Trade Liberalization and Chinese Students in US Higher Education*

Gaurav Khanna† Kevin Shih‡ Ariel Weinberger§

Mingzhi Xu¶ Miaojie Yu‖

Abstract

We highlight a lesser-known consequence of China's integration into the world economy: the rise of services trade. We demonstrate how the US's trade deficit in goods cycles back as a surplus in US exports of education services. Focusing on China's accession to the World Trade Organization, we show that Chinese cities more exposed to trade liberalization sent more students to US universities. Growth in housing income/wealth allowed Chinese families to afford US tuition, and more students financed their studies using personal funds. Our estimates suggest that recent trade wars could cost US universities around $1.1 bn in annual tuition revenue.

JEL: F16, I25, J24; J61

Keywords: Trade Liberalization, International Students, Service Exports.

---

*We thank Robert Feenstra for the Chinese trade data from the CID at UC Davis. We thank Sen Zhou for the National College Entrance Examination data. We thank Bingzhao Li for outstanding research assistance. We thank Francesca Antmann, Sam Bazzi, Patricia Cortes, Kyle Handley, Gordon Hanson, Will Olney, Giovanni Peri, Heiwai Tang and seminar participants at the FREIT Empirical Trade Seminar, the SEA, APPAM 2020, NEUDC, University of Glasgow Migration and Mobility Workshop, Barcelona GSE, Migration and Development Conference (Madrid), SUFE-IESR Trade Workshop, Queens College, UC Davis, UCSD, Center for Global Development, and Peking University for comments. Mingzhi Xu thanks financial support from the National Natural Science Foundation of China (No.72003003) and Peking University Initiative Scientific Research Program (No.7101302576); Miaojie Yu thanks financial support from National Natural Science Foundation of China (No. 71625007) and Social Science Foundation of China (No. 20ZDA050).

†University of California – San Diego, gakhanna@ucsd.edu, econgaurav.com

‡Queens College CUNY, Kevin.Shih@qc.cuny.edu, kevinyshih.weebly.com

§George Washington University, AWeinberger@gwu.edu, aweinberger.weebly.com

¶Peking University, mingzhixu@nsd.pku.edu.cn, mingzhixu.com

‖Liaoning University, mjyu@nsd.pku.edu.cn, mjyu@nsd.pku.edu.cn

1 Introduction

China's remarkable growth over the last two decades began with its entry into the global economy as "the world's factory." That same growth has culminated in rising tensions with the United States, manifesting in an ongoing trade war with geopolitical tensions rising. In this paper, we highlight a lesser-known consequence of China's growth and integration into the world economy in relation to the US: the rise of services trade. We show that trade-driven growth raised income and housing wealth, generating demand for US services, and higher education in particular. As such, a trade deficit in goods can partially cycle back as services exports in the developed country. This provides a new channel through which openness to trade leads to human capital accumulation and flows of individuals from developing countries (Clemens, 2014; Bazzi, 2017; Venables, 1999).

US higher education has been transformed by marked increases in international enrollment since 2005, driven by Chinese students whose enrollment grew 400% over this period (Figure 1a). Full-fare paying foreign students generated much-needed revenue for universities, often used to the advantage of domestic students (Bound et al., 2020; Shih, 2017).[1] In the same decade after 2005, China's GDP per capita quintupled, from $1,500 to more than $7,500 (World Bank WDI). Rapid economic growth in China increased the affordability of US higher education and expanded the size of college-ready, high-school graduate cohorts. A major driver of this change was China's accession to the World Trade Organization (WTO) in 2001 (Zhu, 2012). In this paper, we demonstrate how this episode of trade liberalization was a crucial determinant of Chinese imports of higher education services from the US.

Detailed, sub-national examination of services trade has been severely constrained due to data limitations. We utilize a novel database of US education exports to international students, obtained through a Freedom of Information Act (FOIA) request, detailing students'

[1] However, tensions have now spilled over to education as well, as the US moved to expel Chinese students with ties to the Chinese military (US to Expel Chinese Graduate Students, NYT, 28 May, 2020).

city of origin, degree level, university, the field of study, and financial support. This allows us to exploit variation across Chinese prefecture cities in trade liberalization stemming from the reduction in tariff uncertainty with the US during China's 2001 accession to the WTO.

Previously, regular Congressional approval was required to maintain low Normal Trade Relations (NTR) tariffs on Chinese imports. Failure to renew would result in a sudden increase in high non-NTR rates. In 2001, the US made NTR tariff rates permanent. Gaps between NTR and non-NTR tariffs across products help measure the reduction in uncertainty following the conferral of permanent NTR (PNTR) rates. Eliminating tariff uncertainty increased commerce between the US and China and induced export-driven growth in Chinese cities (Figure 1b) (Pierce and Schott, 2016). We develop a city-level exposure measure that is the average gap between NTR and non-NTR rates across products, weighted by the composition of exports by product within cities prior to 2001. This allows us to compare student flows across cities more and less intensely affected by the conferral of PNTR rates.

We find a significant and positive association between trade liberalization and student flows: a 10 percentage point (p.p.) increase in PNTR exposure led to growth in Chinese student enrollment in the US of around 34 students per million city residents.[2] This accounts for 40% of the increase in the flow of Chinese international students by 2013 (relative to the pre-WTO entry). As such, the WTO accession induced substantial student flows externally, and not just internal migration as shown previously (Facchini et al., 2019).

Our results inform the consequences of the 2018 US-China trade war. Our counterfactuals show that uncertainty in tariff increases of 20 p.ps could cost US universities a quarter of the current flow of Chinese students while universities are increasingly reliant on revenue from China (Bound et al., 2020), and reduce total educational exports by 6%.[3]

---

[2]Our units of analysis are Chinese prefecture-level cities. In the text, we use the terms cities and prefectures interchangeably. We use prefectures, as they determine an individual's *hukou*. Even if individuals move within their *hukou* jurisdiction, we assign them to their correct prefecture.

[3]This estimated loss to universities does not account for spillovers on surrounding localities. Institute for International Education (2019) estimates that there were more than one million international students

Our findings are representative of broader implications. While our unique data allows us to focus on education exports, rising services demand in response to trade liberalization applies to other sectors, such as information and financial services. Although the US goods deficit dominates its services surplus, the global growth of services trade implies that services will soon be sizable enough to shift trade balances (McKinsey Global Institute, 2019). We spell out possible mechanisms for our study and argue that some apply more generally.

Alongside increases in scale, we observe changes in the composition of Chinese students. While Chinese students initially tended towards STEM (science, technology, engineering, and mathematics) majors, trade liberalization induced large responses in social sciences and business-related fields. Chinese students traditionally enrolled in Doctoral programs, which typically funded students. Trade liberalization induced a shift towards undergraduate studies, which provides little funding, and often requires full-sticker price tuition payments. As such, we find that PNTR exposure increased the share of students financing their education through personal funds, rather than through scholarships/fellowships.

We outline a simple conceptual framework where firms' decisions depend on the uncertainty of future tariff levels; local labor and housing markets respond to firm expansions, and households make education choices given their income and financial constraints. The framework informs our estimation and potential mechanisms, which we test empirically. Consistent with the growth in self-funded students, we show that trade liberalization increased global demand for Chinese manufactured goods and, subsequently, the income and wealth of city residents. First, PNTR exposure led to an increase in exports of 34% at the city level. Given the relatively high average cost of US tuition, we focus on various sources of wealth and income growth, including real estate appreciation and own-business income. Given limited investment opportunities in China, a meaningful fraction of wealth expansion occurred through housing ownership (Chen and Wen, 2017). We show that trade liberalization increased property values and rental income, contributing to related findings

in 2019 (a third of which were from China), and they contributed $45 billion to the US economy.

on employment and investment (Cheng and Potlogea, 2017), and wage growth (Erten and Leight, 2020). Expanding income and wealth allowed families with the means to finance the high cost of paying for housing and tuition in the US. We also explore and find a lesser role for other channels, such as changing returns to education, and increased information flows. Although the *returns* channel is specific to the education industry, the income and wealth channels likely apply to other service exports as well.

Empirical identification is derived from industry-level shocks due to the conferral of PNTR, using recent insights on shift-share estimation (Borusyak, Hull and Jaravel, 2020). We demonstrate that industry NTR gaps appear well-balanced with respect to a variety of industry characteristics prior to WTO, and validate our identification assumption – that PNTR exposure is exogenous conditional on industry correlates. Regional balance tests show no evidence of differential trends in student flows and other education measures prior to 2001, no pre-WTO correlation with economic indicators, demographics or skill/capital intensity. Our estimates are consistent under a variety of robustness and falsification tests, and inference corrections for correlation across cities in baseline industry shares.

We contribute to two strands of the trade literature: the importance of labor reallocation and demand in driving trade patterns. Although the detrimental impacts from Chinese goods imports are well documented (Autor, Dorn and Hanson, 2013; Pierce and Schott, 2016), less is known about services trade, which accounts for over a third of US trade activity (Eaton and Kortum, 2018). We exploit detailed data on education service exports to show that trade-driven income growth in China generated strong demand for US higher education, complementing recent findings that trade with China raised non-manufacturing employment (Wang et al., 2018; Bloom et al., 2019; Caliendo, Dvorkin and Parro, 2019). While trade dynamics are driven by relative production costs in previous studies, our empirical findings highlight an increase in the *demand* for services through greater wealth abroad, consistent with theories on non-homotheticity in demand (Matsuyama, 1992; Foellmi, Hepenstrick and Josef, 2017; Dingel, 2016). As such, our findings indicate that a trade deficit in goods partly cycled back to the US as a surplus in educational services.

We also add to two strands of the human-mobility literature on the inverted-U-shaped relationship between migration and development (Clemens, 2014). The first strand highlights how better prospects at home may result in *out*-migration, as income gains are used to overcome migration-cost barriers.[4] These migration costs are quantifiable for international students as standard tuition and living expenses at US higher education institutions. In contrast, canonical models also show that higher local income may also raise the opportunity cost of emigrating (Angelucci, 2015; Bazzi, 2017). As many international students view the study in the US as a pathway to joining the US labor market (Bound et al., 2015; Shih, 2016), better income opportunities at home may lower the option value of a US degree. As such, it is unclear whether economic growth at home, induced by trade liberalization, would lead to more outflows. We resolve this ambiguity, by showing that income/wealth generation, attributable to trade liberalization, encouraged student flows to the United States.

The second strand of studies offers theoretical justifications for whether migration and trade are substitutes or complements. Although the standard Heckscher-Ohlin model predicts that trade is a substitute for migration, extensions to this model can result in a complementary relationship (Venables, 1999). There is scant evidence in this regard, although studies mostly reject substitutability (Collins, O'Rourke and Williamson, 1997). Our paper provides an unexplored channel for trade and migration as complements. Finally, we speak to recent work on trade and education (Liu, 2017; Li, 2018; Xu, 2020). While prior work has analyzed human capital decisions stemming from changes in the returns to education (Greenland and Lopresti, 2016; Atkin, 2016; Blanchard and Olney, 2017), we highlight the role of trade-induced wealth generation in helping overcome financial barriers to study abroad.

[4]While student flows are distinct from work-related migration, they are intertwined. Students consider costs (travel, tuition, and board, being away from family), similar to migration costs for economic migrants. They also consider returns to studying abroad, as a large fraction of students go abroad with the aim of joining the US labor market (Bound et al., 2015). As such, we sometimes use the term student "migrants".

2 China's Accession to the WTO

On December 11, 2001, China joined the WTO, converting the uncertain Most Favored Nation (MFN) tariff regime to a permanent NTR tariff regime. Since 1980, the US granted low MFN tariffs to China–subject to yearly Congressional renewal–despite it not having MFN status. The annual renewals generated uncertainty over the low-tariff regime's longevity, which inhibited the expansion of commerce between the US and China (Pierce and Schott, 2016; Handley and Limão, 2017). Termination of MFN status would have increased tariffs facing US importers eight-fold, from an average tariff of 4% (under MFN) to 35% (Facchini et al., 2019), and affected over 95% of US imports from China (Pregelj, 2001).

The NTR regime made the low MFN tariffs permanent and no longer required Congressional renewal. While not changing actual tariffs, it reduced the uncertainty facing Chinese exporters and US importers, with substantial impacts on trade. China's exports to the US grew by 57% within a year, and by 177% within the first five years of PNTR conferral.[5]

We derive plausibly-exogenous variation in PNTR exposure across Chinese prefecture cities. To quantify the policy treatment, we utilize the potential spike in tariffs under loss of MFN status – the gap between NTR and non-NTR tariff rates (henceforth, NTR gap). For each city, we measure PNTR exposure by calculating the sum of the NTR gaps across industries, weighted by the city's industry export shares in 1997, prior to the policy change.

Importantly, the conferral of PNTR was unlikely to have been known in advance, with previous literature describing Congressional threats to allow MFN status to expire as credible (Pierce and Schott, 2016). We provide formal checks of this identifying assumption and show that city-level PNTR exposure was uncorrelated with economic factors in the years preceding 2001. Chinese cities experiencing strong export growth, high economic activity, or growth in education prior to 2001 did not experience differential treatment intensity.

[5]Calculations based on US imports from China reported by the Census Bureau (December 2020): https://www.census.gov/foreign-trade/balance/c5700.html.

Notably, the conferral of PNTR affected internal "non-*hukou*" migration in China (Facchini et al., 2019). The *hukou* system ties an individual's access to schooling to their prefecture city of birth, making it difficult for youth to attend schools outside their hukou city. Our student-level data measures permanent (likely *hukou* city) addresses, limiting endogenous internal migration in our estimation. We augment our analysis with micro-data from Chinese Censuses to explore in detail how internal migration affects our estimates.

3 Why WTO Entry Affects Student Flows

We formulate possible mechanisms underlying the relationship between PNTR exposure and Chinese student migration, and use this framework to inform our empirical investigation of mechanisms. While other work highlights complementarities between trade and migration (Venables, 1999), we introduce new channels via which trade generates demand for certain types of services (like higher education), driving the flow of individuals across countries.

Consistent with the recent trade literature, we view the conferral of PNTR as a trade liberalization shock that reduced uncertainty over future market access. Allowing for the expansion of exports of Chinese manufactured goods, it contributed to the structural transformation of China's economy, giving rise to manufacturing and generating substantial economic growth (Erten and Leight, 2020; Brandt et al., 2017). Similar to the development and migration literature, economic growth may have opposing impacts on student outflows, making the net effect ambiguous (Clemens, 2014; Angelucci, 2015; Bazzi, 2017).

Appendix A provides a conceptual framework that elucidates how this structural change may affect student flows. Figure A.1 outlines the potential pathways through which a reduction in tariff uncertainty eventually feeds into the household responses that are the mechanisms for student flows that we test empirically. Household responses occur due to changes in the local economy in response to the shock. We provide an intuitive and broad summary of the chain of events in what follows, and leave the detailed discussion to the appendix.

A reduction in tariff uncertainty induces investments in export activities and firm entry. As a result, production and exports increase, which may drive higher business income, wages, capital income, and housing wealth; a rise in information about the US market via business connections; and an ambiguous change in relative skilled-unskilled wages. We delineate four channels through which export-driven economic development potentially influences student flows (Appendix A): (1) income/wealth generation alleviates liquidity constraints associated with financing costs of studying abroad, (2) new income/wealth is used for consumption of high-end services, (3) changes in the returns to education raise the value of a US degree, and (4) increased information and networks influence the flow of students.

First, income and wealth gains relax financial constraints, increasing the number of households that can afford the high cost of US higher education. We formalize a simple theoretical framework in A.3. If education is an investment good, then financially constrained households will respond to income shocks by funding their education (in this case, abroad).[6]

Second, if education is a consumption good, increases in income and wealth reallocate expenditures toward high-end services, like education, when preferences are non-homothetic (Appendix A.3 and Matsuyama (1992)). If the income elasticity of demand for education services is high (as is in Comin, Lashkari and Mestieri, 2019), then growth in income increases expenditure shares on education. We empirically explore the evolution of the services expenditure share in liberalization-exposed cities.

What are the sources of income/wealth growth attributable to trade liberalization? Prior work links PNTR exposure to increased wages in China (Erten and Leight, 2020), and employment and investment growth (Cheng and Potlogea, 2017). Given the high cost of a US education–one year of tuition is 40-50 times the average Chinese household income and almost all costs are self-financed (Bound et al., 2020)–we examine sources of income and wealth applicable to high-income groups. We document changes in income (yearly cash flows from labor, business, interest, or property leasing) and wealth (net asset worth). Although both affect affording US tuitions, they manifest differently in the data. Unlike prior work, we explore growth in real estate wealth (property values) and income (rents) alongside other

[6] Sun and Yannelis (2016) causally link credit constraints and the demand for college education.

sources (business income, capital gains). Recent work documents the importance of the real estate sector in China, where, without a developed financial sector, investment growth and capital gains mainly derive from the housing market (Liu and Xiong, 2018; Chen et al., 2017). As upwards of 80% of urban households in our sample own property, property appreciation comprise a substantial portion of wealth increases among Chinese families.

Other than income and wealth, trade liberalization may affect the returns to a US degree by altering the relative demand for particular skills or relative prices of a US versus Chinese degree. Changes in the returns to education may either increase or decrease educational investments for migrants (McKenzie and Rapoport, 2011; Kuka, Shenhav and Shih, 2020). Growth in the relative demand for unskilled labor might encourage college-ready cohorts to work immediately and forego higher education. Alternatively, greater outflows of students would occur if trade shocks raised the return to a US degree in China, or if the returns to college rise alongside an inelastic supply of higher education within China that raises the relative cost of a degree from a top Chinese university. We empirically assess returns to education by examining whether PNTR created differential benefits to skill-intensive relative to non-skill-intensive industries. We also examine capacity limits at top universities in China.

Finally, China's integration with the US economy and its supply chains may have fostered information flows. Existing work has highlighted the interlinkages between migration and trade networks (Bahar and Rapoport, 2018; Parsons and Vézina, 2018). US universities could become more visible and information on opportunities and admissions procedures clearer to potential Chinese students. In our model, this represents a reduced cost of acquiring a US degree. We empirically assess the importance of networks by examining whether prospective students choose universities that have established networks of students from their origin city.

A unique feature of the latter two channels is the pairwise relationship between China and the US, where more connections drive outflows, while the income/wealth channels may drive flows to other destinations.[7] These latter mechanisms are also more likely generalizable

[7] Given the US has a large fraction of the world's top universities, it is likely that a large share of

to other service industries and thus imply broader implications for US exports.

Various other factors affected aggregate trends in Chinese students to the US (Bound et al., 2021), including changes to visa policy (Chen, Howell and Smith, 2020), increased demand from US universities facing revenue shortfalls (Bound et al., 2020), and the appreciation of the yuan. As our focus is on within-city changes in student flows, we abstract from the influence of countrywide shocks. We emphasize that our empirical variation captures relative changes in student outflows across Chinese cities based on their exposure to trade liberalization from the conferral of PNTR.

4 Empirical Strategy and Data

We construct a city-level measure that captures the differential impact of PNTR across Chinese prefecture cities based on their pre-2001 industrial activity, and then link this to outflows of students to the United States. Prefecture cities reflect the boundaries of *hukou* status, thereby limiting the scope for endogenous internal migration.[8] We examine the relationship between city-level PNTR exposure and student flows to US universities, using the following general specification:

$$\Delta S_c = \alpha + \gamma PNTR_c + \delta Z_c + \epsilon_c \tag{1}$$

The primary outcome variable measures growth in the number of students S from city c that matriculate at US institutions. For each city, we calculate the change in the number of students between 2002 and 2013 and standardize/divide by the fixed initial (2002) city population of those with non-agricultural *hukou* status, from the China City Statistics

income-driven student flows would be to the US.

[8]There are three layers of administrative units. First are provinces, autonomous regions, and centrally-controlled municipalities. Prefecture-level divisions are the second level, mostly consisting of prefecture-level cities. Large prefectures are subdivided into counties. Finally, townships /towns are the third level. Our unit of analysis is the prefecture city. As sub-municipality trade data are unavailable in the customs data, we include the 4 municipalities, Beijing, Shanghai, Chongqing, and Tianjin, in the analysis. We also provide robustness checks without them.

Yearbook.[9] As city population is measured in thousands of persons, our dependent variable measures changes in the number of Chinese students per 1,000 city residents (in 2002).

The Student Exchange and Visitors Information System (SEVIS), obtained through a Freedom of Information Act (FOIA) request, provides records for every F-1 student visa recipient by year of matriculation from 2000-2013, which include their permanent address, university, level of study/program type, major, start and end dates, and amount of financial support by source. We aggregate students to city-of-origin by matriculation-year cells, and calculate cell subtotals by various characteristics to examine heterogeneity (Section 5.2).

The explanatory variable of interest ($PNTR_c$) is a city-level measure of exposure to PNTR. We include city-level controls (Z_c) that may affect trade flows and general access to foreign markets. Our outcome is long-differenced, removing the influence of time-invariant city-specific factors. City-level controls account for differential trends by city characteristic. We first describe the construction of city-level PNTR exposure and controls, before clarifying our identifying assumptions.

We define the size of the PNTR policy treatment for each 4-digit International Standard Industrial Classification (ISIC) industry i, as the gap between NTR and non-NTR tariff rates in 1999 as,[10]

$$NTRGap_i = NonNTRrate_i - NTRrate_i \tag{2}$$

NTR gaps do not vary over time as they only depend on the non-NTR rates (i.e., the

[9] We use the non-agricultural population (i.e., the urban population) for two reasons. First, this ensures consistency with the evaluation of mechanisms, where we use household-level data from the Urban Household Surveys of the National Bureau of Statistics of China. Second, households in agricultural residency status and migrant workers have more difficulty in finding regular jobs in cities, and participate mostly in informal labor markets. Therefore, they are less relevant to the discussion of studying abroad. Nonetheless, we present robustness tests to the main results where we use the total city population in the denominator and also examine altering the population in the denominator to that in 2013.

[10] Following Pierce and Schott (2016), we also aggregate and concord 8-digit Harmonized System tariff rates to our preferred level of aggregation at the 4-digit ISIC industry level.

Smoot-Hawley 1930 Tariffs) and NTR rates in 1999 that apply to all WTO trade partners.

Figure 1c illustrates substantial variation in NTR and non-NTR tariffs across 4-digit ISIC products. Some products had a substantial difference NTR gap. For instance, recorded media faced non-NTR tariffs of nearly 60% compared with an NTR tariff of a 2%. Hence, PNTR eliminated the risk that recorded media exporters might suddenly see tariffs spike by 58 p.ps. In contrast, PNTR had milder impacts on tobacco, which had similarly high non-NTR tariffs but also relatively high NTR rates, and hence, tobacco-producing cities were less impacted by PNTR. Figure E.1 reveals substantial variation in NTR gaps, with some industries facing almost no gap and others having a gap upward of 60%. The mean NTR gap across industries is 30%. We measure each city's exposure by summing these industry-level NTR gaps, weighted by each city's existing activity in each industry as follows:

$$PNTR_c = \sum_i \left(\beta_{ci} \times NTRGap_i\right), \quad \beta_{ci} = \frac{X_{ci}^{1997}}{\sum_j X_{cj}^{1997}}, \tag{3}$$

Existing industrial activity is measured by each industry's share of total city exports, *prior* to the conferral of PNTR, calculated from the China Customs Database.[11] We use the earliest available year, 1997, as the base year. Industry export shares are calculated by dividing exports of industry i from city c (X_{ci}^{1997}) by total exports from city c ($\sum_j X_{cj}^{1997}$). We only use the 119 4-digit ISIC industries that have an associated NTR gap to ensure export shares sum to 1 and avoid complications from "missing shares" (Borusyak, Hull and Jaravel, 2020). Omitted industries only comprise about 0.17% of the total export value in our sample cities.

The conceptual framework in Appendix A.1 rationalizes our use of export shares given

[11]Data were harmonized and generously provided by the University of California, Davis, Center for International Data (Feenstra et al., 2018). We utilize information on the quantity and value of exports classified by the Harmonized System for all international transactions from China. Exports are categorized by the destination country and city of origin. The 4-digit city codes provided in the customs data identify a level of geography more disaggregated than the standard prefecture cities in China. Hence, we aggregate city codes in the customs data up to the prefecture level, based on the reported city name. In the end, the original 479 city codes in the customs data are aggregated to 313 prefecture cities, including four municipalities. We do not include exports categorized as process and assembly or process with imported materials.

that (like Facchini et al. (2019)) we expect exports to be the impetus for regional economic responses. Cities with large export shares in high NTR gap industries had both substantial economic activity and export knowledge/infrastructure, allowing them to capitalize immediately following China's WTO accession. In a robustness check, we construct an alternative measure using city-level employment shares by industry in 1990, using data from China's 1% Population Census of 1990.

As a weighted average of NTR gaps, our PNTR measure represents the average reduction in uncertainty facing a city. It captures the interaction of how much US tariffs would increase (by industry) if China lost MFN status, with the probability of that event. As the probability becomes close to zero post-WTO, the exposure proxies for the magnitude reduction in uncertainty per industry, even as tariffs are mostly unchanged. This episode reduced entry barriers for Chinese exporters (Handley and Limão, 2017) and raised potential market size.

Appendix Table E.1 displays summary statistics for the analysis sample of 268 Chinese prefecture cities (Figure 1d), for which we measure their PNTR exposure and growth in the number of students from 2000-13.[12] Between 2000 and 2013, cities experienced sharp growth in economic activity, with modest growth in population. In contrast, the average number of Chinese students studying abroad in the US increased over tenfold. The share of students pursuing undergraduate and master's degrees experienced substantial growth, offset by declines in the share pursuing Doctoral studies. The share of matriculating students pursuing STEM degrees fell from 81% in 2000 to 35% in 2013. This decline was offset by substantial increases in social sciences and arts/humanities. This period saw large increases in the share of students entering the least selective (tier 4) universities and also large decreases in the fraction of students receiving scholarship funding (from 77% to 22%).

[12] Although there are 343 cities in China, our sample comprises over 90% of employment and population, and over 80% of all export activity. As such, our sample cities are broadly representative of the Chinese economy. We capture all tier 1 cities (e.g., Beijing, Shanghai, Chongqing, Nanjing, and others.) and tier 2 cities (e.g., Xiamen, Kunming, Harbin, and others). Most of the cities missing are those in western China, Tibet, and Xinjiang, which have rural populations and low economic activity.

We assess the descriptive relationship between PNTR and our primary variables of interest: exports and student growth. The scatterplot in figure 2a establishes a positive correlation between city-level PNTR exposure and log changes in exports from 2000-2013 – the best fit line indicates a 10 p.p. higher NTR gap (roughly the interquartile range) increases exports by 34%.[13] The right panel of 2a shows a strong positive relationship between PNTR exposure and student emigration from 2000-13. The right figure in 2b separately illustrates this relationship pre/post-WTO – there is no correlation with student emigration prior to 2001, but a positive association appears after.[14] Finally, we regress year-on-year changes in student outflows on PNTR exposure, and plot coefficients and 95% confidence intervals in the left panel of Figure 2b. There is no immediate response in student flows, and growth occurs after 2002, perhaps as income/wealth gains and college decisions take time. Given the timing of WTO entry, we focus on student flows over the 2002-13 period.

4.1 Validating Identifying Assumptions

The PNTR exposure measure falls under the broad class of "shift-share" variables capturing local exposure to aggregated shocks. We obtain identification from the shifters – the industry-level NTR gaps – consistent with Borusyak, Hull and Jaravel (2020) (henceforth, "BHJ"). We demonstrate that while industry NTR gaps are balanced with respect to initial industry-level factors, they exhibit mild correlation with two known determinants of Chinese trade – export licenses (Bai, Krishna and Ma, 2017) and import tariffs (Yu, 2015). Hence, our key identification assumption is that PNTR exposure is exogenous, conditional on these determinants. We provide substantial evidence in support: after conditioning on these determinants, our PNTR exposure measure is balanced with respect to a variety of city-level pretrends in education, demographics, skill/capital intensity, and other economic indicators.

[13] Table B.1 in Appendix B further separately examines exports to the US and non-US destinations, showing that only exports to the US exhibit an immediate increase.

[14] The pre-period student flow is measured between 2000-1. The post-period is the yearly growth–the change between 2000-13 by 13. Figure E.2 shows the long-difference (2000-13), rather than yearly change.

Causal identification requires satisfying the following orthogonality condition, with regression weights $w_c = 1/N$ in the unweighted case (for all cities $c = 1...N$):

$$\mathbb{E}\left[\sum_c w_c \cdot PNTR_c \cdot \epsilon_c\right] = 0$$

BHJ demonstrate that this can be re-expressed to obtain an equivalent shifter-level orthogonality condition. Given $PNTR_c = \sum_i \beta_{ci} \cdot NTRGap_i$, the shifter-level condition is,

$$\mathbb{E}\left[\sum_c \sum_i \beta_{ci} \cdot NTRGap_i \cdot \epsilon_c\right] = \mathbb{E}\left[\sum_i \beta_i \cdot NTRGap_i \cdot \bar{\epsilon}_i\right] = 0, \quad (4)$$

where $\beta_i = \sum_c w_c \cdot \beta_{ci}$, $\bar{\epsilon}_i = \frac{\sum_c w_c \cdot \beta_{ci} \cdot \epsilon_c}{\sum_c w_c \cdot \beta_{ci}}$.[15] As in BHJ we refer to β_i as "exposure weights".

Empirically assessing the orthogonality condition requires first checking whether industry-level NTR gaps (i.e., our shifters) are balanced with respect to other initial industry-level factors.[16] We follow the method detailed in BHJ, which involves regressing initial industry-level factors on industry-level NTR gaps, using exposure weights β_i as regression weights (see Appendix C.2 for details). Results from these industry balance checks are in Table 1b.

We examine correlations between NTR gaps and factors that have been identified in the literature as strong determinants of Chinese trade. First, prior to joining the WTO Chinese firms required licenses to export directly. Such licenses had large impacts on productivity growth (Bai, Krishna and Ma, 2017). We use data from Bai, Krishna and Ma (2017) on the fraction of export revenues within an industry covered under export licenses in 2000.[17]

Second, we assess balance with respect to the level of tariff rates imposed in 2000 by Chinese imported inputs and final goods, as such tariffs have been shown to affect the

[15] In the unweighted case, $\beta_i = \frac{\sum_c \beta_{ci}}{N}$ is the average of export shares for industry i across all cities c.

[16] We present statistics of our industry-level NTR gaps (shifters) and export shares in 1997 (exposure weights). The first three rows of Table 1a report summary statistics for NTR gaps across 119 ISIC 4 industries, which have an average of 0.327 (i.e., the average gap between NTR and non-NTR rates is 32.7 percentage points), a standard deviation of 0.157 and an interquartile range of 0.178. The fourth and fifth rows summarize exposure weights β_i. Although the largest exposure weight is 0.113, there is sizable and sufficient variation across industries as shown by the inverse Herfindahl Index $(1/\sum_i \beta_i^2)$, indicating adequate effective sample size. Export shares sum to one, thereby avoiding complications from incomplete shares.

[17] For all variables, we provide more specific definitions and sources in Table G.1 in Appendix G.

productivity of Chinese firms (Yu, 2015).[18] If China's import tariffs pre-WTO were driven by their own non-NTR tariffs, possibly due to retaliation, there could exist a mechanical correlation between NTR gaps and import/input tariffs.

Third, the quality of contract enforcement can increase comparative advantage and exports from industries requiring relationship-specific investment (Nunn, 2007). Strengthening institutions among skill-intensive industries could raise demand for higher education. Using data from Nunn (2007), we measure industry contract intensity in 1997 as the fraction of intermediate inputs employed by firms requiring relationship-specific investments.

Finally, we examine additional industry-level performance metrics, by aggregating firm-level data from the 2000 Annual Survey of Industrial Production (ASIP) to the industry-level. We compute labor to value-added, capital to value-added, return on assets, and return on equity, and then average these over firms within each industry.

Table 1b demonstrates that industry-level NTR gaps are well-balanced with respect to most industry-level factors. Yet, there is a positive correlation between import tariffs and export licenses. This is not surprising given China's early emphasis on industry protection. An interpretation is that China may have retaliated against high non-MFN tariffs on its exports (likely high NTR gaps) with similarly high import tariffs. With respect to export licenses, it is possible that more licenses were awarded to those industries facing potentially large tariff uncertainty (high NTR gaps). We also note that despite the significant correlation, the magnitudes are relatively small. A 1 s.d. increase in the NTR gap is associated with a 1.5 p.p. increase in the share of export revenue covered under direct export licenses, accounting for less than one-fifth of the overall standard deviation of that measure. Similarly, a 1 s.d. increase in the NTR gap is associated with a 1.6 p.p. larger import tariff, which represents

[18]Import tariffs for final goods are the applied tariff rates by China in 2000, averaged across origins, from the World Integrated Trade Solution. We use the 2002 input-output table for China, combined with output tariffs during that year. Industry-level input tariffs are the weighted (by share on input usage in the I-O table) average of the output tariffs, but imposed on the inputs used by each industry.

less than one-third of the standard deviation in import tariffs.

Crucially, our identification strategy will account for these factors in estimation. We develop shift-share control variables (Z_c) that follow equation 3, but replace $NTRGap_i$ with the appropriate industry variable (i.e., import tariffs, the share of export revenues covered by direct export licenses, etc.). Although industry NTR gaps are balanced with respect to input tariffs and contract intensity (see Table 1b), we construct shift-share control variables for these measures as well given their regular use in the literature. Our preferred specifications will control for all four of these variables (Z_c).[19]

We now provide evidence in support of our key identification assumption: conditional on controls (Z_c), PNTR exposure is balanced with respect to pretrends in other city-level factors that might relate to student emigration. We follow the method of BHJ to evaluate regional balance, which is operationally equivalent to regressions that replace the dependent variable in specification 1 with pretrends in city level factors (see Appendix C.2 for details).

Results from these regional balance tests are shown in Table 2. We gather a wide variety of pre-period city-level factors that might plausibly be related to student emigration, and organize them into three groups. Column (1) shows results without any controls, while column (2) shows results after including our four primary controls. Column (3) reports the number of cities (observations) underlying the regressions, reflecting the differing availability across the data sources used to measure city pretrends.

The first group in Panel A captures pretrends in city-level educational measures. We first examine student emigration, our primary outcome, measured from SEVIS data as the change between 2000 and 2001, divided by city population in 2000. Data from the 1997-2000 China Statistical Yearbooks provide other education pretrends (measured as the log change between 1997 and 2000) in the number of students attending college domestically, the number of domestic colleges, domestic students attending secondary schools, and the number

[19] We note that export shares always sum to 1 in these shift-share controls to avoid issues of missing shares. Details on the construction of each control variable is provided in the Appendix Section C.1.

of secondary schools. The second group, in Panel B, examines pretrends in general city-level economic factors: the log change between 1997 and 2000 in GDP, employment, FDI flows, real-estate investment, and exports. The final group, in Panel C, provides measures related to city-level demographics (from the 1990 and 2000 Population Censuses) and other measures of skill and capital intensity within the city: the share of 18-year-olds in the population in 1990, the share of college-educated workers in 1990, the share of manufacturing workers in employment in 1994, and the share of capital in output in 1994. We also calculate the growth of these same variables from the initial year in the data to 2000.

After including our 4 control variables, in column (2), only 1 of 18 coefficients is significant at the 10% level. Our regional balance checks help substantiate our identification assumption that conditional on the four other trade factors, PNTR exposure is exogenous to other potential city-level factors that might affect student emigration to the US.

5 Results

Figures 2a and 2b reveal a strong positive association between PNTR, exports, and growth in the number of students studying in the US. The sharp growth in student outflows began a few years after the WTO accession. We estimate our benchmark equation (1) in Table 3. Column (1) excludes controls and shows that PNTR exposure is positively and significantly associated with student emigration. Since we measure long differences in student emigration (2002-13), time-invariant city characteristics and time-varying national trends are accounted for in the estimation. The remaining threats to identification, as discussed in Section 4.1 include city-level exposure to other factors correlated with NTR gaps that might also drive differential trends in student emigration.

To that end, we assess the sensitivity of our results by gradually including our four trade controls. Column (2)-(5) of Table 3 adds controls for import tariffs, export licenses, input tariffs, and contract intensity, iteratively. To get a sense of magnitudes, in the bottom panel, we report the interquartile effect of a rise in PNTR exposure from the 25th to 75th percentiles (about 11 p.ps), in terms of the number of additional students per million city residents/population. We also report the mean of the dependent variable for reference.

Across all specifications, the effect of PNTR exposure remains stable and positive and statistically significant at the 99% level. Our preferred estimates come from the model with the full set of controls in column (5), which indicates that moving from a city at the 25th percentile to a city at the 75th percentile – roughly an 11.4 p.p. increase in PNTR exposure – increased student emigration to the United States by 38 per one million city residents. This magnitude is about 26% of the mean growth of student outflows across cities.

The magnitude of the effect of PNTR exposure can be put into perspective by comparing it with secular trends in Chinese students going to the United States. The 2002-13 period saw the flows of new Chinese students per year at US institutions increase by 86,000. In our specification, the average PNTR exposure across all cities is 0.316, implying that for the average city, 106 new students per one million residents went abroad per year ($0.337 \times 0.316 \times 1000$) as a response to the liberalization. Given the non-agricultural population in 2001, a yearly flow of approximately 35,000 students to the US can be attributed to the elimination of the NTR gap. As such, the trade shock alone explains about 40% of the increase in the flow of Chinese international students in 2013 relative to the beginning of our sample.

The effect of PNTR exposure on student flows to the US also increases over time, as shown in the left panel of Figure 2b and in Table E.2. When we analyze initial (2002-2007), intermediate (2008-2010), and later (2011-2013) growth, magnitudes grow each period. This is consistent with the gradual accumulation of wealth/income as a predominant mechanism.

5.1 Robustness of PNTR Exposure

We provide a variety of sensitivity checks in Table 4.[20] We begin with sample refinements in panel A. In column (2), we remove the four largest cities, which also are under the

[20] Additional robustness checks around inference are in Appendix C.5. We apply insights from Borusyak, Hull and Jaravel (2020) and Adao, Kolesar and Morales (2019) to correct for correlations between the shift-share and residuals across cities with similar exposure shares. Additionally, we apply standard corrections and show robustness for clustering in spatial designs, such as at the more aggregate province level.

direct administration of the central government – Beijing, Shanghai, Chongqing, and Tianjin. Column (3) excludes capital and coastal cities to ensure that results are not driven by particularly large influential cities or places with stronger access to foreign markets. To examine heterogeneity by city size, column (4) reports a specification where we weight the regression by total prefecture population (from the 2005 Census). The coefficient slightly decreases in (2) and (3), and increases in (4), consistent with the effects being slightly greater in the larger cities. Overall, the relationship between student out-migration and trade liberalization is not specific to large cities. We then include region-fixed effects in column (5) to account for any differences in policy, culture, or institutions that vary across regions and over time. The last column includes an additional control for time-varying changes in tariffs. Results are similar to our preferred estimates, reprinted in column (1).

Though our identification is based on exogenous sector shocks derived from industry NTR gaps, we also can evaluate the 1997 export shares used to construct the instrument. Related recent papers on shift-share designs have highlighted concerns with lagged shares potentially endogenously affecting future outcomes (Jaeger, Ruist and Stuhler, 2018), and also created useful diagnostics to help establish share exogeneity (Goldsmith-Pinkham, Sorkin and Swift, 2020). To this end, we provide several checks to assess our 1997 export shares.

Jaeger, Ruist and Stuhler (2018) illustrate how lagged shares may embody past shocks that persist over time and continue to impact outcomes during the period under study. Table 2 reports no correlation between our measure of PNTR exposure and city-level pre-trends in education, economic conditions, demographics, or skill/capital intensity. We now turn to shares with longer lags to help reduce any endogenous correlations that may persist over time. While 1997 is the earliest year for export data, employment shares are available as early as 1990. We construct a similar measure of PNTR exposure using city-level employment by industry in 1990, consistent with related papers that also use employment shares to construct measures of PNTR exposure at different regional levels (e.g., Erten and Leight, 2020).[21]

[21] With the 1990 Population Census, for each city, we interact the share of industry employment (the

Table 4 panel B demonstrates our results are similar when using the PNTR exposure measure created with 1990 employment shares (details in C.3). The first column shows results for the benchmark specification when using this alternative PNTR exposure measure. The estimated effect is positive and significant at the 1% level. While the coefficient appears larger than our export-based PNTR exposure measure, the magnitudes are similar, as the variation in PNTR exposure using 1990 employment shares is on a smaller scale. Moving from a city at the 25th percentile to the 75th percentile – roughly 5.7 p.p. for the 1990-weighted PNTR exposure – increases student emigration by 51 per one million city residents. We note that due to lower coverage in the 1990 Census data, we lose 10 cities from the sample. The remaining columns of panel B repeat the sample refinement checks as in panel A.[22]

We assess whether our findings simply reflect trade-induced internal migration. While cities exposed to trade shocks enacted migrant-friendly policies and sustained in-migration, we note these inflows were primarily low-skilled, non-*hukou* migrants (Facchini et al., 2019). Limited access to local services meant non-*hukou* migrants could not attend schools. Obtaining *hukou* residency in destination cities was extremely difficult. Our data contain permanent addresses, which likely reflect students' *hukou* cities as children must attend high school in their *hukou* city, thereby helping to guard against endogenous in-migration.

Nonetheless, we examine robustness to internal migration in panel C of Table 4. The first three columns control for concomitant changes of in- and out-migration rates for both skilled and unskilled workers.[23] Column (4) uses the entire prefecture population (both rural and

same 119 industries as before) with the industry-specific NTR gaps, and sum over all industries, as in (3).

[22]We implement robustness checks by Goldsmith-Pinkham, Sorkin and Swift (2020) examining the exogeneity of our shares (1997 export shares). We measure Rotemberg weights for each industry's export share (Appendix C.4), capturing the importance of each export share in the overall identifying variation. Removing the five largest Rotemberg weight industries from our PNTR measure does not affect our findings.

[23]We use microdata on skilled and unskilled migration from the Chinese Population Census in 2000 and 2015. For both skilled and unskilled workers, we compute the probability of out-migration and in-migration from each city, and then calculate the change from 2000-2015. Each of the first 3 columns includes two

urban) as the denominator of our outcome variable to account for potential rural-to-urban migration within-prefecture. In column (5), we divide student growth by the 2013 population as it allows our outcome to reflect internal migration over our period. Overall, results remain robust and support our central findings. Notice also that our results are unchanged when excluding large cities that are more likely to attract in-migrants (panel A, column (2)).

5.2 Heterogeneity in Effects by Sub-group and Compositional Changes

Appendix Table D.1 examines whether PNTR exposure affected the composition of students in order to help inform mechanisms that we examine in Section 6. For example, in panel A, we estimate specification 1, altering the dependent variable to be enrollment growth by academic level. We show our main estimates again in column (1). The subsequent columns (2)-(5) reflect how total student growth attributed specifically to the reduction in trade uncertainty is distributed across academic levels. All levels, except doctoral programs, saw significant growth in Chinese students. In the second row, below the coefficient estimates, we report the effect for each academic level as a proportion of the total effect, dividing the academic level coefficients by the coefficient for total students (column 1). The overall PNTR-related growth in students was driven by bachelor's and master's students – 41% and 31% of the total inflow associated with PNTR exposure, respectively. These programs are more likely to be self-funded compared to doctoral programs.

We then compare the proportions of students in 2002, reported in row 3, with the proportion of the effect for each academic level, in row 2. The difference in these proportions is shown in row 4. The last row describes the elasticity: the relative change for each type normalized by baseline value. Although only 6% of Chinese students entering in 2002 matriculated in bachelor's programs, 41% of the inflow generated by PNTR exposure occurred at the bachelor's level, an increase of 35 p.p. In contrast, doctoral students initially accounted for nearly half of all students matriculating in 2002. Since PNTR exposure induced no sig-

measures of internal migration, separately for skilled and unskilled migrants. For details on the Chinese Population Census and the internal migration measures, see Appendix G.

nificant change in doctoral students, the change in proportions is dramatic. While master's students also saw sizable inflows, these were slightly smaller than the proportion in 2002, while the reverse is true for associate degree students.

In panels B-E of Table D.1 we examine other compositional changes including: field of study, quality of US institutions attended, and the type plus amount of funds used to finance the students' higher education in the US. We relegate the discussion to Appendix D, but note that the results all confirm a pattern reflecting underlying income and wealth accumulation.

5.3 Policy Counterfactuals: Consequences of a Trade War

Our results inform the recent resurgence in uncertainty in US-China trade relations. Since 2017 the US government departed from PNTR rates, and instituted across-the-board tariffs on goods from China, affecting incomes in China (Chor and Li, 2021). By mid-2019, average tariffs on Chinese goods sustained a nearly 20 p.p rise. Although an agreement in January 2020 (i.e., the phase I deal) modestly reduced tariffs imposed on Chinese goods in exchange for concessions, tariff uncertainty remains significant.

We use our estimates to infer possible changes induced by this recent tariff uncertainty on international student flows and services exports: if Chinese firms currently fear potentially permanent tariffs that are 20 p.ps higher, how will student flows to the US change? Our reduced-form results on the effect of PNTR exposure (Table 3) indicate that a 10 p.p. increase in potential tariffs leads to (eventually) 34 fewer students per million city residents per year. Thus, as a 20 p.p. rise in PNTR for all cities reduces enrollment by 68 students (per 1 million urban residents) per year, this implies 27,948 fewer students per year.[24]

Given the current average tuition at private institutions is $40,000 per year, this implies that US institutions would lose $1.1 billion each year, and since students tend to stay around 4 years, the tuition loss would come out to $4.4 billion. Our results imply a 6% reduction in

[24]Our analysis captures the change in flows over a 10-year period following the policy change, with the rise in flows materializing gradually. The non-agricultural population at the end of our study period in 2013 is 411 million individuals, implying 27,948 fewer students (68×411) as a consequence of the trade war.

the flow of international students to the US per year, and 28% fewer new Chinese students. A sustained reduction in these flows eventually decreases the stock of international students and total educational exports by similar magnitudes, even excluding general equilibrium multiplier effects that reverberate across local economies (Acemoglu et al., 2016).

6 Mechanisms

We explore several explanations for why trade liberalization induced large student flows to the US, outlined in Section 3 and Appendix A. We focus on the possible changes over time across Chinese cities, rather than shocks to the US that should affect all Chinese cities in an equal manner.[25] We examine whether increased student flows to US universities due to PNTR exposure is consistent with (1) income/wealth generation, (2) changing returns to education, and/or (3) information flows and networks.

6.1 Income/Wealth Accumulation

Greater income or wealth may alleviate credit constraints in financing education abroad, and/or may encourage individuals to increase their consumption of education services. In Section 3 we distinguish between income (annual cash flows to households) and wealth (net worth of assets) since affects US tuition affordability, but manifest differently. While they have similar impacts on student flows, in distinguishing them we aim to note the comprehensive nature of our investigation as prior work ignores housing wealth.

We first establish that trade liberalization raised the fraction of households that could afford US higher education. We then investigate which sources of income and/or wealth grew to account for this increased affordability. We examine overall changes in average income, and real estate income, motivated by work documenting how Chinese growth contributed to asset price appreciation, particularly in real estate (Chen et al., 2017). Finally, we analyze non-real estate sources of income such as business, labor, interest, and transfer income.

[25]For instance, changes to visa policies, or recessions in the US increased the demand from US universities for all international students, regardless of origin city (Bound et al., 2020).

Results on self-financing of education in panels D and E of Table D.1 demonstrated that PNTR exposure had larger effects on enrollment growth among Chinese students without university funding and also among those with large personal funds. To connect increases in student out-migration with potential changes in income and/or wealth, we first examine whether PNTR exposure raises the share of households that can afford US tuition.[26]

Lacking detailed data on wealth (savings, assets), we proxy for tuition affordability using income data from the Urban Household Survey.[27] We define households that can afford US tuition, as those with 10 year income exceeding the cost of a 4-year US degree. We examine changes in the share that meet this threshold between 2002-7, as UHS coverage becomes worse in later years (and avoid the Great Recession). Column (1) of Table 5 shows sizable and statistically significant increases in the share of households that can afford US tuition by 12 p.ps, consistent with our findings on the self-financing of students.

Given that PNTR exposure led to more families being able to afford US tuition, we seek to understand how family income/wealth changed due to trade liberalization. We begin by examining average income growth in cities in panel A of Table 5.[28] We use data from the Chinese statistical yearbook and examine city changes from 2002-2013 in GDP in column (2), population in column (3), and then average income (i.e., GDP per capita) in column (4). Results indicate that PNTR exposure is associated with large and statistically significant

[26]To measure tuition affordability, we multiply the average yearly cost of a college ($27,000) during the 2002-7 period by 4 years, to get the cost of a 4-year degree. We convert this to Chinese currency using the 8RMB-to-1USD rate, yielding the average cost of 860,000 RMB. We use tuition figures on average tuition + fees, room and board at private colleges from https://nces.ed.gov/fastfacts/display.asp?id=76. We use private college figures as they resemble what international students pay.

[27]The Urban Household Survey (UHS) is similar to the Current Population Surveys in the United States and adopts a stratified and multi-stage probabilistic sampling scheme. The UHS has been used to study wage inequality (Ge and Yang, 2014), and we follow their work in taking changes in the average outcome by city between 2002 and 2007. This constitutes more than 30,000 households and more than 120,000 individuals each year. It covers between 151-204 cities for the analysis.

[28]The negative effect of import tariffs seen in our results (Table 3) also support the income channel.

increases in GDP growth, and large but imprecise concurrent growth in population. While impacts on GDP per capita are marginally statistically significant, the magnitudes suggest sizable growth in average income. These findings are consistent with Erten and Leight (2020) who find increases in income in Chinese counties that experienced high PNTR exposure. Additionally, our evidence on population growth in cities, though imprecisely estimated, is consistent with Facchini et al. (2019) and Tombe and Zhu (2019), which show that cities with greater PNTR exposure also saw large in-migration of less-skilled, rural workers.[29]

Given large documented growth in Chinese real estate prices (Chen et al., 2017) we then assess whether the increased ability to pay for US tuition was due to changes in income or wealth from real estate. With respect to income, increasing real estate values alongside the large increases in city population observed in Panel A could result in higher rental prices. As shown by Facchini et al. (2019), cities with high PNTR exposure received inflows of less-skilled, rural workers, which would certainly raise rental income for property owners. Alternatively, higher real estate prices would lead to greater home equity and wealth for homeowners, or increased capital gains from the sale of property.

We explore these various potential changes to real estate income/wealth in panel B of Table 5 using UHS data. Column (1) demonstrates that trade liberalization increased total real estate income (rental income and income from the sale of a property). Column (2) demonstrates that the gains in real estate income are due to increases in rental income. A 10 p.p. increase in PNTR exposure results in a 30% increase in rental income. In column (3), we show that the fraction of households that collect rental income rises, an extensive margin impact. Accordingly, rent becomes a larger share of total income, as shown in column (4). Column (5) shows a positive but imprecise relationship between trade liberalization and self-reported UHS house prices. Column (6) also shows a positive and significant increase in

[29]We note that Cheng and Potlogea (2017) do not find evidence of changes in wage income, but instead find increases in output, employment and investment growth. They explain that the lack of a rise in local wages resulted from increased population growth in export expansion areas.

commercial property values from the Wind Bank dataset.

Finally, we explore changes in non-real estate income sources in panel C of Table 5. These include labor income, business income, capital gains, transfer income, and interest income. While results are imprecisely estimated, coefficient magnitudes suggest possible sizable gains in business income and capital gains, with reductions in income from government transfers. This is consistent with rising income/wealth in cities more exposed to trade liberalization. While the UHS is useful in providing detailed sources of income, the reduction in sample size may contribute to more noise in estimation.

It is quite possible that these gains did not accrue equally to all Chinese families. Panel (a) of Figure E.5 shows that in the early 2000s, slightly more than 80% of families owned a house. Hence, the remaining 20% that did not own and instead rented, all else equal, would not see gains from either rental income or property appreciation. To homeowners, the gains in rental income and property values were sizable. Panel (a) shows average house prices were roughly 80,000-90,000 RMB in the early 2000s and more than doubled by 2007. Our estimates from panel B of Table 5 suggest PNTR exposure may have lifted property values between 30 and 55%, accounting for a third to one-half of the total increase in average prices. The growth was even larger for households owning multiple properties, whose average house price tripled from 2002-2007. Hence, gains in wealth from home equity are likely to have accrued in much greater magnitude to initially wealthier families that owned multiple properties at the onset of China's accession to WTO. Panel (c) of Figure E.5 confirms that multiple property owners are indeed higher up in the income distribution, with total household income about 1.4 times larger than single home owners, and 1.7 times larger than households that do not own property.

Additionally, multiple property owners also benefit from the gains in rental income. Our coefficient estimates from panel B of Table 5 indicate a 10 p.p. increase in PNTR exposure raises rental income by 35%. Panel (b) of Figure E.5 shows that the average rental income was about 3,000 RMB in 2002 and doubled by 2007. Though the fraction of households leasing property was only 4% in 2002, the share of households leasing property grew by just over 2 p.p. from 2002-2007. These gains in rental income disproportionately benefited multiple property owners, whose additional properties could be leased.

In sum, our analysis shows that trade liberalization raised the fraction of families that could afford the cost of a 4-year US degree. Greater income/wealth alleviates credit constraints that families face in financing education abroad. Figure 2b shows that the student response is gradual, consistent with the gradual accumulation of wealth required to afford US tuition. Part of the increase in spending power appears to be connected to the large increase in real estate prices, as many households saw higher rental income, and potentially large gains in property values. As we show in the first two columns of Panel A of Table 5, these gains could have been sufficient to help many families overcome the costs of US tuition.

Our theoretical framework in Appendix A suggests that rising income/wealth can lead to greater numbers of students studying abroad through two possible channels: (1) relaxing credit constraints and (2) reallocating consumption towards higher-end services. We provide some suggestive evidence using UHS data on household borrowing and consumption of services in Figure E.6. Panel (a) displays a scatterplot across cities of growth in borrowing as a share of household income against PNTR exposure, while panel (b) displays growth in the share of expenditures on services against PNTR exposure. The negative but imprecise relationship between growth in borrowing and PNTR exposure in panel (a) suggests that credit constraints indeed relaxed due to greater income/wealth. The positive and significant relationship in panel (b) indicates that greater wealth/income due to trade liberalization led to a general reallocation of consumption toward services, as the income elasticity of services is greater than that of other goods. Although suggestive, these results confirm that households in cities with greater liberalization behave in ways consistent with rising wealth/income.

6.2 Returns to Education and Access to Local Colleges

Rising returns to education due to trade liberalization could also generate the observed pattern of student out-migration. If capacity-constrained Chinese universities were unable to meet increased demand, students would study overseas. Alternatively, in the absence of capacity constraints at Chinese universities, trade liberalization may have increased the return to a US degree. We explore the likelihood of these scenarios.

We examine whether rising incomes in cities affected capacity-constrained local universities and spilled over into more student emigration. This is less likely in a context where individuals choose a US university over one at home and when there are national markets for university admissions. In Figure E.7, we see no meaningful positive relationship between city-level income growth and admissions of city residents to top universities, nor between PNTR exposure and admissions (the exact numbers are in Table E.3).[30] The lack of this relationship suggests that it is unlikely that (1) local returns to education are rising, and (2) students from growing cities are crowded out from top local universities.

We further explore the plausibility of changing returns to education as a potential channel, by examining whether trade liberalization in skill-intensive industries or non-skill-intensive industries explains student flows. We measure industry skill shares from the 2004 Annual Survey of Industrial Production (ASIP) and classify industries as skill-intensive if they are above the median in the ISIC industry data.[31] Using this skill-intensive industry dummy, we construct two new "NTR gap" exposure measures, where the city-level aggregation follows equation (3) but is split into *only* skill-intensive and *only* non-skill intensive industries.[32]

[30]Data details, including the province-level quota used in admissions, are in Appendix G. We measure university eliteness according to its membership in the first-tier class, 211-Project, and 985-Project. Colleges and universities can be classified into three tiers according to the admissions process. with tier 1 being elite. Above them are 39 universities on the 985-Project list and 112 universities on the 211-Project list.

[31]The skill share is the share of skilled workers in the industry, based on the ASIP (only available in 2004). We aggregate the firm-level employment to obtain total employment at city-industry level. Notably, the ASIP industry classification uses the China Standard Industrial Classification at the 4-digit level. To be consistent with the tariff and trade data, we concord this to ISIC Revision three at the 4-digit level, using the NBS crosswalk. We aggregate the firm data to 4-digit ISIC industries. We construct alternative measures using the Indonesian manufacturing census (Amiti and Freund, 2010).

[32]Therefore, the shares sum to one across both measures, but not for each measure. We control for the

Table 6A reports results comparable to our benchmark specification, where each NTR gap measure is constructed using a subset of industries. In the first column, we split industries using skill intensity measures from Chinese industries. In the second column, for robustness, we use a measure from Indonesian industries (Amiti and Freund, 2010). PNTR exposure in *non-skill* intensive industries explains most of the student flows, while cities with greater exposure in skill-intensive industries do not experience relatively higher student emigration.[33]

Overall, it appears unlikely that changes in education returns play a large role.[34] Although increases in the returns to US degrees could occur, recent evidence shows that job applicants with US degrees receive lower call-backs than Chinese graduates (Chen, 2020).

6.3 Information

Finally, student emigration might occur due to greater flows of information/knowledge regarding US educational opportunities. We assess whether prospective students choose universities that have established networks of students from their origin city. We include an interaction of $PNTR_c$ with student flows from city c to the US in both 2000 and between 2000-3. If network effects are important, cities with relatively more student flow to the US before the large influx should continue to see larger flows in the 2002-13 period. From the columns in Table 6B, there is little evidence of this.

Another plausible information channel is learning about the US education market through

sum (across industries) of 1997 export shares of the skill-intensive industries in each city.

[33]That migration was driven by growth in low-skill intensive industries does not imply that these were more liberalized – in fact our regional balance test point to this not being the case – but instead suggests heterogeneous post-WTO effects across sectors of different skill. This could occur for several reasons. For example, if international demand following WTO increased more for China's less-skill-intensive products. In this sense, the PNTR exposure-induced income growth would likely accrue to places where the less-skill-intensive industries were highly exposed to PNTR. Alternatively, demand might have grown equivalently for skilled and less skilled products after WTO, but the beneficiaries of trade-induced income growth in unskilled sectors were those who were previously liquidity constrained and couldn't afford US tuition.

[34]Liu (2017) finds that input tariff reductions raise high school completion, whereas Li (2018) finds education declined.

the process of exporting. However, Figure E.4 shows that the increase in Chinese student out-migration was not confined to the United States only, but rather seen in top destinations across the world (e.g., Canada, Australia, and the UK). This suggests that whatever factors drove the growth in Chinese student flows cannot be explained by US-specific features alone.

While evidence indicates information flows are unlikely to drive our findings, it is possible this mechanism interacts with wealth accumulation. Although we find it most plausible that student out-migration was triggered by gains in wealth, we cannot rule out that future students did not trace the path of initial migrants.[35]

7 Conclusion

International student flows are a function of home and destination country education and labor markets. Several factors drive such flows. US universities suffering secular declines in government appropriations have turned to foreign students (Bound et al., 2020; Shih, 2017) to provide much-needed tuition revenue. Home country demographics or constraints in high-quality education may drive students abroad. The option value of joining the US labor market after obtaining a US degree serves as an attractive incentive. Finally, the capacity to pay for higher education abroad constrains student flows. Our research finds that relaxing financial constraints explains a substantial portion of student flows from China to the US.

However, there has been a dramatic deceleration in international student flows in recent years. Yearly growth of Chinese students in the US averaged about 22% between 2007 and 2013, but has since fallen to under 5% per year. Given the various determinants of student flows, this reflects a few important global changes, including the growth in universities and labor markets across China, political tensions, and the uncertainty in US job prospects.

[35] Appendix F further examines whether intermediary education consulting firms/study abroad agencies play a role in shaping the relationship we find. Such firms professionally assist students in the college application process, and may play an important role in spreading information on US education opportunities. We do not view them as part of the mechanisms above as their proliferation likely follows as a response to the interest in studying abroad, and they can be used to go to any destination.

Local income growth in sending countries generates an important tradeoff for student migrants: forego rising local opportunities or leverage income growth to emigrate. We show that for Chinese students, the latter was the predominant driving force. Recent downturns in student flows suggest that the former may have become an important factor as well.

Such declines in international students may hurt universities increasingly reliant on foreign tuition revenues (Bound et al., 2021; Chen, 2021), and the economy more broadly, as foreign students become entrepreneurs (Amornsiripanitch et al., 2021). Education exports added about $44 billion to the US current account, about as large as the combined exports of soybeans, coal, and natural gas (BEA, 2020). Although the conversation on trade with China focuses on the goods deficit, there has been undeservedly little attention on the trade surplus with respect to educational services. We show that these are inextricably linked, as trade-induced income growth in China drove the export of educational services from the US.

References

Acemoglu, Daron, David Autor, David Dorn, Gordon H. Hanson and Brendan Price. 2016. "Import Competition and the Great US Employment Sag of the 2000s." *Journal of Labor Economics* 34(S1):141–198.

Adao, Rodrigo, Michal Kolesar and Eduardo Morales. 2019. "Shift-Share Designs: Theory and Inference." *The Quarterly Journal of Economics* 134(4):1949–2010.

Amiti, Mary and Caroline Freund. 2010. *The Anatomy of China's Export Growth*. University of Chicago Press pp. 35–56.

Amornsiripanitch, Natee, Paul Gompers, George Hu and Kaushik Vasudevan. 2021. "Getting Schooled: The Role of Universities in Attracting Immigrant Entreprenuers." *Working Paper* .

Angelucci, Manuela. 2015. "Migration and Financial Constraints: Evidence from Mexico." *Review of Economics and Statistics* 97(1):224–28.

Atkin, David. 2016. "Endogenous Skill Acquisition and Export Manufacturing in Mexico." *American Economic Review* 106(8):2046–85.

Autor, David, David Dorn and Gordon H Hanson. 2013. "The China Syndrome: Local Labor Market Effects of Import Competition in the United States." *American Economic Review* 103(6):2121–68.

Bahar, Dany and Hillel Rapoport. 2018. "Migration, Knowledge Diffusion and the Comparative Advantage of Nations." *The Economic Journal* 128(612):F273–F305.

Bai, Xue, Kala Krishna and Hong Ma. 2017. "How You Export Matters: Export Mode, Learning and Productivity in China." *Journal of International Economics* 104:122–137.

Bazzi, Samuel. 2017. "Wealth Heterogeneity and the Income Elasticity of Migration." *American Economic Journal: Applied Economics* 9(2):219–55.

BEA, Bureau of Economic Analysis. 2020. "International Transactions, International Services, and International Investment Position Tables." *BEA International Data* .

Blanchard, Emily and William Olney. 2017. "Globalization and human capital investment: Export composition drives educational attainment." *Journal of International Economics* 106(C):165–183.

Bloom, Nicholas, Kyle Handley, Andre Kurman and Phillip Luck. 2019. The Impact of Chinese Trade on US Employment: The Good, the Bad, and the Debatable. In *American Economic Association Annual Meetings*. Vol. 2019.

Borusyak, Kirill, Peter Hull and Xavier Jaravel. 2020. Quasi-Experimental Shift-Share Research Designs. Technical report Review of Economic Studies. Forthcoming.

Bound, John, Breno Braga, Gaurav Khanna and Sarah E Turner. 2020. "A Passage to America: University Funding and International Students." *American Economic Journal: Economic Policy* 12(1):97–126.

Bound, John, Breno Braga, Gaurav Khanna and Sarah Turner. 2021. "The Globalization of Postsecondary Education: The Role of International Students in the US Higher Education System." *Journal of Economic Perspectives* 35(1):163–84.

Bound, John, Murat Demirci, Gaurav Khanna and Sarah Turner. 2015. "Finishing Degrees and Finding Jobs: U.S. Higher Education and the Flow of Foreign IT Workers." *Innovation Policy and the Economy* 15. Kerr, Lerner, and Stern (eds.).

Brandt, Loren, Johannes Van Biesebroeck, Luhang Wang and Yifan Zhang. 2017. "WTO Accession and Performance of Chinese Manufacturing Firms." *American Economic Review* 107(9):2784–2820.

Caliendo, Lorenzo, Maximiliano Dvorkin and Fernando Parro. 2019. "Trade and Labor Market Dynamics: General Equilibrium Analysis of the China Trade Shock." *Econometrica* 87(3):741–835.

Chen, Kaiji and Yi Wen. 2017. "The Great Housing Boom of China." *American Economic Journal: Macroeconomics* 9(2):73–114.

Chen, Mingyu. 2020. The Value of US College Education in Global Labor Markets: Experimental Evidence from China. Technical Report 627 Industrial Relations Section Working Paper at Princeton University.

Chen, Mingyu. 2021. "The Impact of International Students on US Colleges: Higher Education as a Service Export." *Working Paper* .

Chen, Mingyu, Jessica Howell and Jonathan Smith. 2020. "Best and Brightest? The Impact of Student Visa Restrictions on Who Attends College in the US." *Working Paper* .

Chen, Ting, Laura Liu, Wei Xiong and Li-An Zhou. 2017. "Real Estate Boom and Misallocation of Capital in China." *Working Paper, Princeton University* .

Cheng, Wenya and Andrei Potlogea. 2017. Trade Liberalization and Economic Development: Evidence from China's WTO Accession. In *2017 Meeting Papers*. Number 1648 Society for Economic Dynamics.

Chor, David and Bingjing Li. 2021. "Illuminating the Effects of the US-China on China's Economy." *Working Paper* .

Clemens, Michael A. 2014. "Does Development Reduce Migration?" *International Handbook on Migration and Economic Development* p. 152–185. Robert E.B. Lucas (ed.) Cheltenham: Edward Elgar Publishing.

Collins, William J., Kevin H. O'Rourke and Jeffrey Williamson. 1997. Were Trade and Factor Mobility Substitutes in History? NBER Working Papers 6059.

Comin, Diego A, Danial Lashkari and Martí Mestieri. 2019. Structural Change with Long-Run Income and Price Effects. Technical report National Bureau of Economic Research.

Dingel, Jonathan I. 2016. "The Determinants of Quality Specialization." *The Review of Economic Studies* 84(4):1551–1582.

Eaton, Jonathan and Samuel Kortum. 2018. Trade in Goods and Trade in Services. In *World Trade Evolution*, ed. Lili Ing and Miaojie Yu. Routledge pp. 82–125.

Erten, Bilge and Jessica Leight. 2020. "Exporting out of Agriculture: The Impact of WTO Accession on Structural Transformation in China." *Review of Economics and Statistics* pp. 1–46.

Facchini, Giovanni, Maggie Y Liu, Anna Maria Mayda and Minghai Zhou. 2019. "China's "Great Migration": The Impact of the Reduction in Trade Policy Uncertainty." *Journal of International Economics* 120:126–144.

Feenstra, Robert, Haiyan Deng, Chang Hong, Philip Luck, Alyson Ma, Hong Ma, Shunli Yao, Greg Wright and Mingzhi Xu. 2018. "Chinese and Hong Kong International Trade Data." *Center for International Data, University of California, Davis* .

Foellmi, Reto, Christian Hepenstrick and Zweimüller Josef. 2017. "International Arbitrage and the Extensive Margin of Trade between Rich and Poor Countries." *The Review of Economic Studies* 85(1):475–510.

Ge, Suqin and Dennis Tao Yang. 2014. "Changes in China's Wage Structure." *Journal of the European Economic Association* 12(2):300–336.

Goldsmith-Pinkham, Paul, Isaac Sorkin and Henry Swift. 2020. Bartik Instruments: What, When, Why, and How. Technical report American Economic Review. Forthcoming.

Greenland, Andrew and John Lopresti. 2016. "Import exposure and human capital adjustment: Evidence from the U.S." *Journal of International Economics* 100(C):50–60.

Handley, Kyle and Nuno Limão. 2017. "Policy Uncertainty, Trade, and Welfare: Theory and Evidence for China and the United States." *American Economic Review* 107(9):2731–83.

Institute for International Education. 2019. "Open Doors Report on International Education Exchange." *http://www.iie.org/opendoors* .

Jaeger, David A, Joakim Ruist and Jan Stuhler. 2018. Shift-share Instruments and the Impact of Immigration. Technical report National Bureau of Economic Research.

Kuka, Elira, Na'ama Shenhav and Kevin Shih. 2020. "Do Human Capital Decisions Respond to the Returns to Education? Evidence from DACA." *American Economic Journal: Economic Policy* 12(1):293–324.

Li, Bingjing. 2018. "Export Expansion, Skill Acquisition and Industry Specialization: Evidence from China." *Journal of International Economics* 114:346–361.

Liu, Chang and Wei Xiong. 2018. China's Real Estate Market. Technical report National Bureau of Economic Research.

Liu, Maggie Y. 2017. "How Does Globalization Affect Educational Attainment? Evidence from China.".

Matsuyama, Kiminori. 1992. "Agricultural Productivity, Comparative Advantage, and Economic Growth." *Journal of Economic Theory* 58(2):317–334.

McKenzie, David and Hillel Rapoport. 2011. "Can Migration Reduce Educational Attainment? Evidence from Mexico." *Journal of Population Economics* 24(4):1331–1358.

McKinsey Global Institute. 2019. Globalization in Transition: The Future of Trade and Value Chains. Technical report.

Nunn, Nathan. 2007. "Relationship-Specificity, Incomplete Contracts, and the Pattern of Trade." *The Quarterly Journal of Economics* 122(2):569–600.

Parsons, Christopher and Pierre-Louis Vézina. 2018. "Migrant Networks and Trade: The Vietnamese Boat People as a Natural Experiment." *The Economic Journal* 128(612):F210–F234.

Pierce, Justin R and Peter K Schott. 2016. "The Surprisingly Swift Decline of US Manufacturing Employment." *American Economic Review* 106(7):1632–62.

Pregelj, Vladimir N. 2001. Most-Favored-Nation Status of the People's Republic of China. In *Most-Favored-Nation Status of the People's Republic of China*. Congressional Research Service, Library of Congress.

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

Shih, Kevin. 2017. "Do International Students Crowd-Out or Cross-Subsidize Americans in Higher Education?" *Journal of Public Economics* 156:170–184.

Sun, Stephen T and Constantine Yannelis. 2016. "Credit Constraints and Demand for Higher Education: Evidence from Financial Deregulation." *Review of Economics and Statistics* 98(1):12–24.

Tombe, Trevor and Xiaodong Zhu. 2019. "Trade, Migration, and Productivity: A Quantitative Analysis of China." *American Economic Review* 109(5):1843–72.

Venables, Anthony. 1999. Trade liberalisation and Factor Mobility: An Overview. In *China's Growing Role in World Trade*, ed. Riccardo C. Faini, Jaime de Melo and Klaus Zimmermann. Cambridge University Press pp. 23–47.

Wang, Zhi, Shang-Jin Wei, Xinding Yu and Kunfu Zhu. 2018. Re-Examining the Effects of Trading with China on Local Labor Markets: A Supply Chain Perspective. Working Paper 24886 National Bureau of Economic Research.

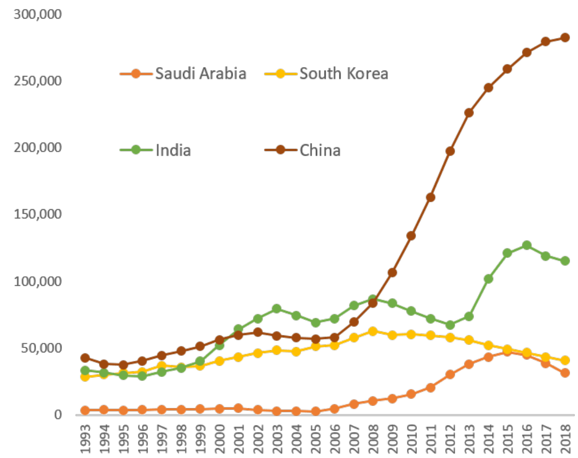
Xu, Mingzhi. 2020. "Globalization, the skill premium, and income distribution: the role of selection into entrepreneurship." *Review of World Economics* 156(3):633–668.

Yu, Miaojie. 2015. "Processing Trade, Tariff Reductions and Firm Productivity: Evidence from Chinese Firms." *The Economic Journal* 125(585):943–988.

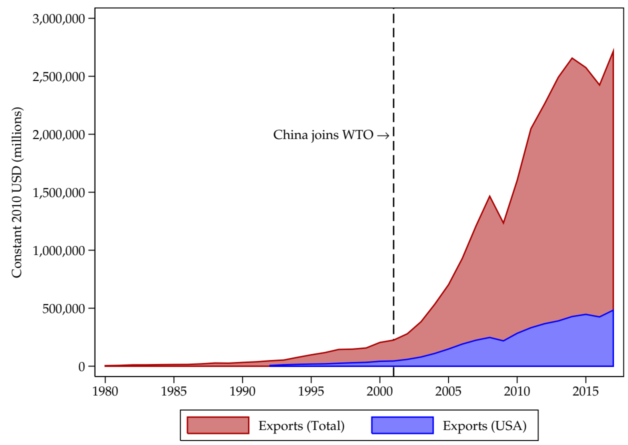
Zhu, Xiaodong. 2012. "Understanding China's Growth: Past, Present, and Future." *Journal of Economic Perspectives* 26(4):103–24.

8 Tables & Figures

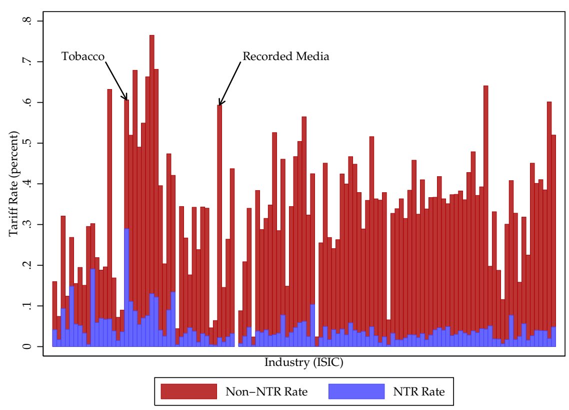
Figure 1: International Students, Chinese Exports, and PNTR Variation



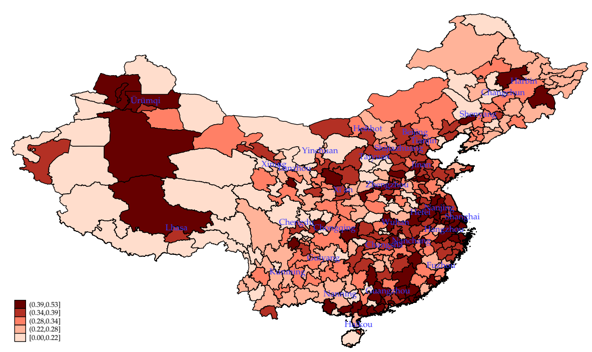
(a) Number of International Students in the United States by Country of Origin



(b) Chinese Exports, 1980-2017



(c) NTR and non-NTR rates across industries

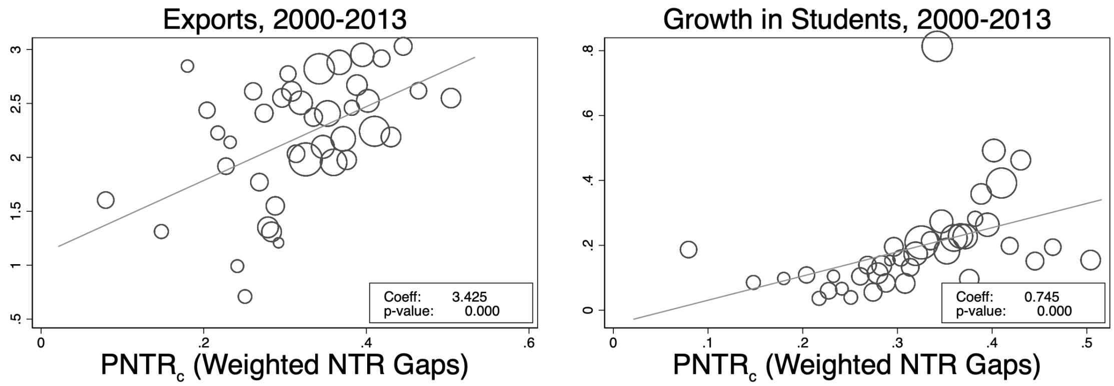


(d) PNTR exposure across Chinese prefectures

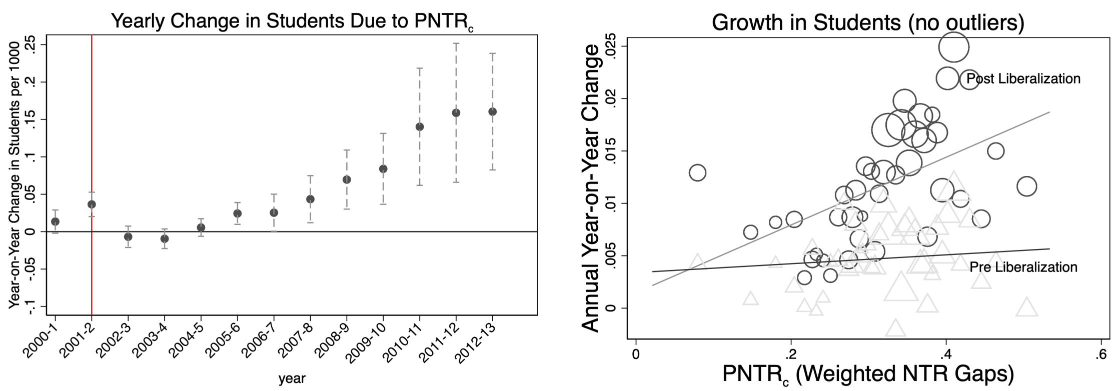
Notes: Figure 1a uses data on enrollment by country of origin from Open Doors, Institute for International Education, 1993-2018, and it includes the sum of graduate and undergraduate students. We show an analogous figure using visa data in Figure E.3. Figure 1b presents Chinese exports to the world as well as exports to the United States only. Data for exports to the United States are from UN Comtrade. Exports to the world are sourced from the World Bank. Both reflect exports in 2010 prices using the US GDP deflator for that year. Figure 1c shows the NTR and non-NTR rates for each 4-digit ISIC industry. The NTR gap is the difference between the two and is plotted in Figure E.1. Figure 1d shows a map of prefecture cities used in the sample, with shading representing the intensity of weighted NTR gaps. We measure city-level exposure as a weighted average of industry-level NTR gaps, weighted by each city's existing activity, as detailed in equation (3). Data on NTR and non-NTR rates by industry are from Pierce and Schott (2016).

Figure 2: PNTR Exposure and post-WTO Outcomes

(a) Correlation between PNTR_c and Long Run Changes in Outcomes



(b) Correlation between PNTR and Year-on-Year Change in Student Outflows



Notes: Figures in 2a show binned scatter plots of the weighted NTR gap (PNTR) and growth in outcomes measured from 2000-2013. Plots show 40 equal-size bins, weighted by population size in each bin. Export growth (first panel) is measured as the log change from 2000-13, using data from the China Customs Database. Student growth (second two panel) is measured as the change in the number of students from 2000-13, divided by the initial city population (only non-agricultural hukou). Coefficients and p-values are based on a regression with no controls, for the full sample available. Data on Chinese students by the city of origin are from SEVIS. Scatterplots showing post- and pre-WTO trends together are shown in Figure E.2. Figures in 2b: the left panel shows the year-on-year change in the number of students per 1000 residents of a city as a function of the weighted NTR gap ($PNTR_c$). We divide the yearly change in students by the initial city population in 2000. Each point is from a separate regression. For instance, the final point shows the change in students per 1000 residents between 2012 and 2013 as a function of $PNTR_c$. The right panel shows binned scatter plots of the relationship between the weighted NTR gap and annual (year-on-year) growth in students per 1000 residents. Plots show 40 equal-size bins, weighted by population size in each bin, plotting the mean value within each bin. The right panel drops the two cities with the largest student growth (Beijing and Shenzhen) to check for sensitivity to outliers. Pre-liberalization student growth is measured as the change in the number of students between 2000-01, divided by the initial city population in 2000. Post-liberalization student growth is measured as the change in students from 2002-13 per year (i.e., divided by eleven years), per initial city population in 2002. City population represents the non-agricultural hukou population (in 1000s). Data on Chinese students by the city of origin are from SEVIS.

Table 1: Shift-Share Diagnostics

(a) Shock-level (NTR Gap) Summary Statistics

Variable	Statistics
Mean	0.327
Std. Dev.	0.157
IQR (p75-p25)	0.178
Largest importance weight	0.113
1/HHI	23.644
# Shocks	119
# Industries	119

(b) Industry Balance Checks

	(1)
Contract intensity, 1997	0.098
	(0.109)
Import tariffs, 2000	0.159***
	(0.053)
Input tariffs, 2002	0.027
	(0.049)
Export licenses, 2000	0.146*
	(0.079)
Ratio of labor to value-added, 2000	0.021
	(0.222)
Ratio of capital to value-added, 2000	-21.454
	(26.322)
Return on assets, 2000	0.004
	(0.015)
Return on equity, 2000	0.446
	(0.466)
Industries	119

Notes: Panel 1a: The table reports summary statistics for our NTR gaps, which vary by industry. We use data on NTR gaps for 119 ISIC 4-digit industries to compute the mean, standard deviation, and max of the NTR gaps. Additionally, we provide summary statistics of exposure weights, which are a weighted sum of initial city-by-industry export shares. For these, we provide the maximum weight, the inverse of the Herfindahl Index, and the number of shocks (which is also the # of industries). See Borusyak, Hull and Jaravel (2020) for further details on why these statistics are useful. Panel 1b: The table checks whether industry NTR gaps are correlated with any other observed industry-level factors, measured during the pre-period, that might also affect student emigration to the US, which Borusyak, Hull and Jaravel (2020) (BHJ) refer to as industry balance tests. See Appendix C.2 for details on the industry-aggregated regression specification used. We regress various industry-level pre-WTO variables on industry shocks (NTR gaps), weighting by exposure weights. Heteroskedasticity-robust standard errors (in parenthesis). ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Table 2: Regional Balance Checks

	(1) Export Share No Controls	(2) Export Share All Controls	(3) Number of Cities (Obs.)
A: Education Indicators			
Change in Chinese Students/City Pop 2000, 2000-2001	0.004	0.003	268
	(0.004)	(0.006)	
Log Change in Chinese College Students, 1997-2000	0.053	-0.025	182
	(0.284)	(0.359)	
Log Change in Chinese Colleges, 1997-2000	0.455*	0.400	184
	(0.265)	(0.312)	
Log Change in Chinese Middle School Students, 1997-2000	0.902	0.778	246
	(0.912)	(1.066)	
Log Change in Chinese Middle Schools, 1997-2000	0.081	-0.050	219
	(0.115)	(0.141)	
B: Economic Indicators			
Log Change in GDP, 1997-2000	0.020	-0.038	246
	(0.131)	(0.178)	
Log Change in Employment, 1997-2000	-0.509	-0.089	219
	(0.483)	(0.664)	
Log Change in FDI, 1997-2000	0.334	0.475	190
	(0.692)	(1.062)	
Log Change in Real Estate Inv., 1997-2000	-0.012	-0.117	217
	(0.581)	(0.807)	
Log Change in Exports, 1997-2000	-0.123	0.526	268
	(0.843)	(1.019)	
C: Demographics & Skill/Capital Intensity			
Share of 18 y.o. in Population, 1990	-0.000	-0.005	185
	(0.004)	(0.006)	
Share of College Educated Workers, 1990	-0.021	0.002	181
	(0.019)	(0.021)	
Manufacturing Employment Share, 1994	-0.177	-0.048	252
	(0.143)	(0.150)	
Capital Share in Output, 1994	-0.316**	-0.175	251
	(0.134)	(0.131)	
Change in Share of 18 y.o. in Population, 1990-2000	0.020*	0.010	185
	(0.010)	(0.014)	
Change in Share of College Educated Workers, 1990-2000	-0.011	-0.020*	181
	(0.008)	(0.011)	
Change in Manufacturing Employment Share, 1994-2000	0.003	-0.018	245
	(0.096)	(0.124)	
Change Capital Share in Output, 1994-2000	0.222**	0.181	244
	(0.111)	(0.138)	

Notes: The table checks whether our PNTR exposure measure is correlated with any other observed city-level factors, measured during the pre-period, that might also affect student emigration to the US, which BHJ refer to as regional balance tests. See Appendix C.2 for details on the industry-aggregated regression specification used to perform these regional balance tests. This industry-aggregated specification is operationally equivalent to using city-level variation and regressing various pre-WTO city-level variables on our PNTR exposure measure. Column (1) shows results without any controls, while column (2) shows results after including our four primary controls. Heteroskedasticity-robust standard errors (in parenthesis). ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Table 3: Effect of PNTR on Student Outflows

	2002-2013				
	(1) No Controls	(2) +Control for Import Tariffs	(3) +Control for Export Licenses	(4) +Control for Input Tariffs	(5) +Control for Contract Intensity
$PNTR_c$	0.386***	0.443***	0.331***	0.353***	0.337***
	(0.114)	(0.121)	(0.114)	(0.113)	(0.116)
Import Tariffs		-0.209	-0.127	0.027	-0.039
		(0.135)	(0.123)	(0.125)	(0.141)
Export License			0.639**	0.560**	0.395*
			(0.280)	(0.262)	(0.207)
Input Tariffs				-1.061***	-1.035***
				(0.382)	(0.392)
Contract Intensity					0.281
					(0.203)
Interquartile Effect:					
Δ *Students per 1m Pop.*	44	50	38	40	38
Mean Dep Var.	0.146	0.146	0.146	0.146	0.146
Obs.	268	268	268	268	268
R2	0.021	0.024	0.038	0.048	0.056

Notes: City-level regressions show the effect of PNTR exposure on Chinese student enrollment growth between 2002 and 2013 per thousand city residents in 2002. Rows below the coefficients scale up the effect size in terms of students per million residents for a change in the PNTR that traverses its interquartile range (≈10 p.p.). In each column, we iteratively include controls detailed in Section 4. All controls are at the city level, constructed by taking weighted averages of ISIC industries in the same way as our PNTR measure. Export licenses refer to the Bai, Krishna and Ma (2017) the fraction of export revenues licensed to export directly. Output tariffs are for the year 2000 (from World Integrated Trade Solution (WITS)), while input tariffs are constructed using WITS tariff data and the 2002 input-output table for China. Contract intensity refers to the Nunn (2007) measure of the proportion of intermediate inputs employed by a firm that requires relationship-specific investments. Heteroskedasticity-robust standard errors reported (in parentheses). ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Table 4: Effect of PNTR on Student Outflows, 2002-2013, Robustness Checks

	(1) Main Effect Col 5 of Table 3	(2) Drop 4 Largest Cities	(3) Drop Capital Coastal Cities	(4) Weighted by Poplation	(5) Control for Region FE	(6) Control for Changing Tariffs
A: Robustness Checks						
$PNTR_c$	0.337***	0.289***	0.302***	0.513***	0.201*	0.341***
	(0.116)	(0.110)	(0.098)	(0.172)	(0.118)	(0.114)
Interquartile Effect:						
Δ Students per 1m Pop.	38	33	34	58	23	39
Obs.	268	264	230	267	268	268
R2	0.056	0.051	0.046	0.086	0.091	0.077
B: Employment Weighted PNTR						
$PNTR_c^{1990,EMP}$	0.826***	0.792***	0.706***	0.882***	0.634**	0.767***
	(0.275)	(0.272)	(0.266)	(0.252)	(0.273)	(0.278)
Interquartile Effect:						
Δ Students per 1m Pop.	51	49	44	54	39	47
Obs.	258	254	220	257	258	258
R2	0.115	0.103	0.076	0.204	0.151	0.120

	(1) Control for In-Migration	(2) Control for Out-Migration	(3) Control for In- and Out-Migration	(4) Total Population in Denominator	(5) 2013 Population in Denominator
C: Internal Migration Checks					
$PNTR_c$	0.318**	0.270**	0.343**	0.146**	0.224**
	(0.128)	(0.129)	(0.136)	(0.067)	(0.087)
Interquartile Effect:					
Δ Students per 1m Pop.	36	31	39	17	25
Obs.	252	252	252	274	275
R2	0.103	0.093	0.138	0.036	0.060

Notes: Regressions show the effect of PNTR exposure on Chinese student enrollment growth between 2002 and 2013 per thousand city residents. The rows below the coefficients scale up the effect size in terms of students per million residents for a change in the PNTR that traverses its interquartile range (≈10 p.p.). We include all main controls. Panel A provides general robustness checks: column (1) reproduces our main estimates from column (5) in Table 3; column (2) drops the four largest cities from the sample; column (3) drops province capitals and coastal cities; column (4) weights the regression by city-wide population; column (5) includes region-level fixed effects, where the region is the first (of four) digits in the prefecture code; column (6) controls for time-varying changes in tariffs at the city-level. Panel B replicates the same specifications as the previous panel but with an alternative construction of $PNTR$. In this case, equation 3 is constructed with industry employment weights from 1990 (where the shifter is unchanged from the benchmark). Panel C assesses endogeneity from internal migration, as Facchini et al. (2019) link PNTR exposure to increases in non-hukou in-migration: column (1) controls for city-level growth in migration rates for skilled and unskilled workers; column (2) for city-level growth in the share of migrants in the skilled and unskilled population; column (3) controls for both migration rates and shares. Therefore, each of the first 3 columns includes *two* measures of internal migration, separately for skilled and unskilled migrants (not shown in table). Column (4) normalizes the change in the number of students by the *total* population, including the surrounding agricultural areas and column (5) normalizes the change in the number of students by the 2013 urban population. Heteroskedasticity-robust standard errors reported (in parentheses). ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Table 5: Mechanisms: Effect of PNTR on Household Wealth and Income

Panel A: US College Affordability and Average Income

	UHS 2002-2007	Statistical Yearbook 2002-2013		
	(1) Share of HHs that can afford US tuition	(2) GDP	(3) Population	(4) Avg. Income (GDP per cap.)
$PNTR_c$	0.121*	0.693***	0.273	0.419*
	(0.065)	(0.258)	(0.246)	(0.250)
Obs.	169	267	267	267
R2	0.11	0.10	0.02	0.09
Controls	x	x	x	x

Panel B: Real Estate Income/Wealth

	UHS 2002-2007					Wind Bank 2002-2013
	(1) Real Estate Income	(2) Rental Income	(3) Share of HHs Collecting Rent	(4) Share of Rent in Total Income	(5) House Price (per sqm)	(6) Commercial Price (per sqm)
$PNTR_c$	2.555*	3.466**	0.109**	0.013**	0.297	0.554*
	(1.466)	(1.234)	(0.041)	(0.005)	(0.364)	(0.297)
Obs.	165	149	169	169	169	204
R2	0.02	0.06	0.05	0.03	0.01	0.06
Controls	x	x	x	x	x	x

Panel C: Non-Real Estate Income/Wealth

	UHS 2002-2007				
	(1) Labor Income	(2) Business Income	(3) Capital Gains	(4) Transfer Income	(5) Interest Income
$PNTR_c$	0.106	1.404	0.988	-0.328	-0.791
	(0.149)	(1.209)	(1.128)	(0.269)	(0.636)
Obs.	169	168	167	169	169
R2	0.03	0.03	0.04	0.05	0.04
Controls	x	x	x	x	x

Notes: Panel A shows city-level regressions of weighted NTR gaps on the share of households that can afford US tuition, the log change in GDP, population, and GDP per capita. Data on GDP and population are from the Chinese Statistical Yearbook 2002-13. Data on tuition affordability is from the Urban Household Survey 2002-07 (UHS). We calculate this by converting the average cost of a 4-year college degree in 2002 (roughly \$27,000 per yr × 4 years) to RMB using the exchange rate of 8 RMB/USD. We then divide this by ten years, which equals about \$86,000 – hence our affordability measure is for those whose accumulated income after ten years is at least equal to the cost of a four-year degree. In Panel B, column (1) examines the log change in real estate income, including rental income and income from the sale of the property; column (2) examines the log change in real estate income that is due to increases in rental income. Data on real estate income is from the UHS. We also examine housing prices (from UHS) and commercial property prices from the Wind Bank dataset, 2002-13. Panel C examines non-real estate income sources, including labor, business, capital gains, transfer, and interest income. Data is from the UHS. Specifications with controls include contract intensity, import tariffs, input tariffs, and export licenses. Heteroskedasticity-robust standard errors reported (in parentheses). $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 6A: Mechanisms: Effect of Skill-specific PNTR on Student Outflows

	(1) China Skill Shares	(2) Indonesian Skill Shares
Skilled NTR CHN	-0.016 (0.445)	
Unskilled NTR CHN	0.270** (0.112)	
Skilled NTR IND		-0.229 (0.204)
Unskilled NTR IND		0.197 (0.245)
Obs.	268	268
R2	.06	.084

Table 6B: Mechanisms: Effect of PNTR on Student Outflows through Network and Information Channel

	(1) Network Defined as Students in 2000	(2) Network Defined as Total Students from 2000-03
$PNTR_c$	0.194** (0.093)	0.261*** (0.094)
$PNTR_c$ X Students in 2000	0.004 (0.006)	
Students in 2000	0.000 (0.002)	
$PNTR_c$ X Students in 2000-03		-0.001 (0.001)
Students in 2000-03		0.000 (0.000)
Obs.	268	268
Controls	x	x

Notes: Regressions show the effect of alternative PNTR exposures on Chinese student enrollment growth between 2002 and 2013 per thousand city residents in 2002. **Table 6A:** As in the baseline specification, we construct the PNTR exposures using (3), but summing across *only* "skill-intensive" and "non-skill intensive" industries. Industry-specific high- and low-skill shares are produced with employment by skill level from ASIP. Given these shares, industries are labeled as "skill-intensive" if above the median across all industries. Column (1) splits the PNTR exposure measure into one based on high-skill-intensive industries and another based on low-skill-intensive industries, using China-specific skill shares of industries calculated from the 2004 ASIP. Column (2) repeats this exercise using Indonesia-specific skill shares from Amiti and Freund (2010). In all cases, the high- and low-skill shares sum to the overall PNTR exposure measure. Across *both* measures the shares sum to 1. For that reason, all regressions include as a control the sum (across industries) of 1997 export shares of the skill-intensive industries (to adjust for incomplete shares).

Table 6B: column (1) defines the city-level network as the number of students matriculating in the US in 2000, while column (2) uses the total students matriculating in 2000-03. We interact it with PNTR. All regressions also include the full set of controls. Heteroskedasticity-robust standard errors reported (in parentheses). ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.