
Father's Edu: Some College or Assoc. Degree	91652	0.085	0.279	0	1
Father's Edu: Bachelor's Degree	91652	0.318	0.466	0	1
Father's Edu: Graduate Degree	91652	0.455	0.498	0	1
Research University	106191	0.745	0.436	0	1
Liberal Arts College	106191	0.144	0.351	0	1
Masters-Granting University	106191	0.094	0.292	0	1
Baccalaureate School	106191	0.016	0.125	0	1
College Rank: Top Tier (Harmonized)	106191	0.661	0.473	0	1
College Rank: Middle Tier (Harmonized)	106191	0.235	0.424	0	1
College Rank: Bottom Tier (Harmonized)	106191	0.104	0.305	0	1
Private University	106191	0.694	0.461	0	1
College Location: New England	106191	0.223	0.416	0	1
College Location: Middle Atlantic	106191	0.282	0.450	0	1
College Location: Great Lakes	106191	0.127	0.333	0	1
College Location: Plains State	106191	0.035	0.184	0	1
College Location: Southeast	106191	0.132	0.339	0	1
College Location: Southwest	106191	0.038	0.191	0	1
College Location: Rocky Mountain	106191	0.008	0.089	0	1
College Location: Far West	106191	0.155	0.362	0	1

Note: Summary statistics of individual score reports sent by international SAT test-takers in academic years 2000-01 through 2007-08. Source: College Board sample data.

Table 3: Baseline Results, College Board Data

Dependent Variable:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Math SAT Score			*Verbal SAT Score*			*Total SAT Score*		
Bound by H-1B Visa Cap	-8.503	-8.408	-7.617	-10.007	-9.840	-12.325	-18.510	-18.248	-19.942
	(4.229)**	(2.173)***	(1.840)***	(7.010)	(2.381)***	(2.244)***	(6.200)***	(3.230)***	(3.109)***
% Sure to Apply for Aid			13.644			14.384			28.029
			(1.570)***			(1.880)***			(2.861)***
% Intent to Play Intercollegiate Sports			0.348			-7.448			-7.100
			(1.662)			(1.733)***			(2.897)**
% Female			-26.337			3.897			-22.439
			(1.539)***			(1.687)**			(2.688)***
% Asian			47.155			-22.539			24.616
			(3.147)***			(3.730)***			(5.575)***
% Black			-19.716			-30.511			-50.227
			(4.686)***			(4.248)***			(7.925)***
% Hispanic			-25.339			-24.383			-49.722
			(4.629)***			(4.495)***			(7.822)***
% Other Non-White Race			2.078			-26.713			-24.635
			(3.400)			(3.599)***			(6.010)***
% Ultimately Wants Advanced Degree			17.592			17.308			34.900
			(1.680)***			(1.856)***			(3.029)***
Mother's Edu: % HS DIPLOMA			-7.149			13.395			6.246
			(3.616)**			(4.399)***			(6.891)
Mother's Edu: % BUSINESS SCHOOL			-16.993			18.339			1.345
			(5.133)***			(5.810)***			(9.532)
Mother's Edu: % SOME COLLEGE or ASSOC			-3.355			17.518			14.163
			(3.448)			(4.488)***			(6.641)**
Mother's Edu: % BACHELORS DEGREE or SOME GRAD			2.769			27.635			30.404
			(3.246)			(4.118)***			(6.182)***
Mother's Edu: % GRAD DEGREE			2.503			29.630			32.133
			(3.519)			(4.364)***			(6.650)***
Father's Edu: % HS DIPLOMA			1.712			0.725			2.438
			(4.048)			(4.886)			(7.748)
Father's Edu: % BUSINESS SCHOOL			1.270			20.126			21.396
			(4.786)			(5.763)***			(8.875)**
Father's Edu: % SOME COLLEGE or ASSOC			10.280			8.470			18.750
			(3.915)***			(4.692)*			(7.376)**
Father's Edu: % BACHELORS DEGREE or SOME GRAD			22.387			21.574			43.961
			(3.598)***			(4.273)***			(6.685)***
Father's Edu: % GRAD DEGREE			25.834			38.254			64.088
			(3.593)***			(4.184)***			(6.597)***
Additional Fixed Effects:	Year School Country	Year School*Country		Year School Country	Year School*Country		Year School Country	Year School*Country	
Observations	36218	36218	30797	36218	36218	30797	36218	36218	30797
R-squared	0.58	0.68	0.72	0.4	0.52	0.56	0.54	0.64	0.69
Robust standard errors in parentheses									
* significant at 10%; ** significant at 5%; *** significant at 1%									

Note: Unit of observation is pseudo-school*country-of-origin*year. Regressions are weighted by population number of score reports. Standard errors are clustered by pseudo-school*country-of-origin cells.

Table 4: Baseline Results, Dependent Variables Measured in Logs

Dependent Variable:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	ln(Math SAT Score)			*ln(Verbal SAT Score)*			*ln(Total SAT Score)*		
Bound by H-1B Visa Cap	-0.012	-0.012	-0.011	-0.016	-0.016	-0.021	-0.014	-0.014	-0.015
	(0.007)*	(0.003)***	(0.003)***	(0.014)	(0.004)***	(0.004)***	(0.006)**	(0.003)***	(0.003)***
% Sure to Apply for Aid			0.023			0.027			0.024
			(0.003)***			(0.004)***			(0.003)***
% Intent to Play Intercollegiate Sports			0.001			-0.012			-0.005
			(0.003)			(0.003)***			(0.003)**
% Female			-0.044			0.008			-0.019
			(0.003)***			(0.003)***			(0.002)***
% Asian			0.075			-0.043			0.021
			(0.005)***			(0.007)***			(0.005)***
% Black			-0.039			-0.058			-0.047
			(0.009)***			(0.008)***			(0.007)***
% Hispanic			-0.044			-0.044			-0.044
			(0.008)***			(0.009)***			(0.007)***
% Other Non-White Race			0.000			-0.051			-0.023
			(0.006)			(0.007)***			(0.005)***
% Ultimately Wants Advanced Degree			0.030			0.033			0.032
			(0.003)***			(0.004)***			(0.003)***
Mother's Edu: % HS DIPLOMA			-0.011			0.028			0.007
			(0.006)*			(0.009)***			(0.006)
Mother's Edu: % BUSINESS SCHOOL			-0.028			0.035			0.000
			(0.009)***			(0.012)***			(0.009)
Mother's Edu: % SOME COLLEGE or ASSOC			-0.004			0.034			0.014
			(0.006)			(0.009)***			(0.006)**
Mother's Edu: % BACHELORS DEGREE or SOME GRAD			0.005			0.054			0.027
			(0.006)			(0.008)***			(0.006)***
Mother's Edu: % GRAD DEGREE			0.005			0.057			0.029
			(0.006)			(0.009)***			(0.006)***
Father's Edu: % HS DIPLOMA			0.005			-0.001			0.004
			(0.008)			(0.010)			(0.007)
Father's Edu: % BUSINESS SCHOOL			0.005			0.037			0.020
			(0.009)			(0.011)***			(0.008)**
Father's Edu: % SOME COLLEGE or ASSOC			0.020			0.014			0.018
			(0.007)***			(0.009)			(0.007)***
Father's Edu: % BACHELORS DEGREE or SOME GRAD			0.043			0.042			0.043
			(0.007)***			(0.008)***			(0.006)***
Father's Edu: % GRAD DEGREE			0.048			0.073			0.060
			(0.007)***			(0.008)***			(0.006)***
Additional Fixed Effects:	Year School Country	Year School*Country		Year School Country	Year School*Country		Year School Country	Year School*Country	
Observations	36218	36218	30797	36218	36218	30797	36218	36218	30797
R-squared	0.57	0.67	0.72	0.4	0.53	0.57	0.54	0.65	0.69
Robust standard errors in parentheses									
* significant at 10%; ** significant at 5%; *** significant at 1%									

Note: Unit of observation is pseudo-school*country-of-origin*year. Regressions are weighted by population number of score reports. Standard errors are clustered by pseudo-school*country-of-origin cells.

Table 5: Timing of Policy and SAT Score Response, Varied Approaches

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable:	*Math*	*Verbal*		*Average SAT Score*		
Bound by H-1B Visa Cap	-9.908	0.105	-9.804	-15.932	-9.583	-13.652
	(2.313)***	(2.675)	(3.638)***	(4.017)***	(3.509)***	(3.950)***
Observations	36218	36218	36218	36218	36218	36218
R-Squared	0.69	0.57	0.67	0.67	0.67	0.67
Dependent Variable:	*ln(Math)*	*ln(Verbal)*		*ln(Average SAT Score)*		
Bound by H-1B Visa Cap	-0.014	0.003	-0.006	-0.011	-0.006	-0.009
	(0.004)***	(0.005)	(0.003)**	(0.003)***	(0.003)**	(0.003)***
Observations	36218	36218	36218	36218	36218	36218
R-Squared	0.68	0.57	0.67	0.67	0.67	0.67
Robust standard errors in parentheses						
* significant at 10%; ** significant at 5%; *** significant at 1%						
Fixed Effects: SAT Date, School*Country						

Note: Unit of observation is pseudo-school*country-of-origin*year. Regressions are weighted by population number of score reports. Standard errors are clustered by pseudo-school*country-of-origin cells. Estimates assume different dates for individual responses to announced policy changes as described in the text.

Table 6: Results When Excluding Potential Outlying Countries

	(1)	(2)	(3)	(4)
Excluded Countries:	China, India, Bulgaria, Romania	Canada	Singapore	Asian & Oceanic Countries
Dependent Variable:	*Average SAT Score*			
Bound by H-1B Visa Cap	-9.553	-14.958	-7.735	-11.204
	(3.856)**	(4.953)***	(4.229)*	(4.943)**
Observations	32331	33844	35341	20789
R-Squared	0.67	0.66	0.65	0.67
Dependent Variable:	*ln(Average SAT Score)*			
Bound by H-1B Visa Cap	-0.006	-0.010	-0.005	-0.007
	(0.003)*	(0.004)**	(0.004)	(0.004)*
Observations	32331	33844	35341	20789
R-Squared	0.67	0.66	0.66	0.66
Robust standard errors in parentheses				
* significant at 10%; ** significant at 5%; *** significant at 1%				
Fixed Effects: SAT Date, School*Country				

Note: Unit of observation is pseudo-school*country-of-origin*year. Regressions are weighted by population number of score reports. Standard errors are clustered by pseudo-school*country-of-origin cells. Estimates assume different dates for individual responses to announced policy changes as described in the text.

Table 7: Results by College Type & Tier

Type & Tier Specific Coefficients on Binding H-1B Policy					
Dependent Variable: Average SAT Score					
School Type		*School Tier*		*School Type & Tier*	
Research	-7.537	Top	-8.466	General Effect	-14.061
	(3.897)*		(4.047)**		(3.957)***
Liberal Arts	-16.547	Middle	-13.165	Differential for Top Research Schools	8.411
	(5.389)***		(4.958)***		(4.205)**
Masters	-14.371	Bottom	-10.670		
	(7.006)**		(6.539)		
Baccalaureate	-23.813				
	(13.787)*				
Observations	36218	Observations	36218	Observations	36218
R-Squared	0.67	R-Squared	0.67	R-Squared	0.67
Robust standard errors in parentheses					
* significant at 10%; ** significant at 5%; *** significant at 1%					
Fixed Effects: SAT Date, School*Country					

Note: Unit of observation is pseudo-school*country-of-origin*year. Regressions are weighted by population number of score reports. Standard errors are clustered by pseudo-school*country-of-origin cells. Estimates assume different dates for individual responses to announced policy changes as described in the text.

Table 8: Effect of Restrictive H-1B Policy on Demographic Composition of Prospective International Students

Dependent Variable:	(1) % Female	(2) % Asian	(3) % Black	(4) % Hispanic	(5) % White	(6) % Sure to Pursue Advanced Degree	(7) % Sure to Apply for Aid
Bound by H-1B Visa Cap	0.005	-0.076	-0.001	-0.003	0.059	0.084	0.044
	(0.011)	(0.014)***	(0.004)	(0.003)	(0.014)***	(0.017)***	(0.012)***
Observations	36213	35226	35226	35226	35226	33763	34079
R2	0.31	0.79	0.79	0.82	0.76	0.30	0.44
Robust standard errors in parentheses							
* significant at 10%; ** significant at 5%; *** significant at 1%							
Fixed Effects: SAT Date, School*Country							

Note: Unit of observation is pseudo-school*country-of-origin*year. Regressions are weighted by population number of score reports. Standard errors are clustered by pseudo-school*country-of-origin cells.

Table 9: Effects of Restrictive H-1B Policy by Quintile of the International Student Ability Distribution

Quintile:	Bottom	2nd	Middle	4th	Top
(SAT Score Range)	(400 - 1000)	(1010 - 1120)	(1130 - 1220)	(1230 - 1320)	(1330-1600)
Dependent Variable:		*Share of SAT Score Reports*			
Bound by H-1B Visa Cap	-0.032	0.018	-0.008	0.040	-0.018
	(0.013)**	(0.013)	(0.014)	(0.012)***	(0.011)*
R-Squared	0.44	0.30	0.26	0.27	0.36
Dependent Variable:		*Share of Average SAT Score Reports Received Over Time*			
Bound by H-1B Visa Cap	-0.065	0.016	-0.018	-0.002	-0.038
	(0.015)***	(0.015)	(0.015)	(0.013)	(0.013)***
R-Squared	0.41	0.29	0.26	0.26	0.32
Robust standard errors in parentheses					
* significant at 10%; ** significant at 5%; *** significant at 1%					
Fixed Effects: SAT Date, School*Country					
Observations: 36139					

Note: Unit of observation is pseudo-school*country-of-origin*year. Dependent variable "Share of SAT Score Reports" measures the proportion of score reports received by a school *s* from citizens of country *c* at time *t* by each quintile of the international student ability distribution (as determined in the pre-binding policy period). Dependent variable "Share of Average SAT Reports Received Over Time" measures the number of score reports received by a school *s* from citizens of country *c* at time *t* by each quintile of the international student ability distribution, normalized by the average total number of reports received by *s* from *c* across time. More details are available in the text. Standard errors are clustered by pseudo-school*country-of-origin cells.

Table 10: Case Study of Applicants to a Highly-Selective University

	(1)	(2)	(3)	(4)
Dependent Variable:	*Math SAT*	*Verbal SAT*	*Math + Verbal*	*High School GPA*
	Dependent Variable Measured in Levels			
Bound by H-1B Visa Cap	-13.284	-0.481	-13.765	-0.093
	(4.992)***	(6.396)	(10.454)	(0.038)**
Observations	612	612	612	612
R-squared	0.85	0.65	0.75	0.68
	Dependent Variable Measured in Logs			
Bound by H-1B Visa Cap	-0.022	0	-0.012	-0.028
	(0.008)***	(0.011)	(0.008)	(0.012)**
Observations	612	612	612	612
R-squared	0.84	0.64	0.73	0.65

Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
Fixed Effects: Country and Academic Year
Constant and Other Coefficients Suppressed

Note: Unit of observation is country-of-origin*year. Regressions are weighted by number of applicants. Standard errors are clustered by country of origin.

$NB(a_i), R(a_i)$

$R(a_i)$

$\rho^0 \cdot NB(a_i)$

$\rho^1 \cdot NB(a_i)$

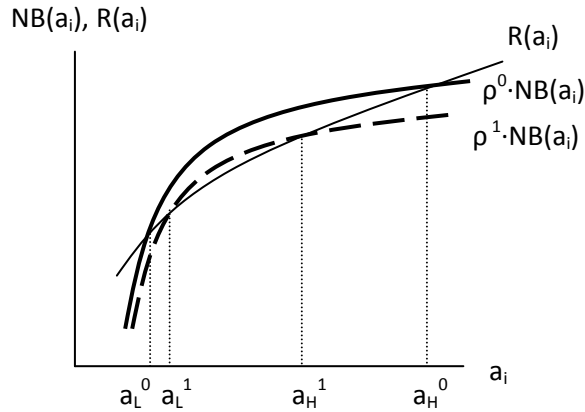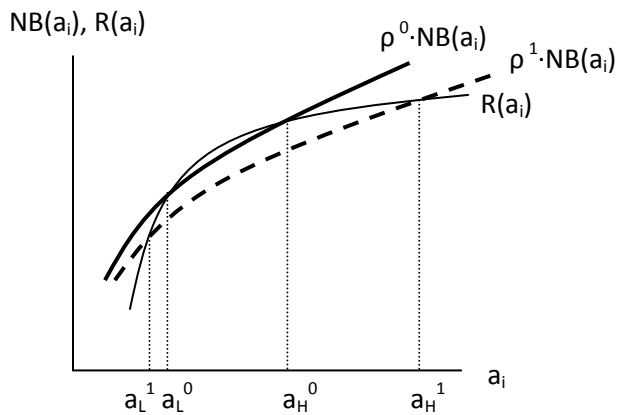a_i

a_L^0 a_L^1 a_H^1 a_H^0

Figure 1a: The Net Benefit is More Concave than the Reservation Wage. Immigration policy becomes more restrictive, reducing the probability of finding employment from ρ^0 to ρ^1. This reduces ability groups who would immigrate from $a_H^0 < a_i < a_L^0$ to $a_H^1 < a_i < a_L^1$.

$NB(a_i), R(a_i)$

$\rho^0 \cdot NB(a_i)$

$\rho^1 \cdot NB(a_i)$

$R(a_i)$

a_i

a_L^1 a_L^0 a_H^0 a_H^1

Figure 1b: The Net Benefit is Less Concave than the Reservation Wage. Immigration policy becomes more restrictive, reducing the probability of finding employment from ρ^0 to ρ^1. This reduces ability groups who would immigrate from $a_i < a_L^0$ and $a_i > a_H^0$ to $a_i < a_L^1$ and $a_i > a_H^1$.

**Figure 2: H-1B Issuances and Undergraduate Enrollment**
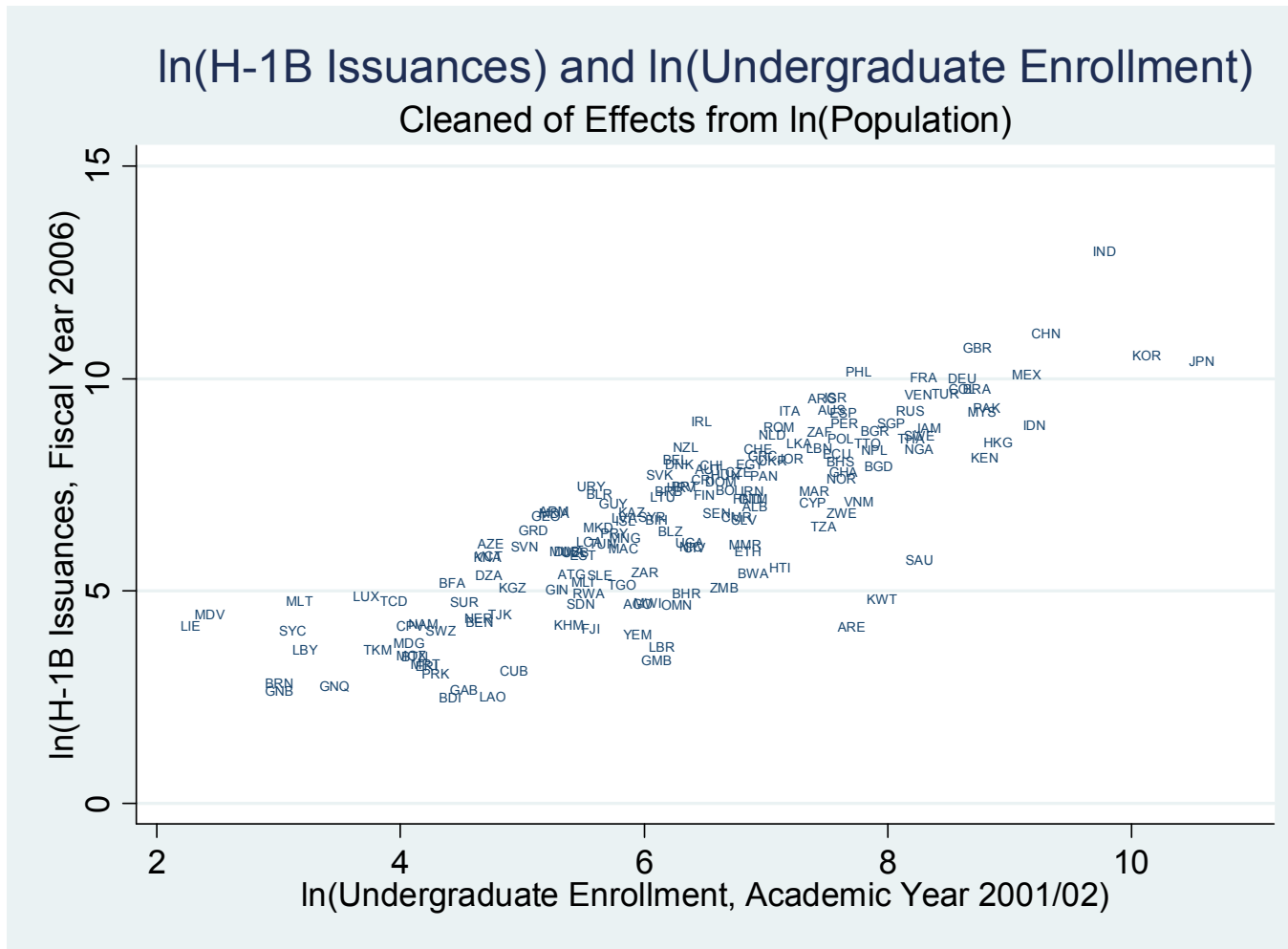
Note: Graph displays predicted values and residuals of H-1B Issuances (in Fiscal Year 2006) for a cross-country regression on Undergraduate Enrollment (Academic Year 2001/02) and Population (2002), all measured in logs. Regression omits Canada since its citizens only need to meet H-1B (or TN) criteria but do not require an actual visa.

Figure 3: Visa Issuances
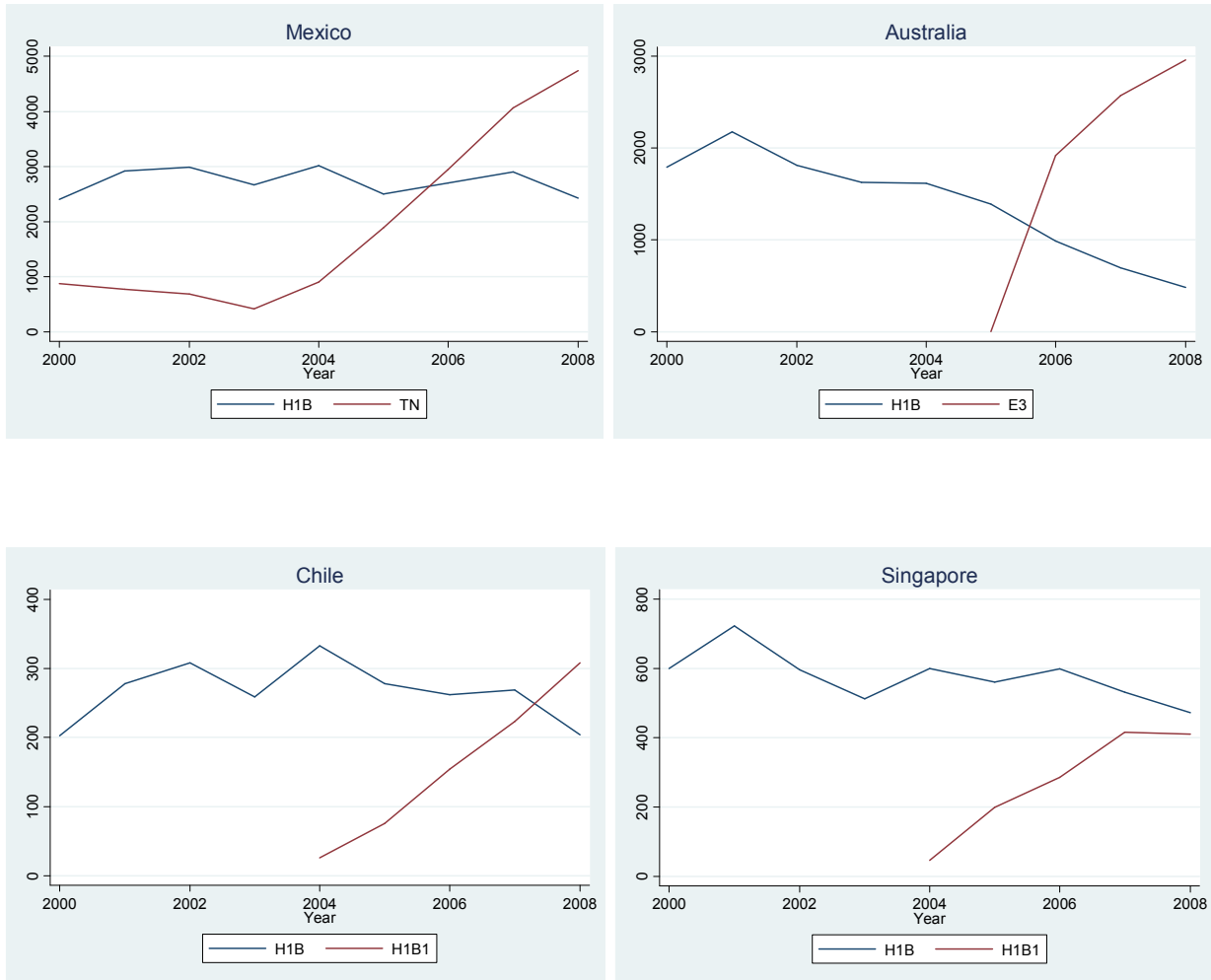
Note: Charts describe the number of new visa issuances by type and country since 2000 (Source US State Department). College-educated citizens from Canada, Mexico, Australia, Chile, and Singapore have viable alternatives to the H1B visa. Canadian citizens do not require H-1B or TN visas to work in the United States, but do need to meet H-1B or TN criteria.

Figure 4: Average SAT Scores of Enrollees and College Rank
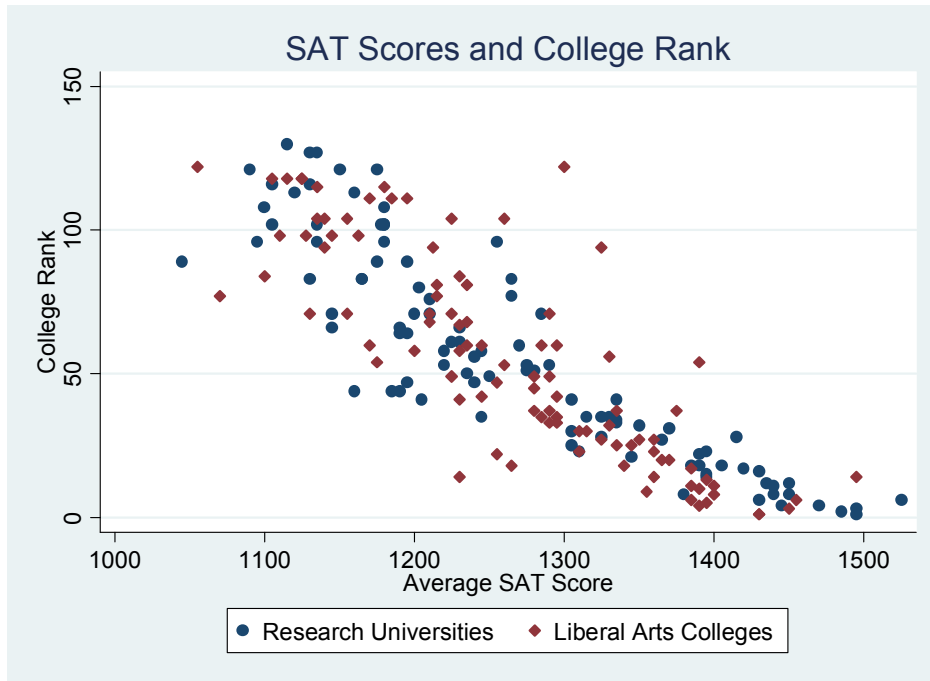
Note: Scatterplot records the average of the 1st and 3rd quartile SAT scores of enrolled students and the *2009 US News and World Reports America's Best Colleges* rank of 195 national research universities and liberal arts colleges. A bivariate regression would produce a coefficient on Average SAT Score of -0.293 and an R^2 of 0.74.