

The Contribution of Foreign Master's Students to US Start-Ups*

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Abstract

This paper estimates the causal effect of international student enrollment in US Master's programs on start-up creation in the United States over the period 1999–2019. Using university-cohort data linked to administrative enrollment records and comprehensive start-up data, we exploit two complementary sources of plausibly exogenous variation in international enrollment: tuition changes and pre-2004 enrollment networks. We find that higher international enrollment significantly increases start-up formation within five years of graduation. A substantial share of this effect operates through spillovers to US-born graduates educated alongside international students. These indirect effects suggest that prior estimates understate the contribution of international students to entrepreneurial activity in the US.

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1 Introduction

Innovation is a central driver of long-run economic productivity, and new firm creation plays a fundamental role in diffusing technologies and ideas. In the United States, start-ups contribute substantially to employment, real output, and productivity growth (Haltiwanger et al. 2016) and are more likely than incumbents to commercialize high-potential innovations (Kolev et al. 2022). Immigrants are significantly overrepresented among entrepreneurs and founders of innovative firms, contributing more than proportionally to the dynamism of U.S. businesses (Azoulay et al. 2022; Amornsiripanitch et al. 2023).

The existing evidence is largely descriptive, focusing on the likelihood that immigrants create new firms relative to natives. This approach captures immigrants’ direct contribution to firm creation but remains silent on general equilibrium effects, including potential spillovers to the entrepreneurial activity of native peers. Most studies therefore miss an important share of the overall contribution of foreigners to start-up formation and innovation. This gap matters given evidence of sizable positive spillovers in entrepreneurship (Anelli et al. (2023)) and findings that firm creation benefits from innovative local environments (Baker & Welter (2024)), suggesting that entrepreneurial ideas cross-fertilize across individuals.

A significant share of foreign-born entrepreneurs in the United States first entered as international students, particularly through graduate programs that serve as gateways to the U.S. innovation system (Hunt 2011; Amornsiripanitch et al. 2023). Since many U.S.-born entrepreneurs are also university graduates, graduate programs constitute fertile ground where future entrepreneurs from diverse backgrounds interact, exchange ideas, develop entrepreneurial attitudes, and form collaborative networks. Exposure to international peers during graduate education may therefore shape the entrepreneurial activity of U.S.-born students in ways that persist well after graduation, even when international graduates subsequently leave the country (Beine, Peri & Raux 2023).

In this paper, we estimate the causal effect of international student enrollment in U.S. Master’s programs on start-up formation by graduates within five years of completing their degree. We identify this effect using two distinct sources of plausibly exogenous variation in international enrollment across university cohorts. Our empirical design distinguishes between start-ups founded by international graduates and those founded by (likely) U.S.-born graduates from the same cohorts, enabling us to estimate both direct and spillover effects of foreign enrollment. We find that greater international enrollment significantly increases start-up formation overall, with roughly one-third to two-thirds of this effect operating through spillovers to U.S.-born classmates. These findings suggest that prior work focused solely on foreign-born entrepreneurs has significantly understated the overall contribution of international students to U.S. entrepreneurship.

A central empirical challenge in studying the link between higher education and entrepreneurship is tracking graduates over their careers to observe both their university affiliation and subsequent firm formation. Standard survey data typically lack precise information on the institution attended by founders of new firms or provide limited coverage of entrepreneurial outcomes of individuals, hindering systematic analysis of how educational exposure relates to start-up creation. To overcome this limitation, we merge several data sources. We first draw on Crunchbase.com, the largest crowd-sourced database of U.S. start-ups and the most comprehensive source of information on firms introducing new products or services to market (see Dimmock et al. 2022). Crunchbase identifies company founders and detailed firm character-

istics—including founding year, location, industry, and capital raised—and, through merged LinkedIn information, records each founder’s university, highest degree, degree type, and year of completion. We use these data to track start-up creation from 1999 to 2019 and construct cohort-level measures of firms founded within five years of graduation by Master’s students from U.S. universities graduating between 1999 and 2014.

We complement these data with administrative records from the Integrated Postsecondary Education Data System (IPEDS), which we use to construct a panel of Master’s graduating cohorts across U.S. universities. For each university and graduation year, IPEDS provides the number and share of international students enrolled, as well as detailed tuition information by institution and year. For public universities, we observe average tuition charged to in-state and out-of-state students—a category that includes international students—and variation in these tuition differentials serves as a source of exogenous variation in international enrollment. Finally, we use individual-level data on F-1 student visas to reconstruct country-specific inflows of international students to the United States in each year between 2001 and 2014. Combining these inflows with the historical distribution of international students by country of origin across universities yields an additional independent source of variation in international enrollment.

Our baseline specification relates start-up creation by graduates in a university-cohort cell to the share of international students in that cohort. OLS estimation raises serious concerns about omitted variable bias and endogenous sorting of students across universities and cohorts. To address these, we rely on two complementary instrumental variable strategies exploiting distinct sources of plausibly exogenous variation in the share of international students in Master’s cohorts. The first uses cost-driven variation induced by tuition differentials across public universities. The second captures push-driven variation from shifts in country-specific international student inflows after 2003—when foreign enrollment began its sustained growth in the U.S.—interacted with pre-existing historical enrollment networks across universities. Because the two strategies operate on different margins, draw on different segments of the university system, and are unlikely to share the same unobservable confounders, they provide complementary evidence on the causal effect of international enrollment. Importantly, both instruments generate variation in cohort composition rather than in overall enrollment levels.

The first identification strategy exploits plausibly exogenous changes over time in the gap between out-of-state and in-state Master’s tuition across public universities. Controlling for university fixed effects and time-varying institutional characteristics, we isolate differential tuition changes across comparable institutions that affect the relative cost of a Master’s degree for international students versus U.S.-born students, thereby generating variation in the share of international students across entering cohorts. We show that this variation is uncorrelated with prior trends in foreign enrollment, local start-up intensity, and the quantity and quality of U.S.-born students.

The second identification strategy, applied to private universities, uses a shift-share design that interacts post-2003 changes in country-specific international student inflows with pre-2003 historical enrollment patterns across universities. This approach generates differential changes in predicted international enrollment reflecting each university’s heterogeneous exposure to origin-country inflows. Controlling for a rich set of fixed effects, the strategy isolates cross-university variation over time that is uncorrelated with pre-2003 international enrollment levels and entrepreneurial intensity.

We subject both strategies to a broad set of validity and robustness checks. The variation exploited by each instrument is uncorrelated with pre-existing trends in start-up creation and

other cohort-level outcomes; both IVs show no significant correlation with lagged international enrollment or pre-entry start-up intensity. We also verify that each instrument predicts enrollment of foreign students but not of U.S.-born students, as required. The shift-share IV is further subjected to the standard [Goldsmith-Pinkham et al. \(2020\)](#) tests. Crucially, despite relying on different samples and distinct sources of variation, the two strategies yield highly consistent estimates. Given that their potential limitations differ in nature, this convergence strengthens the credibility of the causal interpretation and supports the external validity of our findings.

Our main estimates show that a ten-percentage-point increase in the share of foreign students in a Master’s cohort—approximately one standard deviation, corresponding to about 60 students—raises the number of start-ups founded by graduates within five years by roughly 0.5 firms. This is economically meaningful: it corresponds to about two standard deviations of cohort-level start-up creation at public universities, and implies some 4,000 additional start-ups per year attributable to the approximately 500,000 foreign graduate students enrolled. The effect remains strong and statistically significant when we restrict attention to increasingly successful ventures: it persists for firms surviving at least three years, for firms raising above-median capital within their first three years, and for firms filing at least one patent—a highly selective group representing about three percent of the sample. These results indicate that international Master’s students contribute not only to more start-ups but also to more successful ones.

The central contribution of the paper is to quantify what share of this effect operates through spillovers to U.S.-born graduates. Because founders’ place of birth is not directly observed, we infer national origin using a machine-learning algorithm from Forebears.io, which assigns origin probabilities based on the global distribution of first-last name combinations. In a country with a long immigration history, this approach is better at identifying individuals of foreign origin than at distinguishing precisely between foreign-born founders and U.S.-born descendants of immigrants, so some of the latter may be misclassified. We therefore adopt a conservative strategy and bound the indirect effect from below by restricting the analysis to founders most likely to have U.S. origins—thereby excluding anyone with a detectably foreign-origin name and likely understating the spillover. We assess the extent of potential misclassification through extensive manual checks on a subsample of founders, and use this assessment to simulate the implications for our estimates.

Spillover effects account for a substantial share of the total impact. Depending on the identification strategy, the Forebears attribution places the share of the overall effect operating through U.S.-born graduates at between 25 and 50 percent. Correcting for the likely undercount of U.S.-born founders arising from name-based misclassification raises this estimate to between 45 and 75 percent. Taken together, these findings indicate that graduate-level exposure to international students generates sizable entrepreneurial spillovers on native peers.

Finally, we present evidence on the mechanisms behind the spillover effects. Co-founding between U.S.-born and foreign-origin alumni is substantially more frequent in cohorts with higher international enrollment, consistent with collaboration playing an important role—and this extends beyond co-founding with classmates to partnerships with foreign-born entrepreneurs more broadly. We also find that greater international enrollment is associated with greater variety in the start-ups produced by a cohort, as measured by the diversity of keywords describing firms’ products and services. Together, these patterns suggest that exposure to international peers during graduate education expands both collaborative networks and the range of entrepreneurial

ideas brought to market.

This paper contributes first to the literature on immigrant entrepreneurship and firm creation. A large body of work documents that immigrants are disproportionately likely to become entrepreneurs and to found innovative, high-growth firms in the United States and other advanced economies. Early studies establish that foreign-born individuals exhibit higher rates of entrepreneurship than natives and contribute substantially to employment and economic activity (Fairlie 2008; Fairlie & Lofstrom 2015). Subsequent research emphasizes their role in high-tech entrepreneurship, patenting, and innovation (Hart 2011; Hart & Acs 2011; Kerr 2013; Kerr & Kerr 2020), as well as strong job-creation effects and positive impact on firm survival (Azoulay et al. 2022; Kerr & Kerr 2016). Related work highlights the importance of co-ethnic networks and mixed native-immigrant founding teams for firm performance and hiring (Kerr & Kerr 2021; Kerr & Mandorff 2023; Jin et al. 2025). While this literature establishes immigrants as key entrepreneurial actors, it largely focuses on firms founded by immigrants themselves and relies primarily on descriptive evidence, leaving open how immigrants affect entrepreneurial activity beyond their own firm creation.

Second, the paper contributes to the literature on spillovers and peer effects in entrepreneurship. Early work using aggregate data finds little evidence that immigrant entrepreneurs raise native entrepreneurship and even suggests modest negative effects (Fairlie 2008). More recent studies underscore the importance of peer interactions for entrepreneurial activity. Notably, Anelli et al. 2023 show that a large emigration shock in Italy depressed firm creation, pointing to spillovers from the departure of highly entrepreneurial individuals. Our paper differs by focusing on spillovers generated by foreign students, while in school, and highlights diversity and collaboration—rather than the sheer entrepreneurial quality of peers—as a channel for expanding entrepreneurial ideas and innovation.

Finally, the paper contributes to the literature on high-skilled immigration and innovation. Influential studies show that foreign-born individuals are strongly overrepresented among inventors and play a causal role in shaping patenting and inventive collaboration (Kerr & Lincoln 2010; Bernstein et al. 2022). Patenting, however, captures only one channel through which innovation affects economic dynamism, and largely abstracts from firm creation and the educational environments in which entrepreneurial ideas form. Related work documents foreign graduate students’ contributions to scientific output and university patenting (Chellaraj et al. 2008; Stuenkel et al. 2012) and the innovation effects of student visa policies (Crown et al. 2020). We complement this literature by focusing on innovative start-up creation as an important, underexplored channel—distinct from patenting—through which international students contribute to innovation.

The rest of the paper proceeds as follows. Section 2 describes the data. Section ?? details both identification strategies and tests their validity. Section 5 reports the results on overall entrepreneurship. Section 6 focuses on the indirect effects on start-ups created by US-origin graduates and presents evidence on the underlying mechanisms. Section 7 concludes.

2 Data and Summary Statistics

Our empirical analysis combines detailed information on start-ups, their characteristics, and founders with administrative data on Master’s graduates from US universities. Linking founder records to university-cohorts allows us to connect start-up outcomes to the share of international students and average tuition fees for each cohort. A key contribution of the paper is

a novel dataset merging administrative records from the Integrated Postsecondary Education Data System (IPEDS) with proprietary data from Crunchbase. This section describes each data source, its main features, and the procedures used to construct the university-cohort panel and merge it with start-up outcomes.

2.1 International Master’s graduates and tuition fees

IPEDS reports annual enrollment and degree-completion data for all US universities, by degree and field of study. It distinguishes between domestic students and international students, defined as non-resident aliens enrolled on temporary visas (typically F or J visas) who lack the right to remain in the United States indefinitely after graduation; those who stay do so usually on OPT extensions or H-1B visas. Domestic students comprise US citizens and permanent residents.

IPEDS records the number of degree-seeking students enrolled each fall and the number graduating each year, separately by degree type, field of study, and residency status. Our main variables of interest are the size of the Master’s graduating cohort at each university and year, and the share of international students within that cohort. The data span 1999–2014, and we restrict the sample to institutions classified as Master’s- or Doctoral-degree-granting under the Basic Carnegie Classification.

IPEDS also reports posted tuition fees for Bachelor’s and Master’s programs by university and academic year. For public universities, tuition differs between in-state and out-of-state students—a category that includes internationals. These fees vary substantially and idiosyncratically across institutions and over time, reflecting institutional, financial, and administrative factors, with significant year-to-year variation in both fee levels and the in-state/out-of-state gap. We exploit this variation in tuition differentials, after controlling for institutional variables, as a source of exogenous variation in international enrollment at public universities. For private universities, where tuition does not vary by residency status, we rely on an alternative identification strategy based on country-of-origin networks, as described below.

2.2 Founders of Startups

The second key data source is Crunchbase, a crowd-sourced database providing detailed information on US start-up firms and their founders, including the year operations began.¹ Prior research confirms broad coverage of early-stage innovative firms (Block et al. 2015; Dalle et al. 2017; Wang 2018), and the database has recently been used to study entrepreneurial outcomes and start-up dynamics in the United States (Dimmock et al. 2022). Crunchbase combines submissions from investors, firms, and platform users with internal data and validation procedures. Because it launched in 2005, coverage of earlier firms is backfilled and sometimes less reliable; accordingly, we restrict attention to firms founded from 1999 onward.

Our analysis covers Master’s cohorts graduating between 1999 and 2014 and tracks start-up creation within five years of graduation, spanning 1999–2019. We adopt this window because entrepreneurial activity is most tightly linked to skills, networks, and ideas formed during graduate education in the years immediately following graduation; Appendix Figure A2 shows that about 40 percent of founders who start a company do so within five years of completing

¹Data are available at [Crunchbase.com](https://www.crunchbase.com).

their Master’s. The five-year cutoff also ensures consistent measurement of entrepreneurship across early and late cohorts in the sample.

For each start-up, Crunchbase reports the year of founding, geographic location, and a set of descriptive keywords characterizing the firm’s industry, technology, and products or services, as well as key firm outcomes including funding rounds, total capital raised, and the date of exit or cessation. Crunchbase also reports founder names and, where available, highest degree attained, including the university, field of study, and graduation year. These records allow us to identify educational background for approximately 29,000 founders, about 27 percent of all US start-up founders in the database. In Section 2.4, we compare observable firm characteristics for start-ups with and without founder education data to assess the representativeness of this subsample.

We use these records to construct cohort-level measures of entrepreneurial activity by Master’s graduates across universities and graduation years. Specifically, we count start-ups founded within five years of graduation by alumni of each university-cohort cell. Because many start-ups have multiple founders, each firm is assigned fractionally to its founders—each receiving a weight equal to the inverse of the number of co-founders—so that aggregated counts are comparable across cohorts of different sizes.

Beyond start-up entry, we use firm-level data to identify more successful and innovative firms. We first flag firms that remain active for at least three years—a threshold that excludes the least viable new entrants.² We then identify firms that raise more venture capital within their first three years than the median US start-up of the same age, which we term “above-median capital” firms. Finally, we supplement Crunchbase with US Patent and Trademark Office (USPTO) data to identify start-ups granted at least one patent within three years of founding, using fuzzy name matching. Together, these measures capture survival, access to external finance, and innovative activity—key dimensions of firm success.

2.3 Inferring US-origin of start-up founders

In the second part of the analysis, we estimate the spillover effect of international enrollment on start-up creation by US-origin graduates. Because founders’ place of birth is not recorded in Crunchbase, we infer national origin from first and last names. Name-based inference is widely used in the social sciences to study ethnicity, migration, and origin when administrative birth records are unavailable, and has been applied in economics to characterize patterns of innovation, collaboration, and mobility across groups (e.g., [Kerr & Kerr 2018](#); [Clark 2014](#); [Beine, Peracchi & Zanaj 2023](#)). We build on this literature to classify founders as likely US- or foreign-origin, using an approach that yields a conservative lower bound on spillover effects through US-born entrepreneurship.

We implement this classification using an algorithm from Forebears.io, which has compiled the global distribution of first and last names by country of origin. For each first-last name combination, the algorithm assigns a probability distribution over countries of origin based on observed name frequencies worldwide.

The algorithm produces probabilistic attributions of names to origin countries and, as Forebears documentation reports, correctly identifies the most likely country of origin for approximately 85 percent of individuals on average, with somewhat lower accuracy in the United

²According to Bureau of Labor Statistics data, roughly 40 percent of private-sector establishments do not survive three years.

States.³ The main US error is classifying US-born descendants of immigrants—who may carry “ethnic” first names—as foreign-origin. Misclassification is therefore asymmetric: false positives (US-born founders classified as foreign-origin) are substantially more common than false negatives. Since our spillover analysis focuses on US-origin entrepreneurship, such errors mechanically bias estimated spillovers downward, and we interpret our estimates as conservative lower bounds accordingly.

We apply this procedure to all founders in Crunchbase to obtain, for each individual, a probability of US or foreign origin. Since the analysis is conducted at the university–graduation-year level, we aggregate these probabilities to construct cohort-level counts of start-ups founded by likely US-origin and likely foreign-origin graduates, weighting each founder’s contribution by their origin probability.

This approach isolates, within the overall effect of international Master’s students on start-up creation, the spillover operating through US-origin entrepreneurship. Because we use the name-based classification only to distinguish US- from foreign-origin founders—not between specific countries of origin—misclassifications among foreign-origin groups do not affect our measure of US-origin start-ups.

To assess the accuracy of the name-based classification, we conduct a validation exercise on a subsample of approximately 1,500 start-up founders whose place of birth we determine manually. For each, we collect biographical information from publicly available sources—personal websites, company profiles, professional pages, interviews, newspaper articles, YouTube videos, blogs, communications and other online records—to establish whether the founder was born in the United States or abroad. We then compare these manually verified origins with the Forebears-based assignments to quantify the frequency and direction of classification errors. Results are reported in Table 1. Of the 903 founders identified as US-born, the algorithm classified 287 (31%) as foreign-born (column 1); of the 636 identified as foreign-born, only 79 (12%) were incorrectly classified as US-born (column 2). Overall, the algorithm is correct in 76 percent of cases, with false positives—US-born founders classified as foreign-origin—substantially more frequent than false negatives.

This pattern confirms that our spillover estimates are likely conservative. In Section 6, we use the imputed error rates from Table 1 to simulate the implications of misclassification and construct a probabilistic distribution—rather than a point estimate—for the estimated spillover effect.

2.4 Summary Statistics and Trends

This section presents summary statistics describing the distribution of start-up creation by Master’s graduates across US universities and cohorts. We document how entrepreneurial activity varies across institutions, fields of study, and student origins, and we assess the representativeness of the sample used in the empirical analysis. Our final sample includes 37,628 start-ups founded by master’s graduates of US universities between 1999 and 2014, representing roughly one-third of all new US start-ups recorded in Crunchbase over this period.

Table 2 reports summary statistics for start-ups in the Crunchbase sample. Column 1 includes firms for which founders’ names are observed; Column 2 restricts to start-ups for which we can additionally identify founders’ educational information, including degree, institution, and graduation year. Across most observable characteristics—firm age, co-founding

³See <https://forebears.io/onograph/documentation/appendices/nationality-jurisdiction-probabilities>.

prevalence, employment size, founder gender composition, and the likelihood of a foreign-origin founder—the two samples are very similar. We observe some differences in average capital raised and patenting rates, discussed below. Overall, the subsample with complete founder education data is broadly comparable to the larger sample, though potentially somewhat positively selected, supporting its use for analyzing the relationship between educational exposure and entrepreneurial outcomes.

The analysis sample is split into two subsamples based on the identification strategy. Master’s graduates from public universities form the tuition IV sample, while those from private universities form the shift-share sample. Summary statistics for each are reported in Table 3: Columns 1 and 2 correspond to public university graduates and Columns 3 and 4 to private university graduates.

Average cohort size is similar across the two samples, though slightly larger at public universities. The share of foreign graduates is also comparable, at just under 10 percent in both. Within each group, research-intensive universities—classified as R1 and R2 under the Carnegie system—enroll substantially higher shares of foreign students, at approximately 15 and 20 percent, respectively. Entrepreneurial outcomes differ more markedly: the average number of founders per cohort is considerably higher among private university graduates than public university graduates (0.46 founders and 0.51 firms per cohort versus 0.17 founders and 0.19 firms).

Start-ups founded by public university graduates are somewhat more likely to be located in the same state as their institution (56 percent versus 50 percent for private university graduates). In both samples, nearly all start-ups—about 98 percent—survive at least three years, well above the national rate of roughly 60 percent. This high survival rate confirms that our sample is positively selected toward higher-quality firms, and motivates our focus on the creation of successful start-ups rather than entry alone.

Access to early capital is also higher for private university graduates: 39 percent raise more capital in their first three years than the median US start-up of the same age, compared with 33 percent for public university graduates. Early patenting rates are nearly identical across the two groups—3.34 and 3.48 percent of start-ups, respectively, are granted at least one patent within three years of founding—further underscoring that our sample is concentrated in the upper tail of the innovation distribution.

Figure 1 provides additional descriptive evidence on heterogeneity in start-up creation, pooling graduates of public and private universities. It reports creation rates per 10,000 Master’s graduates by field of study, institutional type, and country of origin. The top-left panel shows substantial variation across majors: rates are highest in Business/Management and STEM fields (Computer Science, Engineering, Health Sciences) and lower elsewhere. The top-right panel uses the Carnegie classification to show that graduates of research-intensive universities (R1 and R2) have significantly higher start-up rates, with R2 institutions—which often offer applied Master’s programs—among the leading sources of entrepreneurship. The bottom panel reports creation rates by country of origin for foreign students, using F-1 visa data. Rates are particularly high for graduates from India and China, consistent with prior evidence on the entrepreneurial activity of these groups in the United States (Kerr & Kerr 2020) and with their status as the largest and fastest-growing source of foreign graduate students over the period 1999–2019.

Figure 2 plots average start-up creation rates by graduation cohort, separately for likely US-origin and likely foreign-origin Master’s graduates. Each point represents the number of start-

up founders within five years of graduation per 10,000 graduates. Solid lines cover US-based start-ups; dashed lines additionally include firms founded abroad, also reported in Crunchbase. Although the rest of the paper focuses on US-based firms, the comparison is informative: overseas start-ups represent a meaningful share of total entrepreneurial activity for foreign-origin graduates but not for US-origin graduates. This feature suggests that foreign Master’s students in the US are more entrepreneurial overall relative to US ones.

Start-up creation among US-origin graduates rose from about 0.3 per 10,000 in the 1999 cohort to roughly 0.6 per 10,000 for cohorts graduating between 2009 and 2014. Part of the post-2005 increase may reflect improved Crunchbase coverage: firms founded after 2005 could be recorded contemporaneously rather than backfilled. The upward trend may also reflect the macroeconomic disruptions of the Great Recession (2007–2009), which depressed labor market conditions and increased graduate enrollment—a pattern documented in prior work (e.g., [Bound et al. \(2020\)](#)) that we account for in our identification strategy. Our empirical analysis does not, however, rely on the aggregate time-series variation shown in Figure 2.

The rates we document are comparable to estimates for founders of larger innovative firms provided in the literature. For example, [Azoulay et al. 2022](#) find that roughly one in 10,000 individuals founds a firm with more than 50 employees—similar to the rates we observe among Master’s graduates. Since most start-ups in our sample survive beyond three years, raise above-average capital, and generate patented innovations, this comparison with high-growth firms further supports the representativeness of our dataset.

Foreign-origin Master’s graduates exhibit substantially higher start-up creation rates. In the post-2010 period, they founded about 2.5 to 3 start-ups per 10,000 graduates when restricting to US-based firms, and up to 4–5 per 10,000 when including firms created abroad. Foreign-origin graduates are thus nearly an order of magnitude more likely than US-origin graduates to found start-ups, and despite representing only about 10 percent of graduating cohorts, they account for a comparable number of founders. This disparity suggests that higher international enrollment may substantially raise overall start-up creation, and motivates our analysis of both the direct and spillover effects on US entrepreneurship.

3 Empirical Strategy and Identification

This section describes the empirical approach and identification strategy for the causal effect of international enrollment on start-up creation. We first present the baseline regression framework and discuss the endogeneity concerns with OLS. We then describe the two complementary instrumental-variable (IV) strategies that exploit distinct sources of plausibly exogenous variation in international enrollment.

A higher share of foreign-born graduates in a university-cohort may affect start-up creation through two margins: directly, because foreign-born graduates are more likely to found innovative start-ups; and indirectly, because exposure to entrepreneurially inclined international peers during the Master’s program may affect the entrepreneurial propensity of US-born students. These spillovers -depending whether they are positive or negative- can amplify or offset the direct contribution of foreign graduates. The baseline specification captures the combined total effect of both channels.

We estimate the total effect of international enrollment by relating variation in the share of foreign-born graduates within a university-cohort cell over time to subsequent start-up creation by graduates of that cohort. Outcomes are measured as the number of founders or start-ups

created within five years of graduation. The unit of observation is a university–graduation-year cohort of Master’s students. The baseline specification is:

$$Y_{ut}^n = \alpha_u + \alpha_{c(u)t} + \beta FG_{ut} + \varepsilon_{ut} \quad (1)$$

where Y_{ut}^n denotes the outcome of interest—the number of start-up founders (or start-ups) created by graduates of university u and cohort t within five years of graduation—and in the baseline specification includes all founders, capturing the total effect of international enrollment.

University fixed effects α_u absorb time-invariant institutional characteristics correlated with student selection and entrepreneurial outcomes. Cohort fixed effects interacted with broad Carnegie classification categories, $\alpha_{c(u)t}$, flexibly control for time-varying shocks common to similar institution types (e.g., R1, R2, or other). Together, these fixed effects restrict identification to variation across cohorts within comparable universities over time.

FG_{ut} measures international enrollment in the cohort. In the benchmark specification, it is the share of foreign-born graduates in the Master’s cohort, so that β captures the effect of replacing one percentage point of US-born graduates with foreign-born graduates, holding cohort size constant. In alternative specifications, FG_{ut} is the logarithm of the number of foreign-born graduates, yielding the semi-elasticity of start-up creation with respect to foreign enrollment while holding the number of US-born graduates constant.

3.1 Instrumental Variable Estimation

Potential OLS Bias

OLS estimation of equation (1) is likely biased due to omitted variables and endogenous sorting across universities and cohorts. Local economic conditions—such as labor market opportunities, business dynamism, housing costs, or local policy environments—may simultaneously affect foreign-born enrollment and the propensity of graduates to found firms, inducing spurious correlations between international enrollment and start-up creation and biasing β in either direction.

These concerns are especially acute for international students, whose university and location choices are particularly sensitive to the full costs of enrollment, including local housing and prices. Relative to US-born students, foreign students are more sensitive to tuition, cost of living and face no home-location bias within the United States. Changes in international enrollment across cohorts may therefore reflect shifts in local economic conditions correlated with entrepreneurial outcomes, rather than exogenous variation in student composition.

To address these concerns, we use two IV strategies that generate plausibly exogenous variation in international enrollment across university cohorts over time: idiosyncratic changes in relative tuition costs at public universities, and shift-share variation driven by past networks and country-specific inflows of international students at private universities during a period of rapid growth of some international groups. We describe each strategy in turn.

Residual tuition IV

Our first strategy exploits idiosyncratic changes in tuition fees charged by public universities to out-of-state—and thus international—students relative to in-state students. While tuition levels partly reflect systematic differences in institutional quality, resources, and local conditions, we

isolate a residual component capturing quasi-random, university-specific changes in relative out-of-state tuition over time. Following [Borusyak & Hull \(2023\)](#), we explicitly separate predictable tuition variation from idiosyncratic shocks and verify that the latter is uncorrelated with pre-existing trends in entrepreneurial outcomes and enrollment. Because the out-of-state premium affects international but not most US-born students, it provides leverage over the share of foreign students in a cohort without directly influencing the entrepreneurial environment.

This strategy extends [Beine, Peri & Raux 2023](#), where tuition variation was used to study the supply of foreign-born college graduates in US labor markets. Here we adapt the approach to Master’s programs, using tuition variation to predict international enrollment at that level and its effect on cohort-specific firm creation. We begin with a “stage-0” regression modelling the out-of-state/in-state tuition gap as a function of observable, time-varying institutional characteristics: university resources and financial conditions—total revenues, revenues per student, total and instructional expenditures per student—as well as the share of state budget appropriations, lagged international enrollment, degree-type fixed effects, and year fixed effects. The specification is:

$$\begin{aligned} (\text{Out-of-state tuition} - \text{In-state tuition})_{udt} = & \delta_t + \gamma_1' \text{Quality proxies}_{u,t} \\ & + \gamma_2 \text{State appropriations}_{ut} + \gamma_3 \text{Int. Graduates}_{u,t-1} + \nu_{ut}. \end{aligned} \quad (2)$$

where δ_t denotes year fixed effects and “Quality proxies” is the vector of controls listed above. The identifying assumption is that unexpected changes in the relative tuition faced by international students affect their enrollment decisions but are otherwise unrelated to the entrepreneurial propensity of the cohort. We use the residual from equation (2)—which captures idiosyncratic changes in the out-of-state tuition gap uncorrelated with observable institutional characteristics—as our instrument. To align tuition changes with enrollment decisions, we lag the residual by two years, $\widehat{\nu}_{u,t-2}$, corresponding to the enrollment year of students in two-year Master’s programs. Higher residual tuition gaps raise the relative cost of enrollment for international students and are thus expected to reduce their share in the corresponding graduating cohort.

To illustrate the variation captured by the residual tuition component, consider the institutional context of public university pricing. In many public systems, out-of-state tuition is used as a margin of fiscal adjustment while in-state tuition is partially shielded by political or statutory constraints. A prominent example is the University of California during the 2008–2009 fiscal crisis: following cuts in state appropriations, the system raised in-state tuition by approximately 9 percent system-wide while increasing nonresident supplemental tuition by roughly 15 percent, widening the resident/nonresident gap by about 12 percent, with variation across campuses and programs. These adjustments reflected budgetary pressures and the political unpopularity of large in-state tuition increases, not local entrepreneurial conditions. In this and analogous cases, poor investment performance and fiscal shortfalls drove out-of-state tuition up while limiting in-state increases—adjustments plausibly orthogonal to trends in start-up creation, a claim we verify by testing the instrument’s correlation with pre-period enrollment and entrepreneurship trends.

The first-stage relationship between international enrollment and the tuition instrument is:

$$FG_{ut} = \delta_u + \delta_t + \gamma(\widehat{\nu}_{u,t-2}) + \zeta_{ut} \quad (3)$$

where δ_u and δ_t are university and time fixed effects and ζ_{ut} is an error term.

Shift-share IV

Our second and complementary identification strategy relies on a more standard shift-share design, widely used in the immigration literature to isolate plausibly exogenous variation in local exposure to immigrant inflows (Goldsmith-Pinkham et al. 2020). The core idea is to exploit differences across universities in their pre-2003 composition of international students by country of origin, interacted with aggregate changes over time in the inflow of students from those countries.

Specifically, we focus on international students from the ten largest countries of origin in US Master’s programs and construct predicted changes in international enrollment by interacting each university’s pre-2003 exposure to students from a given country with subsequent national inflows from that country⁴. A consideration makes this period especially suited to a Shift-share analysis, where the shares pre-2003 are likely to be uncorrelated with school-specific shocks in the considered period (2004-2014). The reason is that after 2003 a surge of graduate international students took place in the US, following the restructuring of the Student visa system after 9/11 and the introduction of the SEVIS (Student and Exchange visitor information system) and the origin of students during this rapid surge (mainly from China and India) was quite different from the main origins of graduate students before the surge (mainly Europe and Latina America). This type of country of origin change is what allows us to separate the impact of current students from lingering correlation with lagged immigration (as argued in Jaeger et al. (2018)). As we will test in the validity checks, for this reason, the post-2003 flows are not correlated with pre-period trends of foreign students’ enrollment.

To implement this strategy, we use administrative data on F-1 student visas covering international Master’s students enrolled in US universities between 2001 and 2014. For each university u and country of origin o , we compute the share of Master’s graduates from country o in the base period 2001–2003. We then interact these initial shares with annual national inflows of Master’s students from each country o starting in 2004, allocating aggregate inflows across universities proportionally to their initial exposure. Summing across countries yields a predicted number—and share—of international students in each university–cohort cell.⁵

We apply this strategy to private universities only, where tuition does not differ between in-state and out-of-state students and the tuition-based instrument is therefore unavailable. Restricting attention to private institutions also avoids potential crowding-in effects of foreign enrollment on native enrollment that may arise in public universities (as argued in Shih (2017)). The predicted share of international students is used as an instrument for observed international enrollment in equation (1).

A robust feature of our empirical strategy is that the two instrumental-variable approaches exploit distinct and complementary sources of variation in international enrollment. The tuition-based instrument captures university-side pricing adjustments by public universities that affect the relative cost of enrollment for international students. The shift-share instrument captures post 2003 variation arising from changes in country-specific inflows of international students interacted with historical (pre-2003) networks of enrollment at specific universities. As a result, the two strategies identify effects for different sets of foreign-students-compliers and rely on variation that is unlikely to be correlated to the same omitted variables between

⁴International master students from these 10 countries represented roughly 70% of all international master students in the US in 2014.

⁵We fix the number of native students at its baseline level so that predicted international enrollment is not mechanically affected by subsequent changes in native enrollment.

the two approaches.

The two instruments also apply to different segments of the US higher-education system. The tuition-based strategy is implemented for public universities, where tuition differs between in-state and out-of-state students. In contrast, the shift-share strategy is applied to private universities, where tuition does not vary by residency status and where crowd-in effects of international enrollment on domestic enrollment are less likely to arise. Prior evidence shows that in public systems, inflows of foreign students may increase native enrollment through cross-subsidization or program expansion (Machin & Richard 2017; Shih 2017; Beine & Ragot n.d.) a pattern we also observe in our data— but not in the private-university sample— and create a correlation between number of foreign students and size of a master cohort.

Finally, the two strategies differ in sample composition and time coverage, the tuition-based instrument is implemented for cohorts graduating between 1999 and 2014, while the shift-share instrument is available for cohorts graduating between 2003 and 2015, reflecting the availability of nationality-specific enrollment data. Yet, they yield highly consistent estimates despite relying on different identifying assumptions. Because the potential limitations of each approach are distinct in nature, the convergence of results across instruments and samples substantially strengthens the credibility of the causal interpretation and supports the external validity of our findings.

4 Strength and Validity of the IV's

4.1 IV Strength

Table 4 reports first-stage estimates for the tuition instrument (columns 1–2) and the shift-share instrument (columns 3–4). All specifications include university and Carnegie level-cohort fixed effects, so identification exploits within-university variation in international enrollment across comparable institutions.

Columns (1) and (2) show that the idiosyncratic component of out-of-state tuition differentials strongly predicts international enrollment at public universities. A one-standard-deviation increase in the residual tuition instrument reduces the share of foreign-born Master's graduates two years later by 0.90 percentage points—sizable relative to the unconditional standard deviation of roughly 10 percentage points. The estimate is stable when controlling for cohort size, indicating that tuition variation affects cohort composition rather than overall enrollment. Kleibergen–Paap first-stage F-statistics are around 77, well above conventional weak-instrument thresholds.

Columns (3) and (4) report first-stage results for the shift-share instrument at private universities. A one-percentage-point increase in predicted foreign enrollment raises the realized foreign share by 0.06 percentage points. The Kleibergen–Paap F-statistic is approximately 20, indicating adequate instrument strength. Appendix Figure A3 displays both first-stage relationships via binned scatter plots and confirms no influential outliers.

4.2 Test of exclusion Restrictions

The identifying assumption is that both instruments affect start-up outcomes only through changes in international enrollment. A key testable implication is that each instrument should predict foreign graduates while leaving the number of US-born graduates in the same cohort

unchanged. Table 5 directly tests this.⁶ For the tuition instrument, higher residual tuition differentials significantly reduce the number of foreign graduates (column 3) while leaving native graduates unchanged (column 5), so total cohort size falls entirely through the foreign channel. For the shift-share instrument, predicted foreign inflows significantly raise foreign graduates (column 6) without affecting native enrollment (column 4), with a small and insignificant increase in aggregate cohort size. Both instruments thus operate through the intended channel while leaving native enrollment unaffected.

A further potential threat to the tuition instrument’s exclusion restriction is that out-of-state tuition changes may alter the average quality of US-born students: if out-of-state domestic students respond to tuition changes and differ systematically from in-state students, the instrument could affect entrepreneurial outcomes through cohort quality rather than through international enrollment. Having shown that US-born cohort size is unaffected, we now check whether cohort quality proxies are also unaffected.

We use graduation rates for US-born and foreign students as proxies for cohort quality. As shown in Table A7, the tuition IV is uncorrelated with the US-born graduation rate (column 1), the foreign-born graduation rate (column 2), or the difference between the two (column 3)—all estimated coefficients are small and statistically insignificant. These results support the exclusion restriction.

4.3 Test for differential pre-trends and previous periods correlation

The tuition instrument’s validity rests on the assumption that university-specific changes in the out-of-state/in-state tuition gap are uncorrelated with pre-existing differential trends in enrollment, university resources, or entrepreneurship. We conduct two sets of tests of this assumption.

The first test follows the staggered difference-in-differences validity literature (e.g., [Callaway & Sant’Anna \(2021\)](#)). We discretize the instrument by defining an “event” as each university’s largest increase in residual tuition gap over the sample period, and align universities around the timing of that shock. We then compare pre-event dynamics in entrepreneurship, university resources, and student quality between early-shock and late-shock universities, controlling for university and Carnegie-group-cohort fixed effects, scaling outcomes by the magnitude and sign of the shock to test whether major pricing changes were anticipated or correlated with pre-existing trends.

Table 6 reports Wald test p-values for the joint significance of pre-event coefficients across outcome variables (number of entrepreneurs and firms created by Master’s cohorts), university resources (expenses per student), and student quality proxies (OPT per graduate, graduation rates for US-born and foreign students). For all variables, p-values are well above conventional significance thresholds and associated F-statistics are small, so we cannot reject the null of zero pre-event trends.

The second test regresses the residual tuition differential (predicting graduation in year t , hence corresponding to tuition in year $t - 2$) on earlier measures—at $t - 4$ and $t - 5$ —of foreign student enrollment shares, graduation shares, and start-up rates. This checks whether tuition variation is predictable from prior changes in international student composition or graduate

⁶Outcomes are transformed using the inverse hyperbolic sine to approximate elasticities while retaining zero-valued observations. Appendix Table A4 reports analogous results using $\log(x + 1)$, with very similar findings.

entrepreneurship, which would suggest endogenous university policy responses. Panel A of Table 7 shows that all coefficients are small and insignificant, providing no evidence of such correlations.

The shift-share instrument exploits cross-university differences in pre-2003 origin-specific enrollment shares interacted with national trends in international student inflows by origin. Following a period of stagnation and decline after 9/11, foreign graduate enrollment surged post-2003 when SEVIS replaced an outdated paper-based tracking system.⁷ Crucially, the nationalities driving the post-2003 surge—primarily Chinese, South Korean, and Indian students—differed markedly from those dominant in earlier decades (European, and Latin American), supporting the identifying assumption that post-2003 flows are uncorrelated with pre-period enrollment trends.

We perform an analogous pre-trend test for the shift-share instrument by regressing predicted changes in international exposure over the main analysis period (2004–2014) on changes in entrepreneurship rates and graduate counts in the preceding period (1995–2003). This cross-sectional exercise checks whether universities facing stronger predicted post-2003 exposure were already on differential trajectories before baseline shares were computed. Panel B of Table 7 shows no systematic correlation with prior entrepreneurship or enrollment outcomes. The one exception is a positive and significant association between earlier growth in the number of international graduates and subsequent instrument variation (column 2), likely reflecting the persistence of some origin nationalities across periods. Importantly, we find no pre-trend in start-up rates at the university level. The following section presents the full Goldsmith-Pinkham et al. (Goldsmith-Pinkham et al. (2020)) validity analysis for the shift-share instrument.

4.4 Validity of shift-share IV estimation

Following Goldsmith-Pinkham et al. (2020), we estimate Rotemberg weights to characterize which origin countries drive identification in the shift-share estimates. The shift-share IV estimate $\hat{\beta}^{ss}$ can be written as:

$$\hat{\beta}^{ss} = \sum_k \alpha_k \hat{\beta}^k$$

where $\hat{\beta}^k$ is the IV estimate using only origin country k and α_k is its Rotemberg weight. Countries with large positive weights—which sum to one—contribute the most identifying variation.

Table A1, Panel A reports the Rotemberg weights and associated statistics. Panel B reports the estimated weights $\hat{\alpha}_k$, the size of the inflow shock g_k , and the coefficient from Table 9, column (3), using only that country’s share as the instrument. Figure A1 plots the relationship between country-specific F-statistics and estimated weights.

Panel B shows that China, India, Vietnam, and Canada carry the largest weights and all yield positive and significant $\hat{\beta}^k$ estimates; the estimate for China is closest to the main specification in Table 9. Figure A1 confirms that countries with larger Rotemberg weights also have larger first-stage F-statistics, indicating that the most influential origins are also the strongest instruments.

Table 8 reports joint tests that pre-2003 coefficients are zero for the outcome variables listed in the column headings, separately for the country shares with the largest Rotemberg weights

⁷See “Post-9/11 Policies Dramatically Alter the U.S. Immigration Landscape,” Migration Policy Institute, available at <https://www.migrationpolicy.org/article/post-911-policies-dramatically-alter-us-immigration-landscape>.

(listed in order of relevance). All joint pre-trend tests yield large p-values and small F-statistics across outcomes and origin groups. This is especially notable for Chinese students, who account for the largest share of identification in the shift-share IV. Together with the tuition IV results, both instruments pass the pre-trend validity checks, showing no significant correlation with lagged outcomes, pre-existing trends, or the quality and size of US-born Master’s enrollment.

5 Main Results

5.1 The effect of foreign graduate shares on start-ups

Table 9 reports the main results from estimating equation (1). Column (1) presents OLS estimates for reference; the remaining columns report IV estimates that address omitted-variable and endogeneity bias. The upper panel uses the residual tuition IV in the public university sample (1999–2014 cohorts); the lower panel uses the shift-share IV in the private university sample (2004–2014 cohorts). The OLS coefficient in column (1) is small and insignificant, consistent with the downward bias that we will discuss in more details in Section 5.3 and with [Bound et al. \(2020\)](#), underscoring the need for an IV strategy.

Columns (2) to (7) capture increasingly selective entrepreneurial outcomes. Column (2) measures the number of start-up founders within five years of graduation; column (3) the number of start-up firms. Column (4) restricts to firms surviving at least three years, column (5) to those raising above-median capital within three years, and column (6) to those granted at least one patent within three years. Column (7) covers firms founded in the same state as the university.

Both IV strategies yield economically and statistically significant effects of international enrollment on start-up creation, with estimates that are consistent across instruments and samples. In column (2), a 10 percentage point increase in the foreign share—approximately one standard deviation—raises the number of start-up founders by about 0.5 within five years. Given that the average public-university cohort generates fewer than 0.2 start-ups (Table 3), this implies more than a doubling of start-up creation. Column (3) shows a comparable increase in firms: a 10 percentage point rise in foreign enrollment generates roughly 0.45–0.6 additional start-ups per cohort. Columns (4)–(6) show that the effects extend to more selective outcomes. International enrollment raises the number of three-year survivors and above-median-capital firms under both IV strategies. For patenting firms—3 percent of the sample—the tuition IV yields positive and significant effects; the shift-share IV produces positive but imprecise estimates. Overall, foreign-born graduates raise not only the total of start-ups but specifically the more successful ones. Column (7) shows that roughly 60 percent of additional start-ups are founded in the same state as the university, suggesting the effect operates substantially through local entrepreneurial ecosystems. Overall, the results indicate that higher international enrollment in US Master’s programs causally increases start-up creation, including among successful and innovative firms.

5.2 Robustness to alternative specifications

5.2.1 Alternative sets of fixed effects

Slow trends in university quality, program expansion, or student composition may confound the relationship between international enrollment and entrepreneurial outcomes. Table 10 re-estimates the tuition IV specifications including more demanding controls. Panel A restricts to periods of relatively stable total enrollment and adds university-by-5-year-period fixed effects, absorbing medium-term institutional changes and isolating more idiosyncratic year-to-year tuition-driven variation. Panel B adds university-specific linear time trends to control for gradual shifts in institutional characteristics and entrepreneurial intensity.

The tuition IV estimates remain strongly consistent with the baseline across both panels. If anything, coefficients are slightly larger when controlling for university-period effects, indicating the baseline is not driven by gradual unobserved changes. Analogous exercises for the shift-share IV (Appendix Table A5) show that university-specific trends leave estimates largely unchanged. University-period fixed effects reduce precision and lower point estimates somewhat, but coefficients remain positive, economically meaningful, and way larger than the corresponding OLS estimates.

Finally, we exploit university-reported “peer groups”—sets of comparable institutions used for benchmarking—by adding peer-group-by-year fixed effects, restricting identification to variation among similar institutions. Results in Table 11 closely match the baseline for both IV strategies, with slightly larger effects for the tuition IV. These robustness checks confirm that the main findings are not driven by institution-specific trends or differential evolution across comparable universities.

5.2.2 Semi-elasticities

In the baseline specification, a one percentage point increase in the foreign share mechanically replaces US-born with foreign-born students, holding cohort size fixed. To instead estimate the effect of expanding foreign enrollment while holding US-born graduates constant, we replace the share with the logarithm of the number of foreign graduates, yielding a semi-elasticity of start-up creation with respect to foreign enrollment.

Panels C of Tables 10 and A5 report the corresponding IV estimates. Under the tuition IV, a 10 percent increase in the number of foreign graduates raises start-up creation by approximately 0.5 firms per cohort within five years, consistent with the share-based results and statistically significant across most outcomes. The shift-share IV yields similar semi-elasticities, with slightly larger point estimates in some cases. The results confirm that the positive effect of international enrollment on start-up creation is not an artifact of the use of shares in the benchmark specification: expansions in foreign Master’s enrollment—holding native enrollment constant—generate economically meaningful increases in entrepreneurial activity.

5.3 OLS bias and importance of the IV

OLS estimates in Table 9 are substantially smaller and statistically insignificant, indicating a downward bias consistent with a negative correlation between foreign Master’s enrollment and unobserved local conditions that stimulate start-up creation.

A negative correlation between Master’s enrollment and local economic growth—reflecting the lower opportunity cost of education during downturns—has been documented by [Bound](#)

et al. (2020) and applies to foreign students with particular force. Local booms raise both entrepreneurial activity and living costs (Moretti 2004), deterring internationally mobile students who are especially sensitive to total expenses. Conversely, weaker local conditions attract more foreign students through lower costs while suppressing entrepreneurial activity. These two forces together generate a negative correlation between foreign enrollment and start-up creation, biasing OLS downward.

Figure 3 provides supporting evidence: county-level rent changes are positively correlated with start-up creation and negatively correlated with university enrollment, confirming that favorable local shocks simultaneously increase entrepreneurial activity and reduce foreign enrollment through higher living costs. The IV strategies, which exploit tuition-based and network-driven variation plausibly orthogonal to local economic conditions, substantially mitigate this source of bias.

5.4 Heterogeneity across majors and universities

Section 2.4 showed that start-up rates vary substantially across Master’s majors, with Business, Computer Science, Engineering, Physical Sciences, and Health exhibiting the highest entrepreneurial intensity. We now examine whether the causal effect of foreign enrollment also varies across fields and location.

Heterogeneous effects may arise because foreign students are differentially selected across majors and universities, or because complementarities with US-born students differ across fields. We test whether the effect varies (i) between STEM and non-STEM programs, (ii) between the five highest-entrepreneurship majors and all others, and (iii) between universities in high-density versus less concentrated metropolitan areas. Table 12 reports the results. Columns (1)–(2) compare STEM and non-STEM programs; columns (3)–(4) compare the five most entrepreneurial majors with the rest; columns (5)–(6) split universities by local concentration of higher-education institutions. Panel A reports tuition-IV estimates and Panel B shift-share-IV estimates.

Two findings emerge. First, the effect of foreign enrollment is positive and significant across both STEM and non-STEM majors, and across high- and lower-entrepreneurship fields. The shift-share IV yields larger point estimates for STEM and high-entrepreneurship programs, but formal tests cannot reject coefficient equality, suggesting the marginal contribution of foreign students is not confined to specific disciplines. Second, the effect is significantly larger in areas with a high concentration of universities, consistent with stronger complementarities in thick human-capital environments where foreign and US-born graduates can draw on a denser ecosystem of skills, collaborators, and entrepreneurial resources.

6 Spillover effects on native start-up creation

How much of the total effect estimated in Section 5 operates through spillovers on US-origin graduates’ entrepreneurship? The total effect combines a direct component—reflecting the higher entrepreneurial propensity of foreign graduates—and a potential spillover on US-born entrepreneurs. The direct effect is consistent with the evidence provided by the existing literature on the connection between immigration and entrepreneurship. Main explanations of this effect pertain to the positive selection of foreign students and to the lower opportunity cost of firm creation compared with native graduates.

To isolate the indirect effect, we re-estimate the baseline specification using start-ups founded by likely US-origin graduates in each university-cohort cell as the outcome. Spillovers may arise through the intensive collaboration in graduate coursework, joint projects, and shared activities that facilitate mutual learning and lasting networks. Exposure to foreign-origin classmates can broaden perspectives and transmit entrepreneurial drive, raising start-up activity among US-born students; because many foreign Master’s students leave the US after graduation, any persistent increase in US-born entrepreneurship reflects spillovers formed during the period of study. This implies that the nature of the spillover effect of foreign students is likely to be different from the one associated to other immigrants. Foreign students could alternatively crowd out natives by intensifying competition and discouraging entrepreneurship. We estimate the sign and magnitude of these spillover effects and then explore potential mechanisms.

6.1 Effects on start-up creation by US-origin graduates

Table 13 reports spillover estimates using start-ups founded by likely US-origin entrepreneurs as the outcome. Each founder is weighted by their probability of being US-origin and aggregated within a university-cohort; firm-level counts are constructed analogously, weighting each firm by the inverse of the number of co-founders, each in turn weighted by their probability of being US-born. Because total start-ups equal the sum of US-origin and foreign-origin firms, the difference between the total effect (Section 5) and the spillover estimates here identifies the direct contribution of likely foreign-born graduates.

Panel A reports tuition IV estimates and Panel B shift-share IV estimates. The spillover effect is positive and statistically significant across specifications. Under the tuition IV, a 10 percentage point increase in the foreign-student share raises start-ups founded by US-origin graduates by approximately 0.23—about 40 percent of the total effect. The shift-share IV yields a smaller but still meaningful spillover of around 0.13 firms per 10 percentage point increase. As documented in Section 2.3, misclassification of second-generation immigrants as foreign-origin means these estimates are conservative lower bounds on the true spillover.

Spillover effects remain positive and statistically significant for firms surviving at least three years, raising above-median capital, and obtaining patents. The tuition IV yields significant estimates across all three outcomes; the shift-share IV produces consistently positive but not always significant point estimates. Together, these results indicate that international enrollment raises both the quantity and quality of entrepreneurship among US-origin graduates.

Table 14 reports analogous estimates using a dichotomous classification that assigns each founder to their most likely country of origin, defining them as US-origin if the US is such a country. The resulting spillover estimates are often nearly double those from the probabilistic approach, consistent with measurement error in the continuous method attenuating the estimated indirect effects.

To assess the implications of misclassification more systematically, we simulate the effect of classification errors using the false-positive and false-negative rates estimated in the validation sample (Table 1). We reassign each founder’s origin status with a probability equal to the estimated error rate and repeat the estimation on 1,000 simulated samples to obtain a distribution of spillover estimates. Figure 4 shows that, for both instruments, this distribution lies above zero and the majority of the estimates are between 0.2 and 0.5, confirming that a null of no spillover is rejected at conventional confidence levels after accounting for misclassification and most likely more than one third of the total effect (0.6) is due to spillovers. The spillover

consistently accounts for a substantial share of the total effect across simulations.

6.2 Mechanism 1: Co-founding

A natural mechanism behind the positive spillover effects is increased collaboration in founding new firms. Exposure to foreign schoolmates during the Master’s years may raise trust, lower barriers to cooperation, foster complementary skill matching, and facilitate team formation. If this channel operates, US-born graduates in cohorts with a larger foreign-student share should show a higher propensity to co-found start-ups—with foreigners, other native classmates and possibly beyond their direct classmates.

Table 15 tests this by estimating specifications analogous to column (3) of Table 9, replacing the outcome with the number of start-ups with at least two founders. About 25 percent of firms in our sample are co-founded.

Column (1) shows that a higher foreign share significantly raises co-founded firms, with a magnitude similar to the overall start-up effect, suggesting that a substantial fraction of the additional firms are team-founded rather than solo ventures. Higher foreign enrollment also increases co-founding among graduates of the same university (column 2) and mixed US–foreign founding teams (columns 3 and 4); the size of those coefficients implies that about one-third of the extra co-founding involves US-born and foreign collaborations. These patterns are consistent with graduate-school interactions fostering durable cross-origin relationships that translate into joint entrepreneurial activity.

Columns (5) and (6) extend the definition of collaboration beyond formal co-founding to include early team members, coded from the names and degrees of Chief Officers (Operations, Administration, Finance) listed at founding. The positive and significant coefficients for mixed US–foreign original teams under this expanded definition reinforce the interpretation that exposure to international classmates increases collaborative entrepreneurship.

6.3 Mechanism 2: Idea Diversity

A second mechanism is the expansion of entrepreneurial ideas within a cohort. International students bring distinct skills, experiences, and exposure to foreign markets; through graduate-school interactions, these differences may broaden the range of products and services that US-origin graduates consider viable, increasing the diversity of start-ups created. This is consistent with a broader literature linking immigration-driven diversity to innovation and economic performance ([Ottaviano & Peri 2005](#), [Peri 2009](#), [Alesina et al. 2016](#), [Bahar et al. 2022](#)).

To examine this channel, we use the keyword descriptions available in Crunchbase. Each start-up is characterized by keywords drawn from a pool of roughly 770 potential terms describing its industry, technology, and product space, which we use to measure how similar or dissimilar each firm is relative to benchmark profiles.

We compute the distance between each firm’s keyword vector and (i) the average vector of US-based start-ups founded in the same year and (ii) the average vector of foreign-based start-ups founded in the same year. Greater distance from the US average indicates deviation from the typical US start-up profile; greater proximity to the foreign average indicates similarity to entrepreneurial patterns more common abroad. We aggregate these measures at the university–cohort level, counting firms whose distance lies above or below the median.

Table 16 reports IV estimates using these outcomes. Columns (1) and (2) show that higher

international enrollment significantly increases the number of start-ups with above-median distance to the average US start-up profile, both overall and within industry categories. Columns (3) and (4) show that cohorts with more foreign students also generate more start-ups that are closer to the average foreign start-up profile.

These results indicate that international enrollment shifts the composition of entrepreneurial activity away from the typical US start-up profile and toward a more internationally oriented range of products and services, consistent with exposure to international peers expanding the ideas and market possibilities available to US-origin graduates.

7 Conclusion

This paper examines how international students in US Master’s programs contribute to start-up creation. Combining comprehensive enrollment data with detailed information on start-up founders, and exploiting two complementary sources of plausibly exogenous variation in international enrollment, we provide causal evidence on the impact of international Master’s students on new firm creation.

Higher international enrollment in a Master’s cohort causally increases start-up creation within five years of graduation. A ten-percentage-point increase in the international student share—roughly one standard deviation—raises start-up formation by 0.5 firms per cohort, an economically large effect concentrated in firms that survive at least three years, raise above-average capital, and engage in innovative activity. The additional start-ups are disproportionately located in the same state as the university, underscoring the local economic relevance of graduate education.

A central contribution is showing that between one-third and two-thirds of the total effect operates through spillovers on US-born graduates’ entrepreneurship. These findings imply that founder-based descriptive evidence, limiting the contribution of foreign-born entrepreneurship to companies that they themselves created, substantially understates the overall contribution of international students to US entrepreneurship.

Higher international enrollment increases co-founding among graduates—particularly between US-born and foreign-origin students—and is associated with greater diversity in the types of start-ups created, consistent with exposure to international peers expanding entrepreneurial collaboration and broadening the range of ideas brought to the market.

These effects are especially striking given that many international Master’s students leave the United States after graduation due to visa constraints or personal preferences, yet still generate sizable and persistent impacts on US entrepreneurship through educational interactions formed while studying. This makes the nature of spillover effects different from those exerted by other kinds of migrants. The findings also suggest that policies increasing the retention of international graduates—such as expanding post-graduation work opportunities or streamlining pathways to permanent residence— as for instance advocated by the OECD ([Kamm et al. 2022](#)) could yield additional gains in innovative firm creation. More broadly, the results highlight graduate education as a key channel through which international mobility shapes domestic entrepreneurship and economic dynamism.

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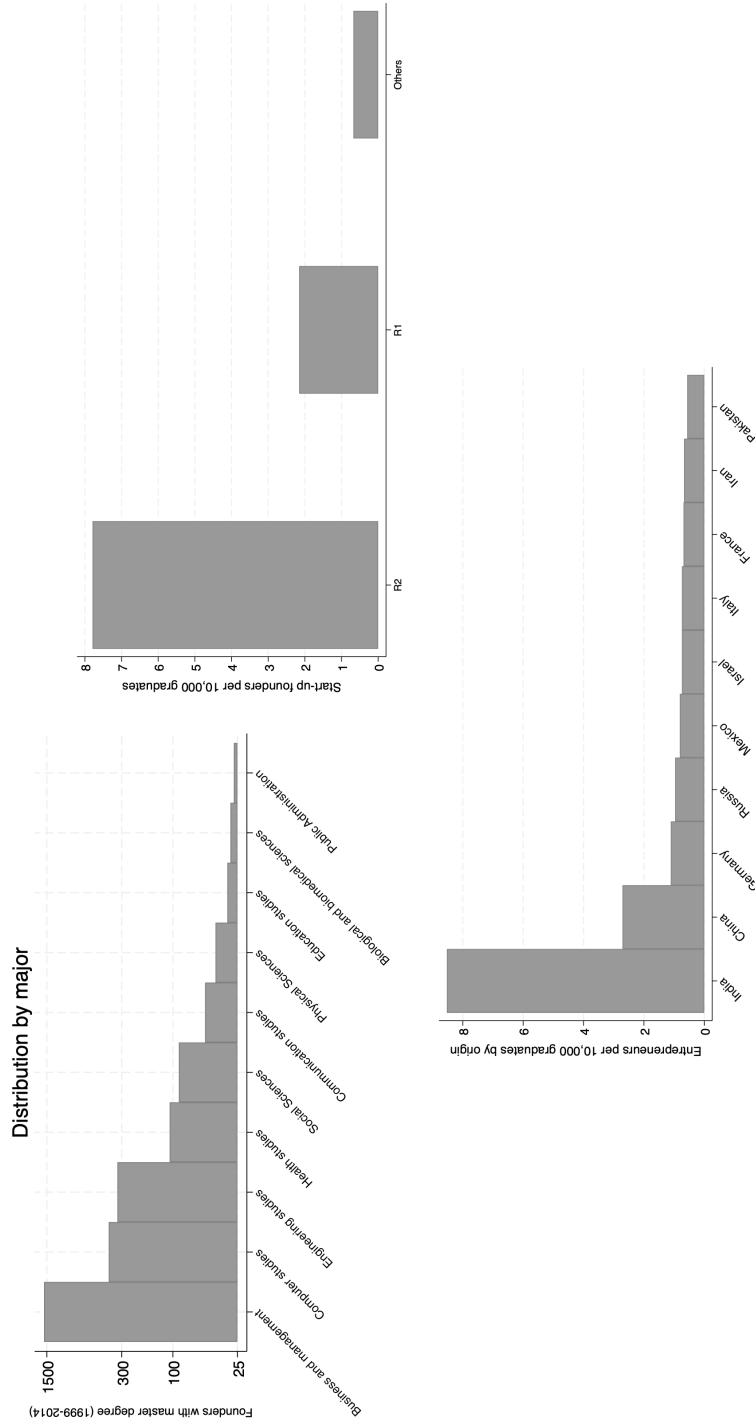
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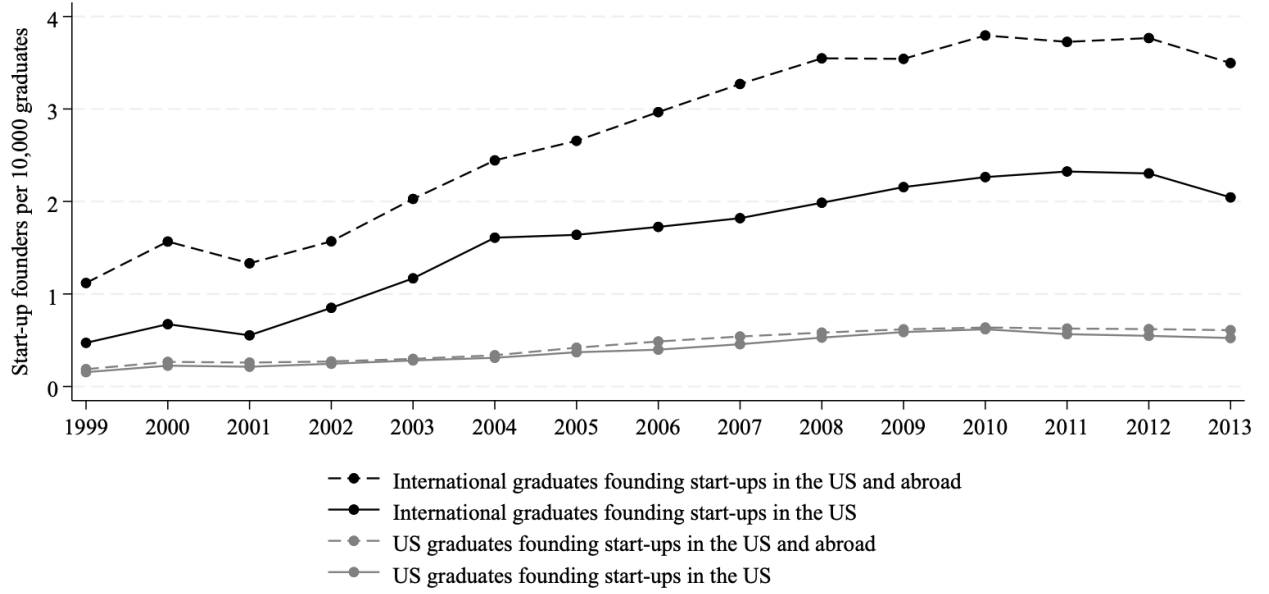
8 Figures

Figure 1: Distributions of Master's graduates start-up founders by study field, Type of university and origin country



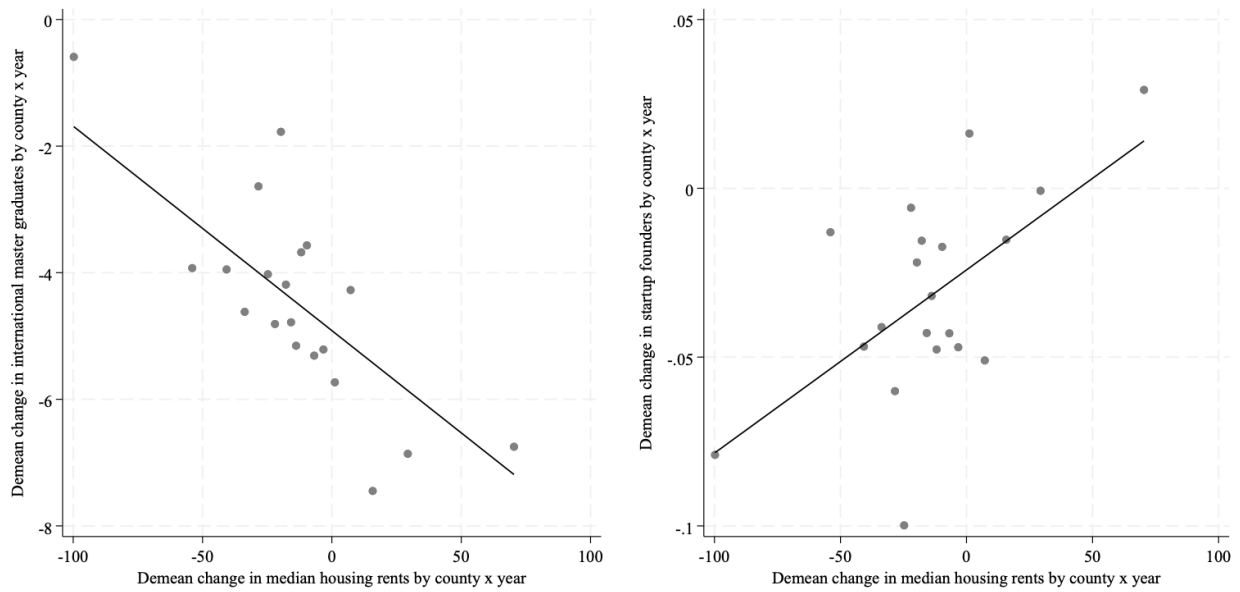
Notes: Panel A: Number of foreign start-up founders by field of their Master's Degree. Panel B: Start-up creation rates of foreign graduates by type of University institutions. Carnegie Classification of Institutions of Higher Education. R1: Doctoral Universities – Very High Research Activity. R2: Doctoral Universities – High Research Activity. Panel C: Start-up creation rates of foreign graduates by country of origin. Country of origin identified using F1 Visa data.

Figure 2: Start-up founder rate of native and foreign Master's graduates.



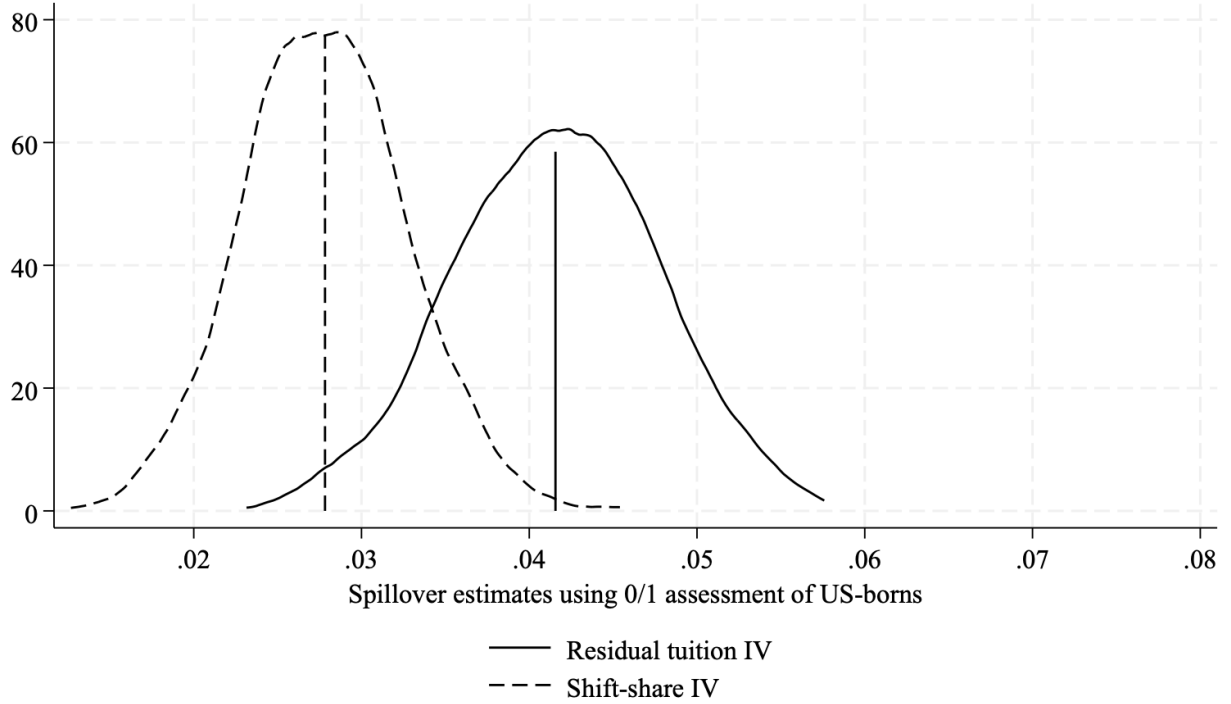
Notes: Evolution of the share of start-up founders within 5 years since graduation per 10,000 Master graduates. Foreign graduates-black line. Native graduates-grey line. The dashed line includes all startup created the continuous line only those created in the US. Decomposition between natives and foreign founders based on probabilistic measures drawn from Forebears.

Figure 3: Yearly changes in median rents vs foreign enrollment and vs. start-up creation: US counties, 1999-2014



Notes: Both figures using bin-scatter plots. Left panel: relationship between changes in the average number of international master graduates and changes in the median housing rents for 1-bedroom apartments by county and year. Right panel: relationship between changes in the average number of start-up founders and changes in the median housing rents for 1-bedroom apartments by county and year. All changes are demeaned by county and year.

Figure 4: Distribution of spillover effect estimates



Notes: Empirical distributions of the estimates of the spillover effects of foreign student share on start-ups creation estimated with residual tuition (solid line) and shift-share (dashed line) IVs. Estimates are obtained using 1000 iteration in which each time we re-draw foreign- and US-origin status of the founders following the probabilities of false positive and negatives obtained from Table 1. Smoothed distributions are obtained using a Kernel density estimation, with the selected bandwidth parameter based on Silverman's rule of thumb.

9 Tables

Table 1: Validation of the Forebears imputation

	Observed US-born	Observed foreign-born	Total
Predicted US-born	616 (68.22 %)	79 (12.42 %) False negatives	695
Predicted foreign-born	287 (31.78 %) False positives	557 (87.58 %)	844
Total	903 (100%)	636 (100%)	1539

Notes: The table compares a sub-sample of 1500 startup founders, manually checked to obtain almost certainty of the place of birth of individuals, with the attribution of U.S.-born and foreign-born using data from Forebears. The manual checks involved gathering information from various sources, including personal websites, LinkedIn profiles, videos, social media, news sites and similar to reach almost certain attribution of the place of birth of the start-up founder.

Table 2: Summary statistics for samples with/without founder's education information

	Start-ups with info on founders' name	Start-ups with info on founders' name + edu.	Difference in averages b/w samples
	(1)	(2)	(3)
Number of observations	80297	37628	
Average firm's age	7.47 (5.02)	7 (4.77)	-.47 (.03)
Average number of cofounders	1.43 (.72)	1.74 (.98)	.31 (.01)
Average capital raised within 3 first years (in millions of US dollars)	12.11 (369.78)	22.74 (261.63)	10.64 (1.88)
Average firm's imputed number of employees	107.35 (646.87)	118.52 (664.6)	11.18 (4.2)
Percentage of firm's patenting	10.04 (30.05)	12.4 (32.96)	2.36 (.2)
Percentage of foreign-born founders	61.3 (25.08)	62.14 (25.28)	.84 (.18)
Percentage of male founders	85.76 (34.95)	84.84 (35.86)	-.92 (.22)

Notes: This table compares summary statistics for two samples of start-ups in the Crunchbase data. In column (1) those including founders' name; in column (2) those including name and information on their highest degree attained.

Table 3: Summary statistics For the Tuition IV and Shift-Share IV samples.

	Tuition IV sample		SSIV sample	
	Mean	Standard Deviation	Mean	Standard Deviation
Total number of graduates	649.38	649.53	461.45	761.12
Number of international graduates	85.90	142.68	60.72	184.91
Number of US graduates	563.49	540.09	400.73	628.70
Share of international graduates	9.61	9.77	7.36	12.14
Share of international graduates in research universities	14.91	9.62	19.55	13.50
Share of international graduates in other universities	5.99	8.07	5.27	10.56
Number of entrepreneurs	0.14	0.65	0.36	2.13
Number of companies	0.15	0.71	0.40	2.37
Share of local start-ups	57.45	45.81	50.76	42.70
Share of start-ups surviving at least 3 years	98.62	10.53	99.16	5.44
Share of start-ups with funding above the median	33.95	42.26	40.46	39.56
Share of patenting companies	2.39	13.24	3.78	14.94

Notes: This table presents summary statistics for each sample used in the two instrumental variable (IV) identification strategies. The tuition IV sample consists of 463 public universities, classified as Doctoral Universities or Master's Colleges according to the Carnegie Classification of Institutions of Higher Education, covering the period from 1999 to 2014. The SSIV sample includes 548 private, not-for-profit universities, also classified as Doctoral Universities or Master's Colleges, covering the period from 2004 to 2014.

Table 4: First stage estimates and power of IV's.

Dependent variable:	Share of international graduates			
	(1)	(2)	(3)	(4)
Sample:	Public universities		Not-for-profit universities	
Standardized predicted residuals from equation (1)	-0.9026*** (0.1025)	-0.9023*** (0.1023)	-	-
Shift-share IV	-	-	0.0577*** (0.0128)	0.0547*** (0.0132)
Log number of master graduates	-	0.0418 (0.3808)	-	0.5898*** (0.2260)
Observations	6,899	6,899	6,028	6,028
University fixed effects	Yes	Yes	Yes	Yes
Carnegie x Year fixed effects	Yes	Yes	Yes	Yes
First-stage F-statistic	77.5	77.72	20.38	17.28

Notes: Coefficients of the first-stage regressions of the IV estimation procedure. Instruments: Cols (1-2): innovations of non resident tuition fees; estimation period: 1999-2014; sample: public US universities. Cols (3-4) predicted shares of foreign graduates based on shift-shares computed from 10 most important origins of foreign students; estimation period : 2004-2014; sample: private US universities.

Table 5: Impact of instruments on native and foreign graduates.

Dependent variable:	asinh(Number of graduates) (1) (2)		asinh(Number of foreign graduates) (3) (4)		asinh(Number of US graduates) (5) (6)	
Standardized predicted residuals from equation (1)	-0.0071 (0.0061)		-0.1043*** (0.0178)		0.0041 (0.0062)	
Shift-share IV		0.0061 (0.0045)		0.0049*** (0.0017)		0.0052 (0.0045)
Observations	6,899	6,028	6,899	6,028	6,899	6,028
University fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Carnegie x Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Dependent variable is the Hyperbolic Sine transformation of the number of Total (1 and 2), foreign (3 and 4) and US (5 and 6) graduates. Cols 1, 3 and 5: instrument: innovation of non resident tuition fees; estimation period: 1999-2014; sample: public US universities. Cols 2, 4 and 6: instrument: shift-share; estimation period: 2004-2014; sample: not-for-profit US universities.

Table 6: Test for pre-trends with tuition-IV

Dependent variable	Number of entrepreneurs (1)	Number of companies (2)	Expenses per master student (3)	Ratio of OPTs over foreign master graduates (4)	Ratio of graduates over enrollees in t-2 (5)	Ratio of foreign graduates over foreign enrollees in t-2 (6)	Ratio of US-born graduates over US-born enrollees in t-2 (7)
Joint pre-trends test p-value	.34	.3	.6	.81	.45	.86	.55
Joint pre-trends test F-statistic	(1.12)	(1.23)	(.68)	(.4)	(.92)	(.33)	(.76)

Notes: Each cell reports the p-value of a joint Wald (F) test of the null hypothesis that all pre-event event-study coefficients are equal to zero in specifications centered on university-specific changes in the tuition differential between international and domestic students. The event year is defined as the cohort year with the largest absolute change in the tuition differential at a given university, and event-time indicators are scaled by the signed magnitude of this change. The corresponding F-statistic is reported in parentheses. All specifications include university and year fixed effects. Standard errors are clustered at the cell level.

Table 7: Validity test of tuition and shift share IVs: correlation with previous values and pre-period trends.**Panel A: Residual tuition IV**

Controls :	Share of international graduates (4 years lag) (1)	Share of international graduates (5 years lag) (2)	Share of international enrollees (4 years lag) (3)	Share of international enrollees (5 years lag) (4)	Entrepreneurs per 10,000 graduates (4 years lag) (5)	Entrepreneurs per 10,000 graduates (5 years lag) (6)
<u>Dependent variable:</u>						
Predicted residuals from equation (1)	-6.6032 (6.0618)	-4.4219 (6.0834)	-0.4319 (13.5527)	6.5706 (14.4648)	-4.5844 (8.0873)	-3.5880 (8.4551)
Observations	7,791	7,791	7,651	7,627	7,606	7,577
Carnegie x Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
University fixed effects	Yes	Yes	Yes	Yes	Yes	Yes

Panel B: Shift-share IV

Controls :	Graduates (1)	Foreign graduates (2)	Change in number between 1995 and 2003		Foreign entrepreneurs (5)	US entrepreneurs (6)
			US graduates (3)	Entrepreneurs (4)		
<u>Dependent variable:</u>						
Change in predicted share of international graduates from SSIV b/w 2004 and 2014	0.1233 (0.1517)	1.9070*** (0.4835)	-0.0687 (0.1632)	-93.0237 (69.5576)	-210.2281 (165.8605)	-80.3994 (77.8220)
Observations	548	548	548	548	548	548

Notes: Panel A provides the correlation of the tuition based instrument with lagged values of the share of foreign enrolled and graduates 4 and 5 years before (cols 1-4) and lagged values of start-up founder rates. Unit of analysis: university-year. Panel B gives the cross-sectional correlation between the change of the share of international graduates predicted by the shift-share instrument with change in key explanatory variables and outcomes (number of foreign and US graduates and number of US and foreign start-up founders) over the period prior to the IV shares, namely 1995-2003. Col 1-3: previous change in total, foreign and native graduates. Col 4-6: previous change in total number of start-up founders, foreign ones and natives ones. Unit of analysis: university.

Table 8: Test for pre-trends correlations for main shares in IV

Dependent variable	Number of entrepreneurs (1)	Number of companies (2)	Expenses per master student (3)	Revenues per master student (4)	Ratio of OPTs over foreign master graduates (5)	Ratio of graduates over enrollees in t-2 (6)	Ratio of foreign graduates over foreign enrollees in t-2 (7)	Ratio of US-born graduates over US-born enrollees in t-2 (8)
China	.9298 (.1498)	.9857 (.0488)	.6633 (.5276)	.3194 (1.1704)	.9989 (.0087)	.731 (.4308)	.3466 (1.1026)	.9664 (.0885)
India	.9926 (.0311)	.9967 (.0179)	.8806 (.2229)	.6442 (.5558)	.9997 (.0036)	.8149 (.3145)	.5688 (.6725)	.9054 (.1869)
Canada	.5554 (.6944)	.8269 (.2979)	.6839 (.4976)	.3803 (1.0249)	.9951 (.0235)	.9630 (.0947)	.9154 (.172)	.6495 (.5479)
Vietnam	.6868 (.4935)	.8709 (.2366)	.8769 (.2281)	.734 (.4265)	.9991 (.0076)	.728 (.435)	.3378 (1.124)	.9627 (.0952)
Saudi Arabia	.8584 (.2542)	.9113 (.1781)	.9394 (.1348)	.8381 (.2825)	.9978 (.0138)	.7256 (.4384)	.6934 (.484)	.7079 (.4633)

Notes: For each country of origin (rows) and outcome (columns), the table reports the p-value of a joint Wald (F) test of the null that pre-treatment event-study coefficients are jointly equal to zero. Treatment intensity is defined as the baseline share of international students from the corresponding country at the university level, interacted with event-time indicators relative to 2007. The reported F-statistic appears in parentheses. All regressions include university and year fixed effects. Standard errors are clustered at the cell level.

Table 9: Impact of foreign-student share on number of startups: main specifications.

Dependent variable:	Number of entrepreneurs		Number of companies	Number of companies survived>3y	Number of companies funded above median	Number of patenting companies	Number of local companies
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A: Residual tuition IV							
Share of international master graduates	0.0014 (0.0009)	0.0563*** (0.0185)	0.0604*** (0.0196)	0.0596*** (0.0195)	0.0534*** (0.0139)	0.0075** (0.0032)	0.0351** (0.0138)
Observations	6,899	6,899	6,899	6,899	6,899	6,899	6,899
University fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Carnegie x Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
First-stage F-statistic	.	77.50	77.50	77.50	77.50	77.50	77.50
Panel B: Shift share IV							
Share of international master graduates	-0.0007 (0.0013)	0.0515*** (0.0189)	0.0461** (0.0195)	0.0473** (0.0196)	0.0394*** (0.0147)	0.0028 (0.0027)	0.0306** (0.0137)
Observations	6,028	6,028	6,028	6,028	6,028	6,028	6,028
University fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Carnegie x Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
First-stage F-Statistic	.	20.38	20.38	20.38	20.38	20.38	20.38

Notes: OLS and IV estimations of equation (1). Panel A: instrument : innovations to non resident tuition fees (equation 2); estimation period : 1999-2015; sample: public US universities . Panel B : shift-share IV based on 10 most popular origins of foreign graduates; estimation period : 2004-2015; sample: not-for-profit US universities. Col. (1-2): number of start-up founders. Col 3: Number of firms. Col 4: Number of firms still active after 3 years. Col 5. Number of firms with funding above the sample average. Number of companies patenting within 3 years. Number of firms located in same graduation state. Standard errors clustered at university-cohort level.

Table 10: Impact of foreign student share on start-up creation: robustness checks-Tuition-IV.

Dependent variable:	Number of entrepreneurs (1)	Number of companies (2)	Number of companies surviving>3y (3)	Number of companies funded above median (4)	Number of patenting companies (5)
Panel A: Controlling for University $\times$ period fixed effects					
Share of international master graduates	0.0817*** (0.0284)	0.0914*** (0.0300)	0.0910*** (0.0298)	0.0723*** (0.0216)	0.0108** (0.0048)
Observations	5,942	5,942	5,942	5,942	5,942
University x period fixed effects	Yes	Yes	Yes	Yes	Yes
Carnegie x Year fixed effects	Yes	Yes	Yes	Yes	Yes
First-stage F-statistic	55.11	55.11	55.11	55.11	55.11
Panel B: Controlling for University $\times$ time-trend fixed effects					
Share of international master graduates	0.0562*** (0.0185)	0.0603*** (0.0197)	0.0594*** (0.0196)	0.0534*** (0.0139)	0.0075** (0.0032)
Observations	6,900	6,900	6,900	6,900	6,900
University x time-trend fixed effects	Yes	Yes	Yes	Yes	Yes
Carnegie x Year fixed effects	Yes	Yes	Yes	Yes	Yes
First-stage F-statistic	76.60	76.60	76.60	76.60	76.60
Panel C: Estimating semi-elasticity					
log number of international master graduates	0.5037*** (0.1787)	0.5426*** (0.1898)	0.5348*** (0.1885)	0.4958*** (0.1412)	0.0694** (0.0305)
Observations	6,852	6,852	6,852	6,852	6,852
University fixed effects	Yes	Yes	Yes	Yes	Yes
Carnegie x Year fixed effects	Yes	Yes	Yes	Yes	Yes
First-stage F-statistic	41.79	41.79	41.79	41.79	41.79

Notes: This Table provides robustness checks of estimations results reported in Table 9, Panel A (tuition IV). In Panel A: equation (1) supplemented with university-period fixed effects. In Panel B: equation (1) supplemented with university specific trends. In Panel C: explanatory variable is (log of) number of foreign graduates rather than share of foreign graduates. Standard errors clustered at university-cohort level.

Table 11: Robustness: replicating the main specifications with Competitor group $\times$ Year fixed effects

Dependent variable:	Number of entrepreneurs (1)	Number of companies (2)	Number of surviving companies (3)	Number of companies funded above median (4)	Number of patenting companies (5)
Panel A. Tuition IV					
Share of international master graduates	0.0534*** (0.0192)	0.0572*** (0.0204)	0.0565*** (0.0203)	0.0508*** (0.0144)	0.0073** (0.0033)
Observations	6,899	6,899	6,899	6,899	6,899
University fixed effects	Yes	Yes	Yes	Yes	Yes
Peer Group x Year fixed effects	Yes	Yes	Yes	Yes	Yes
First-stage F-statistic	72.43	72.43	72.43	72.43	72.43
Panel B. Shift-share IV					
Share of international master graduates	0.0735*** (0.0223)	0.0707*** (0.0231)	0.0710*** (0.0232)	0.0578*** (0.0173)	0.0047 (0.0030)
Observations	6,028	6,028	6,028	6,028	6,028
University fixed effects	Yes	Yes	Yes	Yes	Yes
Peer Group x Year fixed effects	Yes	Yes	Yes	Yes	Yes
First-stage F-statistic	19.20	19.20	19.20	19.20	19.20

Notes: This table replicate the main specifications but include peer-group-by-year fixed effects. Peer groups are sets of comparable institutions defined for benchmarking purposes. These fixed effects absorb time-varying shocks common to similar universities, so identification relies on within-peer-group variation in international enrollment across universities over time. Estimation period: 1999-2015. Sample: public US universities. Panel B : shift-share IV based on 10 most popular origins of foreign graduates. Estimation period: 2004-2015. Sample: not-for-profit US universities. Definitions of dependent variables in cols (1-5): see Table 9.

Table 12: Heterogeneity in the effects, across Majors and locations.

Dependent variable:	(1)	(2)	Number of entrepreneurs		(5)	(6)
Sample:	STEM majors	non-STEM majors	Top 5 majors	Other majors	CZ with several universities	Other CZs
Panel A: Residual tuition IV						
Share of international master graduates	0.0299** (0.0122)	0.0264** (0.0109)	0.0320** (0.0125)	0.0244** (0.0111)	0.0887** (0.0350)	0.0383 (0.0236)
Observations	6,899	6,899	6,899	6,899	3,038	3,861
University fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Carnegie x Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
First-stage F-statistic	77.50	77.50	77.50	77.50	22.05	51.08
Panel B: Shift-share IV						
Share of international master graduates	0.0332** (0.0140)	0.0183** (0.0093)	0.0350** (0.0143)	0.0164* (0.0087)	0.0486** (0.0212)	0.0659 (0.0469)
Observations	6,028	6,028	6,028	4,400	1,628	
University fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Carnegie x Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
First-stage F-statistic	20.38	20.38	20.38	20.38	16.72	1.894

Notes: Estimation of equation (1) with tuition IV. In col (1): Science, Technology, Engineering and Mathematics (STEM) fields only. Col (2) : non STEM fields only. Col (3): top 5 majors of graduation only. Col (4): majors of graduation outside top 5. Col (5) graduates from universities located in commuting zones with more than 1 university. Col (6): Graduates from universities located in commuting zones with only 1 university. Standard errors clustered at university-cohort level.

Table 13: Spillover effects of foreign student share on US-origin start-ups, identified using probability of US-born from names.

Dependent variable:	Number of entrepreneurs (1)	Number of companies (2)	Number of surviving companies (3)	Number of companies funded above median (4)	Number of patenting companies (5)
Panel A: Residual tuition IV					
Share of international master graduates	0.0228*** (0.0082)	0.0231*** (0.0086)	0.0229*** (0.0085)	0.0252*** (0.0067)	0.0020* (0.0010)
Observations	6,899	6,899	6,899	6,899	6,899
University fixed effects	Yes	Yes	Yes	Yes	Yes
Carnegie x Year fixed effects	Yes	Yes	Yes	Yes	Yes
First-stage F-statistic t	77.50	77.50	77.50	77.50	77.50
Shift-share IV					
Share of international master graduates	0.0133*** (0.0064)	0.0108 (0.0068)	0.0115* (0.0068)	0.0131** (0.0053)	0.0005 (0.0010)
Observations	6,028	6,028	6,028	6,028	6,028
University fixed effects	Yes	Yes	Yes	Yes	Yes
Carnegie x Year fixed effects	Yes	Yes	Yes	Yes	Yes
First-stage F-statistic	20.38	20.38	20.38	20.38	20.38

Notes: US and native born status imputed with probabilistic prediction from the Forebears algorithm. See Text for full explanation. Panel A: tuition-based instrument. Panel B: shift-share instrument. See Table 9 for definition of dependent variables used in cols (1-5). Standard errors clustered at university-cohort level.

Table 14: Spillover effects of foreign student share on US-origin start-ups, identified using 0-1 assessment of US-born from names.

Dependent variable:	Number of entrepreneurs (1)	Number of companies (2)	Number of surviving companies (3)	Number of companies funded above median (4)	Number of patenting companies (5)
Panel A: Residual tuition IV					
Share of international master graduates	0.0423*** (0.0143)	0.0431*** (0.0149)	0.0432*** (0.0149)	0.0442*** (0.0116)	0.0053* (0.0029)
Observations	6,899	6,899	6,899	6,899	6,899
University fixed effects	Yes	Yes	Yes	Yes	Yes
Carnegie x Year fixed effects	Yes	Yes	Yes	Yes	Yes
First-stage F-statistic	77.50	77.50	77.50	77.50	77.50
Panel B: Shift-share IV					
Share of international master graduates	0.0205* (0.0111)	0.0171 (0.0121)	0.0185 (0.0121)	0.0215** (0.0099)	0.0010 (0.0018)
Observations	6,028	6,028	6,028	6,028	6,028
University fixed effects	Yes	Yes	Yes	Yes	Yes
Carnegie x Year fixed effects	Yes	Yes	Yes	Yes	Yes
First-stage F-statistic	20.38	20.38	20.38	20.38	20.38

Notes: US and native born status imputed with dichotomous (0-1) prediction from Forebears, based on the country of origin with largest probability. See main text for full explanation. Panel A: tuition-based instrumentation. Panel B: shift-share instrumentation. See Table 9 for definition of dependent variables used in cols (1-5). Standard errors clustered at university-cohort level.

Table 15: Effect of foreign-born share on number of co-founded startups.

Dependent variable:	Number of cofounded companies					
	All co-founded	from same univ.	b/w US/foreign born founders	b/w US/foreign born from same univ.	b/w US/foreign born early collaborators	b/w US/foreign born early collaborators from same univ.
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A. Residual tuition IV						
Share of international master graduates	0.0580*** (0.0143)	0.0161** (0.0066)	0.0154** (0.0070)	0.0072* (0.0038)	0.0208*** (0.0077)	0.0093** (0.0045)
Observations	6,899	6,899	6,899	6,899	6,899	6,899
University fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Carnegie x Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
First-stage F-statistic	77.50	77.50	77.50	77.50	77.50	77.50
Panel B. Shift-share IV						
Share of international master graduates	0.0437*** (0.0156)	0.0211*** (0.0078)	0.0140 (0.0097)	0.0046 (0.0053)	0.0092 (0.0111)	0.0059 (0.0058)
Observations	6,028	6,028	6,028	6,028	6,028	6,028
University fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Carnegie x Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
First-stage F-statistic	20.38	20.38	20.38	20.38	20.38	20.38

Notes: Panel A: IV estimation with tuition based instrument. Panel B: IV estimation with shift-share instrument. Dependent variables : col (1): all co-founded firms; col (2) : number of co-founded firms with founders from same university; col (3) : number of co-founded firms with founders from same university and cohort; col (4): number of co-founded firms with founders with different foreign born/native status (predicted by Forebears, dichotomous approach); col (5): number of co-founded firms with founders with different foreign born/native status from same university (predicted by Forebears, dichotomous approach) . Standard errors clustered at university-cohort level.

Table 16: Effect of foreign-born share on count of startups differentiated from US ones and similar to Foreign ones, by keyword type.

Dependent variable:	(1) Number of companies above median median distance with US start-ups	(2) Number of companies above median median distance with US start-ups from same category	(3) Number of companies below median median distance with start-ups abroad	(4) Number of companies below median median distance with start-ups abroad from same category
Panel A. Residual tuition IV				
Share of international master graduates	0.0258** (0.0107)	0.0267** (0.0123)	0.0273** (0.0116)	0.0378*** (0.0122)
Observations	6,899	6,899	6,899	6,899
University fixed effects	Yes	Yes	Yes	Yes
Carnegie x Year fixed effects	Yes	Yes	Yes	Yes
First-stage F-statistic	77.50	77.50	77.50	77.50
Panel B. Shift-share IV				
Share of international master graduates	0.0253** (0.0098)	0.0255** (0.0111)	0.0143 (0.0127)	0.0065 (0.0109)
Observations	6,028	6,028	6,028	6,028
University fixed effects	Yes	Yes	Yes	Yes
Carnegie x Year fixed effects	Yes	Yes	Yes	Yes
First-stage F-statistic	20.38	20.38	20.38	20.38

Notes: Panel A: IV estimation with tuition based instrument. Panel B: IV estimation with shift-share instrument. Diversity is measured through the Euclidian distance from a set of 770 keywords describing the activity and type of start-ups. Distance of a given start-up is measured from the average frequency of keywords of start-ups. Standard errors clustered at university-cohort level.

Online Appendix

1 Shift share IV based on the 10 main origins of foreign students

We use the F1-FOIA data to construct the foreign born students enrolled from each specific country of origin (Denoted as o) as share of the total students enrolled. We also use the F1-FOIA data to measure the foreign students in each origin country in each university in the initial year.

We denote as t_0 the initial year which will be the year 2001. Then the construction of the IV and the analysis will be for years $t = 2002, 2003, \dots 2013$.

u is the index for individual universities. The universe of universities considered is U

o is the index for countries of origin. The universe of countries of origin is denoted as O .

t denotes years.

The notation $N_{u,o,t}^{F1}$ indicates the number of enrolled students, N , in university u from country of origin o in year t , obtained from source $F1$, where "source" is the dataset of $F1$ obtained using the FOIA.

We describe the procedure to construct the shift-share IV step by step. The procedure should be done separately for "Master" and for "Bachelor" students, obtaining separate cells for each and then we pool them in the regression. Therefore we will not use the indicator "degree", as the same procedure will be done separately.

1.1 Defining and constructing the “shift”

First calculate, the total number of foreign students enrolled (in the US) from country of origin o in year t by aggregating those data across universities as follows:

$$N_{o,t}^{F1} = \sum_{u \in U} N_{u,o,t}^{F1} \quad (4)$$

Then we aggregate further to obtain the total number of foreign students (from any origin, in the US) in year t , based on the $F1$ data, as follows:

$$(NFOR)_t^{F1} = \sum_{o \in O} N_{o,t}^{F1} \quad (5)$$

1.2 Constructing the “share”

The number of initial foreign-born students from country o enrolled in university u in year t_0 as share of total students from country o (so that the sum across universities in each year, for each

country of origin is 1, and we will use this to distribute the total foreign-born from country o across universities) is as follows:

$$(Share)_{u,o,t_0}^{F1} = \frac{N_{u,o,t_0}^{F1}}{N_{o,t_0}^{F1}} \quad (6)$$

1.3 The “shift-share” IV

The imputed number of foreign-born students from country o enrolled in each university u in Year t using the initial share and the yearly "flow" of enrolled students will be as follows:

$$(\hat{N})_{o,u,t} = (Share)_{u,o,t_0}^{F1} * (N)_{o,t}^{F1} \quad (7)$$

And the total number of imputed foreign students overall for university u and year t will be:

$$(\hat{N})_{u,t} = \sum_{o \in O} (\hat{N})_{o,u,t} \quad (8)$$

This variable, $(\hat{N})_{u,t}$, which varies at the university and year level, is what we will use as Instrument.

The share of foreign students in a school, obtained from *IPEDS* will then be instrumented by the imputed share that uses the shift-share imputation for foreigners as follows:

$$(\hat{Share})_{u,t} = \frac{(\hat{N})_{u,t}}{(\hat{N})_{u,t} + (NUS)_{u,t_0}} \quad (9)$$

where $(NUS)_{u,t_0}$ is the total number of Native US students enrolled in university u in year t_0 (2000, 2001), so as to keep the number of natives fixed and unaffected by foreign flows in the IV.

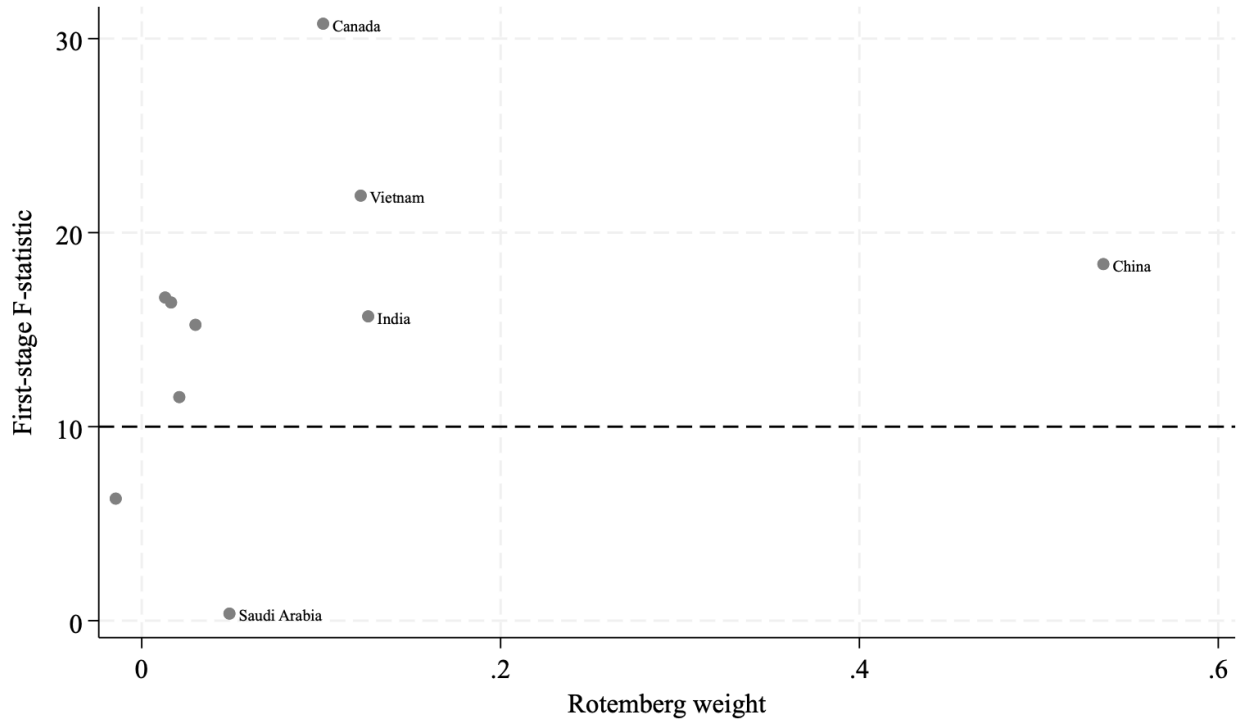
Table A1: Rotemberg weights in the shift-share IV

Panel A: Correlations of country aggregates					
	α_k	g_k	β_k	F_k	SD(share _k)
α_k	1				
g_k	-0.166	1			
β_k	-0.120	-0.101	1		
F_k	0.285	0.108	0.162	1	
SD(share _k)	-0.279	-0.123	0.463	-0.068	1

Panel B: Top 5 Rotemberg weight countries					
	$\hat{\alpha}_k$	g_k	$\hat{\beta}_k$	95% CI	Mean share (%)
China	0.536	9.560	0.458	(0.20,0.50)	0.051
India	0.126	9.224	0.196	(0.00,0.20)	0.035
Vietnam	0.122	11.082	1.363	(0.30,1.50)	0.042
Canada	0.101	17.795	0.823	(0.20,0.80)	0.087
Saudi Arabia	0.049	12.628	0.682	(-10.00,10.00)	0.058

Notes: Panel A provides the correlation between Rotemberg related statistics of the shift-share IV estimation. α_k is the country k specific weight in the shift share IV estimation. g_k is the size of the country k shock, i.e. the size of the shift from country k . β_k is the country k specific IV estimation and F_k is its related estimated F-stat. SD(share_k) is the cross-university dispersion of the historical share of students from country k . Panel B provides estimates of country specific statistics. Mean share gives the average historical share of students from that country across universities.

Figure A1: Country specific F-stats and Rotemberg weights



Notes: The Figure provides a plot of country k specific F-stat and estimates of Rotemberg weights for the 10 origin countries used in the shift-share IV estimation. On the X axis : $\hat{\alpha}_k$. On the Y axis: F_k . Horizontal dashed line gives the usual threshold of F-stat showing evidence of strong instruments.

2 Additional Tables

Table A2: Top 10 public and private universities by number of startups.

University	Number of start-ups (1)	Start-ups by 10,000 graduates (2)	Average share of international graduates (3)
Public universities			
University of California-Berkeley	90	28.82	22.77
University of California-Los Angeles	82	20.65	16.64
The University of Texas at Austin	65	14.38	22.24
University of Michigan-Ann Arbor	53	9.51	25.09
University of Virginia-Main Campus	34	13.27	13.56
University of Washington-Tacoma Campus	27	111.52	1.47
University of North Carolina at Chapel Hill	23	7.83	10.19
University of Central Florida	23	7.87	9.87
University of Colorado Boulder	21	11.92	14.79
Georgia Institute of Technology-Main Campus	21	8.84	39.77
Private universities			
Stanford University	373	111.75	33.55
Harvard University	297	53.45	29.03
Massachusetts Institute of Technology	229	91.55	36.25
Columbia University in the City of New York	178	21.26	32.9
University of Pennsylvania	173	37.14	27.38
New York University	114	12.12	21.42
Northwestern University	114	25.88	22.87
University of Chicago	107	27.23	25.53
University of Southern California	90	13.04	32.47
Carnegie Mellon University	72	26.53	44.43

Notes: Sources: Col (1-2): Crunchbase; col (3) : IPEDS.

Table A3: Preliminary regressions of the tuition IV procedure.

Dependent variable: :	Difference between in-state and out-of-state tuitions		
	(1)	(2)	(3)
Share state appropriations	925.3*** (100.6)	1,247*** (95.37)	2,877*** (130.4)
Number of international graduates (1 year lag)	-	14.97*** (0.189)	3.773*** (0.286)
University revenues (in dollars)	-	-	3.66e-06*** (5.38e-08)
Revenues per student (in dollars)	-	-	-0.00111*** (0.000213)
Instruction expenses per student (in dollars)	-	-	-0.000849* (0.000498)
All expenses per student (in dollars)	-	-	0.00112*** (0.000240)
Constant	4,002*** (24.73)	3,595*** (23.97)	3,325*** (46.80)
Observations	54,673	54,673	32,342
R-squared	0.209	0.291	0.320
Year FE	Yes	Yes	Yes
Degree FE	Yes	Yes	Yes

Notes: This table presents regressions of equation 2 used to generate $\widehat{\nu_{u,t}}$, the innovations in the difference between out-of-state and in-state tuition fees which are subsequently used as instruments in equations (1) and (3). Sources of all covariates: IPEDS.

Table A4: Impact of instruments on native and foreign graduates.

Dependent variable:	log(Number of graduates + 1) (1)	log(Number of graduates + 1) (2)	log(Number of foreign graduates + 1) (3)	log(Number of foreign graduates + 1) (4)	log(Number of US graduates + 1) (5)	log(Number of US graduates + 1) (6)
Standardized predicted residuals from equation (1)	-0.0071 (0.0061)		-0.1043*** (0.0178)		0.0041 (0.0062)	
Shift-share IV		0.0061 (0.0045)		0.0049*** (0.0017)		0.0052 (0.0045)
Observations	6,899	6,028	6,899	6,028	6,899	6,028
University fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Carnegie x Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Dependent variable is the log number of Total (1 and 2), foreign (3 and 4) and US (5 and 6) graduates + 1. Cols 1, 3 and 5: instrument: innovation of non resident tuition fees; estimation period: 1999-2014; sample: public US universities. Cols 2, 4 and 6: instrument: shift-share; estimation period: 2004-2014; sample: not-for-profit US universities.

Table A5: Robustness checks of overall effects estimated with shift-share IV.

Dependent variable:	Number of entrepreneurs (1)	Number of companies (2)	Number of surviving companies (3)	Number of companies funded above median (4)	Number of patenting companies (5)
Panel A: Controlling for University $\times$ period fixed effects					
Share of international master graduates	0.0296 (0.0217)	0.0260 (0.0222)	0.0271 (0.0226)	0.0265 (0.0171)	0.0018 (0.0038)
Observations	4,008	4,008	4,008	4,008	4,008
University $\times$ period fixed effects	Yes	Yes	Yes	Yes	Yes
Carnegie $\times$ Year fixed effects	Yes	Yes	Yes	Yes	Yes
First-stage F-statistic t	18.93	18.93	18.93	18.93	18.93
Panel B: Controlling for University $\times$ time-trend fixed effects					
Share of international master graduates	0.0506*** (0.0189)	0.0452** (0.0194)	0.0464** (0.0196)	0.0388*** (0.0147)	0.0027 (0.0028)
Observations	6,028	6,028	6,028	6,028	6,028
University $\times$ time-trend fixed effects	Yes	Yes	Yes	Yes	Yes
Carnegie $\times$ Year fixed effects	Yes	Yes	Yes	Yes	Yes
First-stage F-statistic	20.22	20.22	20.22	20.22	20.22
Panel C: Estimating semi-elasticity					
log number of international master graduates	0.6863** (0.3232)	0.6152* (0.3179)	0.6308* (0.3218)	0.5256** (0.2501)	0.0369 (0.0386)
Observations	6,028	6,028	6,028	6,028	6,028
University fixed effects	Yes	Yes	Yes	Yes	Yes
Carnegie $\times$ Year fixed effects	Yes	Yes	Yes	Yes	Yes
First-stage F-statistic	10.10	10.10	10.10	10.10	10.10

Notes: This Table provides robustness checks of estimations results reported in Table 9, Panel B (shift-share IV). In Panel A: equation (1) supplemented with university-period fixed effects. In Panel B: equation (1) supplemented with university specific trends. In Panel C: explanatory variable is (log of) number of foreign graduates rather than share of foreign graduates. Standard errors clustered at university-cohort level.

Table A6: Impact of foreign graduation on start-ups: accounting for size of native cohort.

Dependent variable:	Number of entrepreneurs (1)	Number of companies (2)	Number of surviving companies (3)	Number of companies funded above median (4)	Number of patenting companies (5)
Panel A. Tuition IV					
Share of international master graduates	0.0563*** (0.0185)	0.0604*** (0.0197)	0.0596*** (0.0195)	0.0535*** (0.0139)	0.0075** (0.0032)
log number of master graduates	0.0015 (0.0234)	0.0016 (0.0255)	0.0017 (0.0252)	-0.0171 (0.0210)	-0.0013 (0.0031)
Observations	6,899	6,899	6,899	6,899	6,899
University fixed effects	Yes	Yes	Yes	Yes	Yes
Carnegie $\times$ Year fixed effects	Yes	Yes	Yes	Yes	Yes
First-stage F-statistic	77.72	77.72	77.72	77.72	77.72
Panel B. Shift-share IV					
Share of international master graduates	0.0554*** (0.0202)	0.0496** (0.0207)	0.0508** (0.0209)	0.0424*** (0.0157)	0.0030 (0.0029)
log number of master graduates	-0.0447** (0.0195)	-0.0389** (0.0197)	-0.0393** (0.0199)	-0.0335** (0.0151)	-0.0024 (0.0028)
Observations	6,028	6,028	6,028	6,028	6,028
University fixed effects	Yes	Yes	Yes	Yes	Yes
Carnegie $\times$ Year fixed effects	Yes	Yes	Yes	Yes	Yes
First-stage F-statistic	17.28	17.28	17.28	17.28	17.28

Notes: IV estimations of equation (1) supplemented with size of cohort. Panel A: instrument: innovations to non resident tuition fees (equation 2). Estimation period: 1999-2015. Sample: public US universities. Panel B : shift-share IV based on 10 most popular origins of foreign graduates. Estimation period: 2004-2015. Sample: not-for-profit US universities. Definitions of dependent variables in cols (1-5): see Table 9.

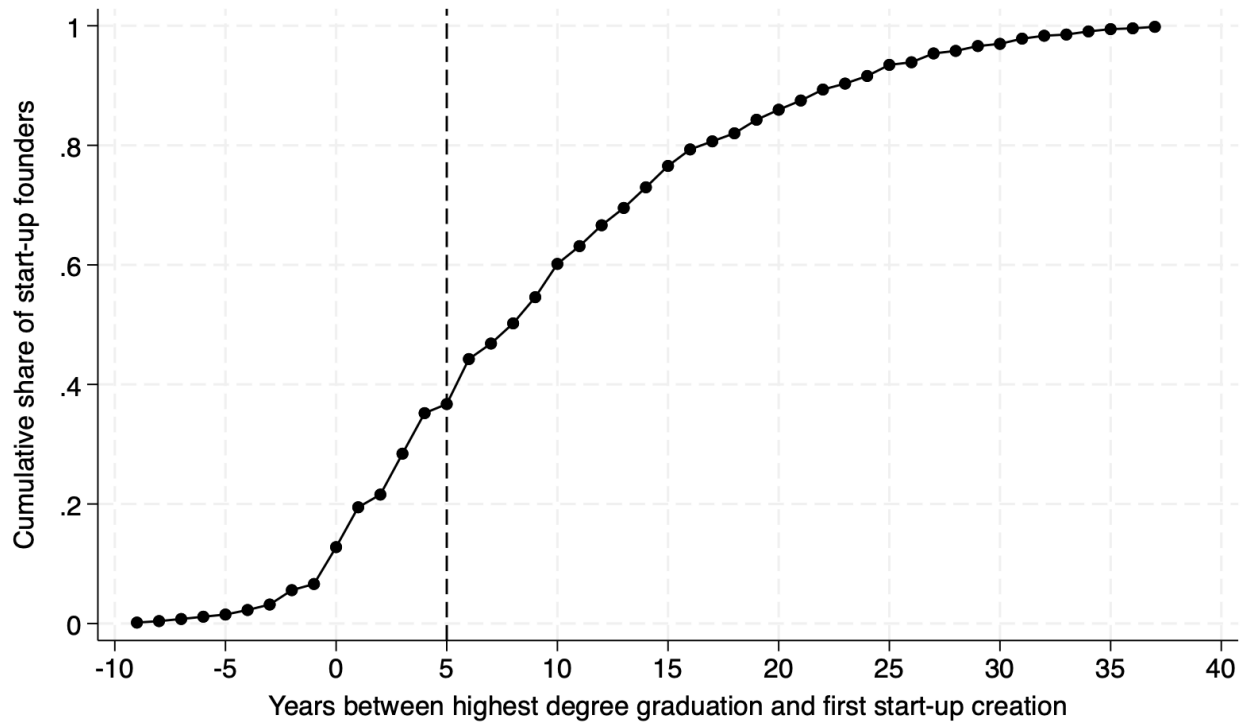
Table A7: Validity test: relationship between residual tuition-IV and graduation rates.

Dependent variable:	Graduation rate US-born students (1)	Graduation rate International students (2)	Difference b/w graduation rates of US-born and international students (3)
Predicted residuals from equation (1)	-0.0018 (0.0024)	-0.0017 (0.0101)	0.0015 (0.0086)
Observations	6,899	6,899	6,899
University fixed effects	Yes	Yes	Yes
Carnegie $\times$ Year fixed effects	Yes	Yes	Yes

Notes: This table regresses the ratio of graduates per enrollees by university cohort on the residual tuition IV specifically computed on tuition charged to students. Standard errors are clustered at the university-cohort level.

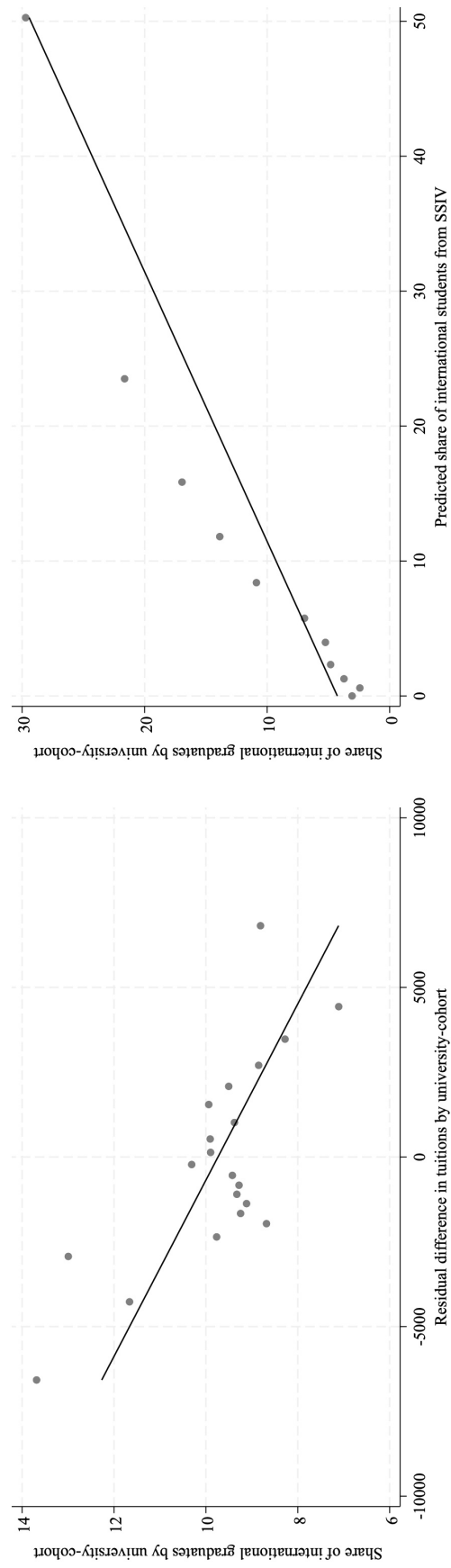
3 Additional Figures

Figure A2: Time between graduation and first start-up creation



Notes: This figure provides the cumulative distribution of the proportion of start-up creation dates compared with timing of graduation. Founders include US-born and foreign born founders. Timing of start-up creation drawn from Crunchbase database. Timing of graduation drawn from IPEDS.

Figure A3: Bin scatter plots of first stages of tuition-based IV and shift-share IV.



Notes: These figures present bin scatter plots of the tuition-based and shift-share instruments with the share of foreign graduates at the university-cohort level. Left panel: tuition-based instrument. Right panel: share of foreign graduates predicted by shift-share instrument.