The Exports of Higher Education Services from OECD Countries to Asian Countries. A Gravity Approach

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Abstract: We analyze bilateral exports of higher education services between OECD countries and Asia, using a gravity equation approach, panel data from 1998 to 2016, and PPML regression. The approach treats higher education consumption by Asian countries as a consumable durable good reflecting investment in human capital. Asian Students come to OECD countries to obtain degrees from their universities. Structurally, the flow of students from Asian country *j* to OECD country *i* depends on the higher-education capacity of *i*, the perceived quality of universities in *i*, expected earnings in *i*, a series of bilateral transaction costs between *i* and *j*, the income per capita in *j*, school-age demographics in *j*, and the usual multilateral trade resistance terms. We find that bilateral flows of students are strongly influenced by wage levels in the host country, bilateral distance, importers' income, demographics, common language, the visa regime prevailing in bilateral country pairs, and the network of migrants from *j* in *i*. These results hold through a variation of specifications, proxies, and estimation methods. We find mixed evidence on the role of tertiary education capacity in OECD countries and no evidence of a country's universities reputations explaining the flow of students. The evolution over time of education capacity, earnings, visa regimes, migrant networks, strong income growth and changes in demographics in nearby export markets explain the emergence of Australia, Canada, Korea, and New Zealand and the loss of market share by the US, which still strongly dominates international trade in higher education services. The decline in Chinese students coming to the US is also predicted for the most recent years driven by reduced by its college-age population.

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Introduction

International trade in services has been increasing globally. OECD countries have been particularly adept at exporting services to other and often poorer countries. In particular, trade in higher education services has been on the rise globally, and especially in OECD countries which have been very successful at increasing their exports of education services. This trade has more than doubled in the last two decades. About 3.5 million foreign students enroll in OECD countries' universities (OECD, 2018) of which, a majority, nearly 2 million students, comes from Asia (see Figure 1 and Figure 2).

<Figure 1 about here>

Higher-education trade flows have taken place in several forms (Bashir, 2007). Some OECD universities open campuses in other countries, but more predominantly, foreign students from Asia come to OECD countries to acquire degrees representing about 55% of the OECD trade in higher education services. Some OECD students also study overseas but mostly within the OECD countries, and the latter trade flows represent about 28% of the OECD trade in higher education services and take place mostly with students from European countries (see Figure 2).

<Figure 2 about here>

The dominant form of exports remains the flow of university students from Asian countries to OECD countries (Bashir, 2007; OECD, 2018). Other countries in Africa and Latin America only represent 8% and 3% of foreign students enrolled in OECD countries' universities. In our investigation, we focus on the large Asian component of higher-education trade and explain its evolution since 1998. Competition in the provision of higher education has increased considerably. The dominance of US universities remains but has decreased, in terms of their market share, to the benefit of other OECD countries such as Australia, Canada, Korea, Turkey, several EU countries, and New Zealand. Almost all OECD countries have experienced a dramatic increase in foreign enrollment despite this competition among providers. The growth in foreign student enrollment has been fueled by rising affluence in many Asian countries both through expectation of higher income coming from education and through the demand for higher education as consumable durable goods and the associated nonpecuniary benefits. The appeal of studying abroad remains powerful. Growing demographics in parts of Asia, and a global decrease in visa restrictions, and an increase in the size of the higher education sector in OECD countries could explain the growth as well. Substantial migrant networks facilitate the decision to study abroad and might have helped easing the decision to study abroad. Our investigation explores these conjectures and brings rationalization to the rich and contrasting patterns that have emerged in the last 20 years.

This growth in trade in higher education services through foreign students coming to OECD countries has been organic in the sense that international trade policy and multilateral trade agreements have played a moderate role. The Global Agreement on Trade in Services (GATS) of the WTO covers trade in higher education services, but in practice, signing members of the GATS have mostly focused on liberalizing foreign investment regimes in higher education in importing countries. The GATS's objective is to reduce frictions and expand trade in twelve types of services, including education and higher education (Knight, 2015). The GATS sets up principles and guidelines to progressively liberalize services. In higher education, it is less clear how this is done. GATS centers on national treatment, market access, Most Favored Nation, and transparency issues. Given the dominance of OECD universities, national treatment and market access are mostly an issue for OECD universities trying to establish campuses in non-OECD markets, rather than the opposite. In addition, there are large exemptions for services broadly provided by governments. Public provision tends to dominate in higher education provision in many OECD countries.

In sum, multilateral trade agreements and rules do not seem to have a direct influence on the flow of university students crossing borders to study. These flows are largely undistorted in the sense that restrictive trade policies at the border reduce market access and impede the flow of students. Knight (2006) identifies the following minor trade liberalization issues for the "consumption abroad" of higher education: restriction on travel abroad based on discipline or area of study, restriction on export of currency and exchange, a quota on the number of students proceeding to a county or institution, and prescription of minimum standards or attainments. Some countries also subsidize a restricted number of students as governments recognize the multiple benefits of having better-skilled labor force (Institute for International Education).

Income growth, demographics, the strong return on higher education, and other factors have genuinely fostered the growing international trade between Asian countries and OECD providers of higher education. Governments recognize the multiple benefits of having students studying abroad both in hosting and sending countries. These countries have facilitated these flows with some policies promoting international exchanges in the last decades with scholarships or other means (Institute of International Education). The latter remain small to negligible relative to the sheer magnitude of the flow of foreign students crossing borders. Visa regimes have been liberalized in all countries and that has fostered the flow of international students as we explain later in our investigation.

The economics literature sees the demand for higher education made of two components. First, there is an investment demand to acquire human capital (a production durable based on a net return to investment) and then there is a consumable durable element to derive non-market benefits from higher education (e.g., Willis and Rosen (1979); Becker, 1964; Schultz, 1961; and Campbell and Siegel, 1967). In practice, because it is difficult to gather data on expected net return to higher education, the two approaches are often used in confluence with similar price/unit cost and income argument (e.g., Campbell and Siegel, 1967; Beine et al., 2014; and Perkins and Neumayer, 2014).

There is also a large political science and sociological literature looking at the globalization of higher education, often from a critical perspective of the "commoditization" of higher education (e.g., Altbach and Knight, 2007; and Tilak, 2011). Education scholars also have looked at factors influencing the number of foreign students in a country (e.g., Wei, 2013). There are investigations exploring the geography and migration of international students using reduced forms based on heuristics of cost and benefits of acquiring foreign education (Perkins and Neumayer, 2014; Abbott and Silles, 2016; and Beine et al., 2014 for a formal approach). Beine et al. (2012) develop a migration model using a random utility model, which leads to a bilateral migration flow equation with determinants capturing the costs of migrating, living and education, expected return to skills, and nonpecuniary benefits as proxied by university ranking. They apply the model to 13 destinations countries for years 2004-2007. The latter investigation is the closest to our investigation, although it uses a migration model rather than a bilateral trade flow model.

Looking at the literature on trade in services, Kimura and Lee (2006) have estimated a gravity equation for aggregate service trade between 10 OECD countries and partner countries. McMahon (1992) estimated reduced form equations to assess "push and pull" factors explaining bilateral flows of foreign students coming to the US. Naidoo (2007) uses a reduced form to look at factors influencing Asian students to attend UK universities such as access to their own universities, tuition, exchange rate, income and integration in the global economy.

Our contribution is to spell out an international-trade approach based on education consumption to acquire human capital in OECD countries and to systematically analyze exports of higher education services and their economic determinants. In addition, we characterize the supply side of higher education in OECD countries and address the potential endogeneity of the provision of higher education in OECD countries. Our analysis takes place in a larger global context than previous investigations, using a much larger panel dataset. Finally, we account for a more comprehensive set of transaction costs than in previous investigations. We then use our parameters estimate to decompose the change over time in student flows between key countries based on variation in their determinants. We also use our estimates to explain the observed decrease in Chinese students coming to the US in recent years.

More specifically, our quantitative approach investigates the determinants of bilateral flows of university students from 51 Asian countries to 34 OECD countries using a gravity equation approach and Poisson Pseudo Maximum likelihood (PPML) estimation applied to panel data from 1998 to 2016. The approach treats higher education consumption by Asian countries as human capital consumption decisions. Asian Students come to OECD countries to enroll and obtain degrees from these OECD universities based on perceived costs and benefits of attending a particular OECD country. We derive a sectoral structural model based on Constant Elasticity of Substitution (CES) preferences for these services and higher education capacity in OECD countries. A market equilibrium is formalized in higher education markets in OECD countries, under these assumptions. This step leads to a well-specified gravity equation approach to bilateral exports of higher education services. In the empirical investigation, we explore the potential endogeneity of the supply of higher education services in OECD countries and we account for perceived reputation heterogeneity among OECD countries and their influence on bilateral export demand. Further, we account for an array of transaction and trade costs between importing and exporting countries, including the effect of migrant network, cost of obtaining visas, cultural costs, and the usual costs associated to distance and language.

The flow of students from country *j* to OECD country *i* depends on expected earnings from attending university in country *i*, various bilateral transaction costs between *i* and *j*, the income per capita in *j*, the higher education capacity of *i*, demographics in *j*, the quality of universities in *i*, and the usual multilateral resistance terms in *i* and *j*. In our econometric investigation, we find that bilateral flows of students are strongly influenced by the level of wages in OECD destinations, the existing network of migrants from their own country in OECD countries, bilateral distance, income of the importer, demographics of college-age population in the importer's country, common language, and the visa regime prevailing in bilateral country pairs. We find mix evidence of a systematic effect of the size of the higher education sector in OECD countries depending on the proxy used to characterize capacity of the tertiary education sector; endogeneity of capacity with exports does not appear to be the cause of the mixed result. We also find no significant effect of the perceived reputation of universities in OECD countries.

In the following sections, we first spell out a simple human capital approach to education consumption leading to an aggregate demand in each Asian country for a particular OECD university system. Then, we derive our sectoral model of higher education services based on export demand for these services in Asian countries, and the provision of these services in OECD countries and then the equilibrium between demand and supply. Next, we describe our empirical implementation including, the empirical specification, the panel data used, and a series of diagnostic tests and the strategy to address potential endogeneity issues. We follow with a presentation of the regression results, the decomposition of trade flows over time for key country pairs, and the recent decrease in the flow of Chinese students coming to the US. We also present robustness checks. We draw some implications for service trade policy. An appendix presents additional results on endogeneity tests and robustness checks.

A Sectoral approach

The approach parallels the gravity equation of Anderson and Van Wincoop (2003), but with distinct features. First, we start from a human capital approach (Willis and Rosen, 1979) to the consumption of higher education considered a tradable good. Then we make use of the result established by Anderson, De Palma, and Thisse (1989) mapping discrete choices into CES preferences. The latter authors characterize the discrete choice as a two-step process in which the consumer first choose the specific variety of the good and then the level of consumption. Anderson, De Palma, and Thisse show the equivalence of the logit discrete choice and the CES utility function.[1]

In addition, our bilateral trade variable is a physical measure of consumption (the number of students from Asian country j going enrolled in OECD country *i* in a given year). Further, in our model, trade costs are borne mostly by the importer (in country *j*) who must come to country *i* to consume the exportable service. This assumption is consistent with the preponderant real-world stylized facts explained in the introduction. This second element affects the melting iceberg from the importer to the exporter markets and not vise-versa as in the typical characterization of bilateral merchandise trade.

Foreign students in country *j* choose a university training consumption level in country *i*

[1] There is a parallel justification to use a CES to represent discrete choices. McFadden has established a closely related equivalence between aggregated discrete choices and a representative consumer CES utility function (Mc Fadden 1978 and 1981; and Feenstra, 2004).

(destination and numbers of years) that optimizes the following choice $c_{ij} = \mathrm{Max}(V_{1j}, V_{2j}, \ldots, V_{mj})$ for m possible higher education destinations which are in the feasible set of these students. Value function V_{ij} expresses the value students in j put on education option i. Function V is increasing in expected earnings from the gained education. It is also increasing in non-pecuniary benefits associated with the same higher education choice; and finally, it is decreasing in the costs associated with the destination choice. We have $V=V$(*expected earnings*, *non-pecuniary benefits*, *costs associated with the school choice*).

Non-pecuniary benefits are, for example, the quality and reputation of the school and the attractiveness of the foreign location as in Beine et al. (2014). Costs include economic and cultural costs. Difficulty to obtain a visa, travel cost to the destination country, fees, and cost of living are the main economic costs. Cultural costs are associated with language barriers (absence of common language), religious differences between the home and destination country, the lack of potential network of nationals as captured by formal colonial links, contiguity (proximity), and immigrant networks from the home country present in the destination country.

We then invoke Anderson, De Palma, and Thisse (1989), to characterize these higher education discrete choices as coming from maximizing utility maximization with CES preferences. Assume agents in country j have homothetic preferences assumed CES and choose to purchase higher-education services in country i to maximize their utility. These higher education services are differentiated by country of origin (i.e., OECD countries' higher education sectors in our empirical investigation). Denote c_{ij} the consumption of higher education services of OECD country i by students coming from country j. Consumers in country j maximize utility

(1) $U_j = \left(\sum_{i=1}^{m} \beta_{ij}^{\frac{1-\sigma}{\sigma}} c_{ij}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}$,

subject to income constraint

(2) $\sum_{i=1}^{m} p_{ij} c_{ij} = Y_j$,

where β_{ij} is the taste parameter for perceived returns, quality and reputation of higher education services in country *i* by consumer *j* ($\beta_{ij} = \beta_{ij}$*(expected earnings, non-pecuniary benefits (quality*$_i$*)))*; σ is the constant elasticity of substitution of consumers, p_{ij} is the price of higher education services of country *i* for students in country *j*, and Y_j is consumer income in country *j*. The price for education service *i* p_i (at the border of *i*) varies by importing country *j* (p_{ij}) because of economic and cultural trade costs between *i* and *j*, linked to distance, visa cost, cultural cost, such as language, religion, and other differences, and real exchange rate capturing the relative cost of living.

These costs are made explicit in $p_{ij} = p_i\, t_{ij}$, with t_{ij} denoting the bilateral trade cost factor between *i* and *j*. Here, the trade cost is born by the importer *j* moving to country *i* to consume the higher education services. Taste parameters β_{ij} are unobserved but assumed to be increasing in perceived quality. Later in the empirical investigation, we use a reputation proxy for perceived quality as an explanatory variable.

Maximizing utility (1) subject to (2) leads to export demand from country *j* for higher education service *i*:

(3) $c_{ij} = \left(\frac{\beta_{ij} p_i^{-\frac{\sigma}{1-\sigma}} t_{ij}^{-\frac{\sigma}{1-\sigma}}}{P_j} \right)^{(1-\sigma)} Y_j$, with price index P_j, $P_j = \left(\sum_{i=1}^{m} \left(\beta_{ij} p_i t_{ij} \right)^{1-\sigma} \right)^{\frac{1}{1-\sigma}}$.

Index *i* covers *m* OECD countries. Because we follow a sectoral approach, we can safely adopt the assumption of specialization in a single service sector as in Anderson and van Wincoop (2003).

Denote the supply of higher education services in *i* as C_i. This variable represents the capacity in the tertiary education sector in country *i* in a given year. We assume the capacity as being pre-determined and investigate the potential endogeneity of the supply. The supply is actually a hybrid supply composed of non-profit public and private universities, and for-profit universities. Even though many universities are considered nonprofit entities, budget cuts in the last 20 years, may have changed the behavior of these institutions, which may respond to incentives potentially expanding supply to meet the demand from foreign students. The lion share of higher education is provided by "nonprofit" universities and depends on public funding and tuition revenues for a large segment. At one extreme, supply could be considered as fixed (zero price response or capacity response). Else, if the supply is somewhat price responsive with a price elasticity s larger than zero, ($C_i = C_{io} p_i^s$), we have an equilibrium condition equating this supply with the sum of demands for higher education services from all countries:

(4) $C_i(p_i) = C_{io}\, p_i^s = \sum_{j=1}^{all} c_{ij} = p_i^{-\sigma} \sum_{j=1}^{all} t_{ij}{}^{-\sigma} \beta_{ij}^{1-\sigma} \left(\frac{Y_j}{P_j^{1-\sigma}}\right).$

Equation (4) can be solved for scaled price $p_i^{-\sigma-s}$ as a function of supply element C_{io}, trade cost factor t_{ij}, income Y_j, taste parameters β_{ij}, σ, and price index P_j. Substituting the scaled price into equation (3), yields

$$(5) \qquad c_{ij} = C_{io}^{\sigma/(\sigma+s)} \left(\frac{\beta_{ij}\, t_{ij}^{-\frac{\sigma}{1-\sigma}}}{P_j P_i^{\sigma/(\sigma+s)}} \right)^{(1-\sigma)} \quad (pop_j y_j),$$

with $P_i = \left(\sum_{j=1}^{all} t_{ij}^{-\sigma} Y_j \left[\frac{\beta_{ij}}{P_j}\right]^{1-\sigma} \right)^{\frac{1}{1-\sigma}}.$

Equation (5) expresses the equilibrium consumption of higher education services in OECD country i consumed by country j as a function of the non-price element of higher education supply in i, C_{io}, bilateral trade cost factor t_{ij}, preference parameter β_{ij} for schooling in OECD country i as a function of expected earnings, perceived quality and cost of attending universities in i), the sectoral equivalent of the multilateral trade resistance terms faced by i and j,

P_i and P_j, and income of consumers in country *j*, Y_j. The latter is decomposed into its income per capita component y_j, and demographic component pop_j. Note that is supply C_i is not price responsive, then $s = 0$ in equation (5). In the empirical investigation, we assume C_i is predetermined and then test the endogeneity of the higher education capacity in OECD countries as a way to evaluate the potential supply response.

With more structure, the two trade resistance terms can be solved eventually, as a function of trade cost factors, income, and shares of total income and total OECD higher education supply (see Anderson and Van Wincoop (2003), their equations (10) through (12)). In the empirical investigation, the trade resistance terms are captured by country fixed effects (Thibault, 2015). These effects are not central to our economic investigation. These fixed effects for exporters may also capture some of the non-pecuniary attributes of the OECD destination not captured by the other determinants.

Equation (5) is the base of our empirical implementation. The preference parameters β_{ij} will reflect expected earnings from being schooled in country *i*, non-pecuniary benefits from location *i*, that is, perceived quality and the size of the facilitating migrant network. Trade cost factors are expressed as a power function of bilateral distance, *d*, four cultural dimension variables (with dichotomous variables common language, *cl*, geographical contiguity, *cont*, colonial ties, *col*, and a continuous variable reflecting religion heterogeneity, *reli*), the difficulty to obtain a visa, *visa*, real exchange rate, *rer*, capturing the cost of living differential (purchase power rate of exchange), and a scaling factor *h*, with subscripts *i* and *j* as previously defined. It is:

(6) $t_{ij} = hd_{ij}{}^{\alpha 1}\left(1 + cl_{ij}\right)^{\alpha 2}(1 + cont_{ij})^{\alpha 3}(1 + col_{ij})^{\alpha 4} reli^{\alpha 5} visa_{ij}{}^{\alpha 6} rer_{ij}{}^{\alpha 7}$.

Equation (6) is then substituted into equation (5) as well as the variables reflecting the benefits of the destination to reflect all explanatory variables. This step is presented in the next section. The trade cost factor is time varying through the time variation of *visa* and *rer*. The benefits of the OECD destination are time varying in OECD wages and perceived quality/reputation. Capacity in tertiary education is also time varying.

We use equations (5) and (6) in exponential form to accommodate zero bilateral trade flows which is consistent with the PPML estimation method used here. This is unlike logarithmic specifications and their known drawbacks. Since we use panel data, we also add a time subscript *k* to time-varying variables and add time fixed effects T_k. These added features lead to bilateral trade flows between countries *i* and *j* at time *k* expressed as

(7) $c_{ijk} = exp\big(\lambda_0 + \lambda_1 lnC_{ik} + \lambda_2 lnReputation_{ik} + \lambda_3 lnE_{ik} + \lambda_4 N_{ijk} + \lambda_5 lnd_{ij} + \lambda_6 cl_{ij} + \lambda_7 cont_{ij} + \lambda_8 col_{ij} + \lambda_9 lnreli_{ij} + \lambda_{10} lnvisa_{ijk} + \lambda_{11} lnrer_{ijk}\big) \times exp\big(\lambda_{12} lny_{jk} + \lambda_{13} lnpop_{jk} + \lambda_{14} Foreign_k + \lambda_{15} P_i + \lambda_{16} P_j + \beta\lambda_{17} T_k\big) + \varepsilon_{ijk}$.

Variable *Reputation* represents the perceived quality of the higher education sector in country *i* by students from country *j*; *E* represents expected future earnings in year *k* from enrolling in higher education in country *i*; variable *N* represents the size of the network of immigrants from country *j* in *i*.

Variable $Foreign_k$ is dichotomic and equal to 1 if the data used refers to foreign students is used in year *k*, as opposed to data on international (non-resident) students as explained in the data section. Our dataset comprises a mix of foreign and international students. This dummy variable captures the difference between foreign and international students. Our export equation is of the form $I = exp(\lambda' X)$, with *X* denoting the vector of determinants in (7), other than $Foreign_k$. International students, *I*, are a subset of foreign students, *F*, which also includes students who are resident of the host country. Define the share of international students, α =

I/F. Then, we have: $F = I/\alpha = exp(\lambda' X - ln(\alpha))$. Therefore, we can append the foreign student data from countries, which do not disaggregate their *I* subset by using a dummy variable ($Foreign_k$) which corrects for the data inflation ($-ln(\alpha)$). In this case, parameter α captures the average proportion of *I* in *F*, across exporters. We expect the effect of this variable *Foreign* on trade flow to be positive because international students are a fraction of foreign students as explained in the data section.

Variable ε denotes a random term with mean zero and conditional variance assumed proportional to the conditional mean (E($y|x$)∝V($y|x$)). These are the typical assumptions to motivate the PPML estimation approach used here. PPML has been widely used in the estimation of bilateral trade flows for some key reasons. It can handle zero observations, even when they are present in large numbers (Santos Silva and Tenreyro, 2006 and 2011). The PPML estimation method provides regression estimates that are not biased unlike those obtained from a double log specification. In addition, the estimates tend to be more efficient than those from other methods for which the conditional variance $V(y_i|x)$ is proportional to higher order terms of the conditional mean. The latter puts too much weight on large observations, which often are noisier (Santos Silva and Tenreyro, 2006). Heteroskedasticity often increases with the conditional mean and PPML addresses this potential heteroskedasticity. Trade data are characterized by their variance increasing with larger observations of trade flows. The logarithm approach cannot accommodate this characteristic and provides inconsistent estimates. The PPML method is implemented using Stata. Given the panel nature of our dataset, we use clustered errors based on the bilateral distance variable.

The potential endogeneity of variable C_{ik} complicates somewhat the estimation approach. We use a control function with PPML to endogenize C_{ik} and account for potential omitted variables generating the possible endogeneity. This approach yields consistent estimators and provides a way to test endogeneity (Wooldridge, 1997). We also consider the instrumental variable approach in Stata (the IVPoisson command) (Windmeijer and Silva 1997). However, the estimators in this approach suffer from the incidental parameter problem and will be inconsistent as we have fixed effects for importer, exporter and time and the approach uses GMM (Cameron and Trivedi 2013). As a third way to investigate endogeneity, we use direct instruments for C_{ik}. All three approaches are considered.

For additional robustness check on the estimation methods and specifications, we also provide results for truncated non-zero data using a double log specification, double log specification for (c_{ij}+1) with OLS, and negative binomial PML (NBPML).

Data and sources

Dependent variable

For our dependent variable, we use OECD data on international student enrollment covering 51 Asian countries and 34 OECD countries for years 1998 to 2016. The country coverage is shown in Table 1. OECD countries report the number of international students according to three categories: Foreign (Non-citizen) students, Non-resident students, and students with prior education outside the reporting country. Foreign students are defined as *students who are not citizens of the country in which they are enrolled and where the data are collected* (OECD, 2018). International students are defined either as non-resident students or as students with prior education outside the reporting country. Non-resident students are those with permanent residence outside the reporting country, which means *holding a student visa or permit, or electing a foreign country of domicile in the year prior to entering the education system of the* *country reporting the data* (OECD, 2018) in practice. The country of prior education is defined as *the country in which students obtained their upper secondary or the qualification required to enroll in their current level of education* (OECD, 2018).

There are two large data sets for international students flows. The first one covers 1998 – 2012, and the second covers 2013-2016. In the first set, only the number of foreign students is available prior to 2004 and both foreign and international student categories are available from 2004 to 2012 for many countries, but not all values for these categories are available. For example, the United States only reported the number of international students while United Kingdom reported both the number of foreign and international students during this period. The second set only provides the number of international students regardless of the category and is based on updated criteria used for defining international students. These criteria are available in the annex of *Education at a Glance 2018* (OECD, 2018).

Using the number of foreign students as a proxy for the number of international students overestimates the number of mobile students because it accommodates long-term residents who came to the reporting country as a result of prior migration. However, the exclusion of the number of foreign-students data leads to a loss of most observations for important markets in international higher education, such as Czech Republic, Finland, France, Greece, Hungary, Israel, Italy, Japan, Korea, Norway, and Turkey. Not to lose these observations, we account for both categories (International and Foreign) and control for the difference between categories by including the dummy variable *Foreign*, as explained in the model section. International students are a subset of foreign students (OECD, 2018). For example, we use the number of international students (i.e., non-resident or prior education category) if it is reported. However, the number of foreign students is used as a measure of international students with the dummy variable if only the Foreign (Non-citizen) category is available.[2]

Because of data gap issues for both the enrollment and explanatory variables, we drop Mexico, North Korea, and Palestine. In principle, we have (34 OECD x 51 Asia x 19 years) 32,946 data points. The panel is unbalanced with different time coverage for different countries, although for key markets we have 19 years. Because of missing data for several countries and because of the countries that are dropped, we have 25,265 bilateral trade flow observations including 5,616 zero flows. Hence, the share of observations that are equal to zero is about 22%. This is well within the range of zeros handled by PPML. Because of missing data for some explanatory variables, we eventually use 21,238 of these observations of which 3,428 are zeros, or about 16%.

<Table 1 about here>

Explanatory variables

The same database of the OECD provides total college-age (15-24) population for OECD countries, which we use as a first variable to approximate the supply of higher education services, *C*. An instrumental variable approach is then used to address the potential endogeneity of this variable with the bilateral trade flow variable.[3] We predict the college-age population variable using a reduced form including all the exogenous variables included the bilateral trade flow equation (7), and death rate per 1,000 people as an instrument for the college-age population. We also use total population per OECD country and total tertiary education enrollment for OECD countries as alternative proxies of tertiary education capacity, as well as lagged values of college-age population. Presumably, OECD population, especially of college-

[2] If both non-resident and prior education categories are available, the number of students in the non-resident category is used.
[3] In earlier runs, without migrant networks and OECD wages, we encountered endogeneity issues with this variable, which motivate this section.

age, is predetermined to the tertiary education capacity in the same countries.

For the *Reputation* variable (perceived quality of universities in each country), we use the country count of universities in the top 100 universities of the Shanghai university ranking (Shanghai university ranking). The ranking was originally known as the Academic Ranking of World Universities computed by Shanghai Jiao Tong University. Since 2009, the ranking has been published by ShanghaiRanking Consultancy. It is based on Clarivate Analytics (formerly Web of Science) information and other honorific and reputational metrics. The ranking is available from 2003 to 2016. For years prior to 2003, we use 2003 values. Despite the lack of values for early years, the index shows variation over time. The US dominates the ranking, especially for the top 20 universities, but other countries have been progressively improving their standing, gaining a significant chunk of the top 100 universities. The index is also available for top 500 universities. The latter was used as an alternate proxy in some of the specifications. This Shanghai ranking indicator has been used in previous analyses of the global competition in higher education (Marginson, 2006; Beine et al., 2014). Beine et al. normalized the ranking by the number of students enrolled in the country, which seems to us peculiar given the non-rival nature of the reputation effect.

For the OECD earning variable (E), we use the OECD Employment database, which provide wages time series in OECD countries. The earnings are properly deflated by the country CPI and expressed in local currency units.

For the network variable (N), we use three alternative proxies. First, we use the Global Bilateral Migration Database from the World Bank. We use the bilateral migrant stock variable. This dataset is for 2000 and is time invariant, which is a major drawback. The advantage is that the variable is available for many countries and minimize the loss of observations. Second, we use the Docquier, Lowell, and Marfouk (DLM) dataset available from Marfouk's website (http://www.abdeslammarfouk.com/dlm-database.html). This dataset has been used frequently to capture migrant networks. We rely on the stock of migrants by country of origin. Zeros are dropped for the log transformation with the consequence of having a smaller dataset. The dataset contains only 20 countries.[4] The data is for 2000 (no time variation). The total number of observation is 16,898. The third source comes from the Brucker, Capuano and Marfouk (BCM) dataset (http://www.abdeslammarfouk.com/bcm-database.html). In the latter, the total number of foreign-born individuals is used as a proxy for the migrant network. Only 20 countries are available, also in 5-year intervals. We use 1995 values are used for 1998-1999, 2000 values are used for 2000-2004, 2005 is used for 2005-2009, and so on.

For transaction costs linked to geographical and cultural distances, we use the CEPII Geodist database (CEPII; and Mayer and Zignago, 2011), which provides geographical distances between countries (*d*) and dichotomous variables for a pair of contiguous countries (*cont*), countries with a common language (*cl*), and countries with colonial ties (*col*). These variables are fixed over time. Contiguous countries include 7 countries around Turkey and 3 countries around Israel. Common language includes English and French-speaking countries, and then, Portuguese, Greek, and Turkish languages. Colonial ties originate with the UK, France, and then Turkey, Portugal, Greece, Spain, and the United States. Colonial ties capture some cultural familiarity and likely network effects from the colony's population in the former colonizing country not captured by the network variable.

To capture further cultural costs, we look at the effect of religion heterogeneity on the decision of students to choose the country to study (*reli*). We construct a religion heterogeneity

[4] Belgium, Czech Republic, Estonia, Hungary, Iceland, Israel, Italy, Japan, Korea, Poland, Slovak Republic, Slovenia, and Turkey are dropped (13 countries in total).

variable between origin and destination countries. We do so using the Religious Diversity Index Scores from the Pew Research Center.[5] Pew reports percentage shares of each religious group in populations by country for 2010. We measure religion heterogeneity as the sum of the squares of the differences in shares of five major world religions (Christian, Muslim, Hindu, Buddhist, and Jewish) between exporter and importer countries. The variable varies between zero and two and increases with heterogeneity in shares between the two countries.

We use Henley's Passport Index (Henley) to capture transaction cost linked to visas[6]. The index counts the number of countries the passport holder can travel visa-free. It is based on International Aviation Travel Association (IATA) raw data. The index is reported from 2005 to 2016. Most countries exhibit a rising index over time, suggesting a better integration and freer movement of people over time. For example, Denmark, which has been consistently ranked among the countries with the highest index, had an index of 130 in 2005, which reached 187 in 2016. Japan's index increased from 128 to 190 during the same period. The ranking has changed quite significantly over time for countries such as Korea, which has moved from top 30 to top 5, with a jump in its index from 115 to 188. To capture the change in bilateral cost linked to visas we multiply the scores of the two countries. The product behaves as expected (increasing in the number of visa-free destinations for each country in the pair). For the years 1998 to 2004, we use the 2005 value of the index. For 2008, we use the average of the index values for 2007 and 2009. A direct measure of actual bilateral restrictions would be a more exhaustive way to capture the

[5] http://www.pewforum.org/2014/04/04/religious-diversity-index-scores-by-country/

[6] We check if the passport index is an appropriate proxy for student visa. Due to the unavailability of data for the number of student visas issued by countries covered in this chapter, we partially investigate a correlation between passport index and nonimmigrant visa (F1) issue of USA by country for 2006 – 2016. There is a strong correlation of 0.99 between the F1 issue and passport index. The F1 visa data are obtained from U.S Department of State – Bureau of Consular Affairs (https://travel.state.gov/content/travel/en/legal/visa-law0/visa-statistics/nonimmigrant-visa-statistics.html).

trade cost of visas, but this would require prohibitive work to be collected manually using primary IATA data (see Neumayer, 2011).

We rely on The World Bank WDI database to obtain exchange rates and GDP deflators to derive real exchange rates (*rer*). For exporters other than the US, bilateral exchange rates are obtained by using the ratio of US dollar exchange rates of the two countries involved in bilateral trade. Income per capita of the importer (*y*) is approximated by GDP per capita, expressed in real LCU based in 2004 prices. The data come from The World Bank WDI database. Exchange rates and GDP deflators were described before. Population data focus on the population in or near college-age (15 to 24 years old) in Asian countries and in OECD countries. The former is the population shifter of the demand for higher education in importing countries (*pop*). The latter was explained above and related to OECD capacity in higher education. Our database and Stata codes are available upon request.

Results

Before we estimate equation (7), we run collinearity diagnostics for explanatory variables. We follow Besley et al. (2004)'s approach, computing condition indices and a variance decomposition proportions to identify potential numerical problems indicating near collinearity among our explanatory variables. Collinearity issue can potentially be exacerbated by the large number of fixed effects (time, importer, and exporter) and the presence of time-invariant bilateral dichotomous variables (contiguity, common language, and colonial link) and the time-invariant distance and religion heterogeneity variables. Results indicate that when we exclude Iceland (as STATA selects) there is a correlation between the ln(wage) variable and the constant and also between importer fixed effects (Japan and Kazakhstan). However, when we exclude the exporter

USA and importer Kazakhstan dummies, there was no significant collinearity issue found with extreme variance inflation in two or more explanatory variables per high condition index. The inflation remains much below any alarming level as per recommended by Besley et al. (2004). Besley et al. suggest that a condition index larger than 30 with more than 80% of the variance of two or more coefficients indicate an underlying near dependency among explanatory variables, which leads to degraded estimates. We do not encounter numerical issues when we estimate the regressions.

Following the preliminary check, the central results are presented in table 2. Tertiary education capacity in OECD countries (as proxied by OECD college-age population) appears to be significantly linked to the trade flow of foreign students in one of the three runs presented in table 2 (see last column). The three runs present results for three proxies of migrants' network effects and with varying datasets as explained in the data section. The third column shows results for the smaller of the three datasets with migrant networks being time varying. The elasticity is quite high and much larger than for the two other runs. In any case this result is mixed as the significance of the capacity proxy disappears in the estimations shown in columns (1) and (2) and with the magnitude varying so much across runs but with the sign being as expected.

<Table 2. about here>

The next issue is the potential endogeneity of the supply of tertiary education in OECD universities. The college-age population could be endogenous to its foreign student component in that we do not specify the public funding and tuition revenues due to unavailability of the data. To check the possible endogeneity, we run an endogeneity test using the control function approach (Wooldridge, 1997). It is done by first predicting the college-age population as a function of the other explanatory variables included in (7) and an additional exogenous variable specific to OECD countries (death rate in the OECD country). The estimated residuals from this regression are then used as an additional regressor in the PPML estimation. If they are significantly linked to the bilateral trade variable, then they provide evidence that the proxy is endogenous. The results indicate that residuals obtained from the control function are not endogenous to the dependent variable, which means it does not suffer from an omitted variables bias.[7] We also use another instrumental variable approach using the IVPOISSON command in Stata considering the potential endogeneity bias created by simultaneity. The IVPOISSON, however, suffers from the incidental parameter problem as mentioned previously. Nevertheless, the same conclusion holds and no evidence of endogeneity created by simultaneity is found with IVPOISSON since the college-age population is found insignificant as well. Finally, we also use three direct instruments (OECD total populations, foreign enrollment and lagged college-age population). However, none of these proxies was significant. The detailed results of the endogeneity investigation are shown in Appendix table 1.

The perceived quality/reputation of universities does not matter statistically in all the PPML runs. We also tried rankings based on top 300 and top 500, without success. The ranking represents the right tale of the distribution of universities and may not represent the reputation of the whole university systems at the national level. Results for the alternative proxies are available upon request. The findings of Beine et al. (2014) cannot be confirmed with our larger dataset and we keep in mind their normalization of reputation. In addition, we have a panel as the latter authors use 2007 data.

Expected earnings as captured by OECD wages appear significant and positively related to bilateral flows of students in all PPML runs presented in table 2 and the appendix table 1. The

[7] To implement the control function approach, we use bootstrap standard errors (1000 iterations). Each pair of countries are resampled over clusters based on the bilateral distance variable.

implied elasticity is high between 1.7 and 2.7 in table 2, and it persists in the PPML runs in Appendix tables. These high elasticities are smaller than those found by Beine et al. (2014), which were as high as 5.5. Wages in the latter investigation were for workers with tertiary education. In any case, these results on wages are also consistent with those found by Rosenzweig (2008). As a note of caution, we tried GNI per capita in OECD countries and relative GNI per capita between exporter and importer and could not find systematic significance with these alternative proxies. Results are available from the authors.

Next, network effects are positive and significant for the three measures used, and with elasticities in the range of .24 to 0.43, depending on the migrant network measure. These results hold for all PPML runs and appear solid. These results and magnitudes confirm findings by Beine et al. (2014) in their smaller dataset for 2007.

As found in many investigations of merchandise trade, distance matters significantly for exports in education services with a response between -.77 and -1.02, depending on the specification. Again all PPML runs confirm the negative role of distance. These values in table 2 are near the median of estimates analyzed in Disdier and Head (around -0.9), and larger than magnitudes found by Beine et al. (2014).

Common language is also important with a significant response between roughly between 1.0 and 1.2 Using the Halvorsen-Palmquist formula [(exp(beta)-1) x100], this common language coefficient (1.228) in column 1 is equivalent to an effect of 241% on the flow of students! Common language has a very strong effect on these foreign students flows, in line with results of existing papers (Abbott and Silles, 2016; Beine et al., 2014; Perkins and Neumayer, 2014). This effect captures the important role of English, but also of French, Greek and Portuguese among these countries. Contiguity and the former colonial ties are not statistically significant. This absence of effect holds through all PPML runs.

Cultural distance as captured by religion dissimilarity does not appear to create cost to students. The religious profile of OECD countries does not seem to play a significant role in a choice of country to study. In the robustness check section, we investigate another dimension of religion, and found some temporary influence post 2001. (See that section below).

The elasticity of trade with respect to the bilateral trade cost linked to visas is strong and around 1. These results are verified through all the PPML runs. Countries can further integrate and improve their bilateral visa regimes to facilitate the flow of foreign students. OECD countries have increased their passport access by 43% on average between 2003 and 2016. Some countries have improved by great strides (Turkey, and Korea). Similarly, some Asian countries sending their students have been improving their access, by 85% on average. They are still lagging on OECD countries and could do more. This is actionable.

The real exchange rate variable is not statistically significant in columns 1 and 2, and marginally significant in column 3. The real exchange rate has the expected negative impact on bilateral trade in higher education. The estimated standard deviations are relatively high. This mixed to inconclusive result on real exchange rates follow the inconclusive findings of Abbott and Silles (2016), who found a statistically insignificant but positive effect of real exchange rate on the number of international student migrants.

Furthermore, demand shifters in importing countries are significant. Income per capita shows an estimated elasticity in the range (0.63 to 0.745). The population of college-age shows a comparable magnitude for its elasticity with the range (0.535 to .760) with a small loss of significance in column 3. These two results hold through all the PPML runs. The income shifter is the major drive of the growth of this trade in higher education service. Changes in demographics have been smaller on average with strong growth in India, and Malaysia, smaller growth in Indonesia and reductions in China, given its tight control policy on household size. China's income growth has been phenomenal, and that effect swamps the negative impact of the contraction of the college-age population over the period analyzed. Below we look at the recent development in China's demographic and income to analyze the projected flow of Chinese students in the US in 2017.

Lastly, the coefficient of $Foreign_{it}$ is significantly positive in all PPML runs. Using the first estimation in column 1 of table 2, we have $-ln(\alpha) = 0.373$, leading to $\alpha = exp(-0.373) \approx 69\%$. It indicates that international students on average represent 69% of foreign students. This proportion is quite close to the average proportion of 71% reported in *Education at a Glance* (OECD, 2007).

Prediction of Chinese student flows to the US for 2017

Using the available variables (visa, real exchange rate, GDP, and population) for 2017, we predict the number of students from China to the US by using predicted coefficients with other variables being constant in 2016. The number of international students coming from China to the US is predicted to decrease by 1% in 2017, which is a smaller effect in absolute value than the actual decrease of 6.6% in 2017 (Hackman and Belkin, 2018). The predicted decrease is mostly driven by the decrease in college-age population of China despite of a decrease in real exchange rate and despite an increase in visa regime and GDP of China. Furthermore, the number of students from China to US might continue to decrease by 2022 based on the decreasing population of China as predicted by UNESCO, with other variables held constant. The estimation does not account for the recent tightening of immigration by the Trump administration.

The effect of 9/11

The aftermath of the US tragedy of September 11, 2001 may also have influenced the choice of university destination. There were some restrictions imposed on visa seekers and some public anti-foreign and Muslim sentiments, especially in the US (Neiman and Swagel, 2009). We further investigate how the 9/11 event affected bilateral trade in education, in terms of a relationship between Muslim proportion and bilateral trade in education after 9/11. We interact the Muslim proportion of importing countries (i.e., Asian countries) from the data of Pew Research Center with year dummies from 2001 to 2016 and add these variables ($pctmus * year\ dummy$) to our model specification (7).

Table 3 shows the estimated effect of 9/11 event from 2001 on. At a 5% significance level, there are statistically significant and negative relationships between Muslim population proportion of importing countries and the bilateral trade in education from 2002 to 2009. Two interpretations are possible and not mutually exclusive. Exporting countries were reluctant to accept students from countries that have higher proportion of Muslims after 9/11 and students from these countries may have felt less welcome in OECD countries following the event. This contraction reached an apex in 2005 and weakened from 2006 on. The negative impact of 9/11 on trade in education appears to be insignificant from 2011 on, indicating that the effect of 9/11 has persisted almost 8 years but has subsided since 2011.

<Table 3 about here>

Robustness Checks

To check the robustness of our results, we ran alternative specifications including double-log on truncated and original data adding an arbitrary small number to zeros, and NBPML with 2 different data scaling. Results are shown in Appendix table 2 for two proxies of OECD tertiary education capacity and using the WB network proxy. Silva and Tenreyro (2006) point out that parameters of interests are likely to be biased because the log-normal specification does not treat zero-value observations and from the presence of heteroskedasticity. Furthermore, even if we accommodate zero-value observations in the log-normal specification by manually adding a small positive number, the magnitude of parameter estimates depends on the number added to zero-value observations (King, 1988). Nevertheless, results in double log confirm many results except for the estimated parameters of the enrollment variable (significantly negative), the reputation variable (significantly positive), contiguity (significantly negative), colonial link (significantly positive), visa (not significant), and population changes in Asian countries (insignificant). The explanatory power is not as good as the PPML approach and the zero observations are not rationalized properly.

The NBPPML results are shown in column (3) and (4) of appendix table 2. They exhibit the poorest explanatory power of all the runs with an obvious issue with scaling. Scaling down the dependent variable by 100 improves the fit considerably but still falls short of the PPML explanatory power. The scale dependency of NBPML is a well-known drawback. We focus on the latter run since the fit is better. Results are at odds with PPML results for the OECD enrollment (significantly negative), reputation (significant), contiguity (significantly negative), and colonial link (significantly positive).   Nevertheless, the results confirm many of the PPML results but with some variations in some magnitudes of the effects.

The last robustness check concerns the *Foreign* correction for the inflation in the count of international students when using Foreign data. We modify equation (7) to allow for some variation in the (F/I) correction for as many countries as possible. Six countries have all F or all I data (see Appendix 1). We allow for country-specific effect for the remaining 27 countries. Results are reported in Appendix table 3. The results show that there is variation in the value of these country-specific *Foreign* data correction, although many are around the range of values obtained for the common Foreign correction in the previous runs. Luxembourg exhibits a negative correction which is at odds with the fact that I is comprised in F. Luxembourg has very small bilateral flows of foreign students and many zeros or near zeros. The latter element may be source of the poor fit, as PPML estimations tend to "overestimate" small values near zero.

Decomposition

Following Heien and Wessells (1988), we decompose the percentage change in the number of students involved in bilateral trade between notable exporters and importers into the elasticity sum of the percentage changes in the time-varying explanatory variables. For the decomposition, we choose exporters (Australia, Canada, United Kingdom and the United States) and importers (China, India, Japan, Korea, and Malaysia). Since only the number of foreign students is available prior to 2004, we use two points (2004, 2016) to compare the annual growth rate of actual international students with that of predicted international students.

From the equation (7), the annual compound rate of growth of international students ($\hat{r}$) between two points can be derived as:

(8) $\hat{r} = \frac{1}{T}\left(ln\hat{c}_{ijk} - ln\hat{c}_{ijk-T}\right) = \frac{1}{T}\hat{\beta}_1(lnC_{ik} - lnC_{ik-T}) + \frac{1}{T}\hat{\beta}_2(top100_{ik} - top100_{ik-T}) +$
$\frac{1}{T}\hat{\beta}_7\left(lnvisa_{ijk} - lnvisa_{ijk-T}\right) + \frac{1}{T}\hat{\beta}_8\left(lnrer_{ijk} - lnrer_{ijk-T}\right) + \frac{1}{T}\hat{\beta}_{10}\left(lny_{jk} - lny_{jk-T}\right) +$
$\frac{1}{T}\hat{\beta}_{11}\left(lnpop_{jk} - lnpop_{jk-T}\right) + \frac{1}{T}\hat{\beta}_{12}(Foreign_{ik} - Foreign_{ik-T}) + \frac{1}{T}\hat{\beta}_{13}\left(\hat{v}_{ijk} - \hat{v}_{ijk-T}\right) +$

$\frac{1}{T}(\hat{\alpha}_k - \hat{\alpha}_{k-T})$,

where $\hat{\alpha}$ and $\hat{v}$ denote the coefficient of time dummy and residuals from the first stage regression for the control function, respectively with T=13 in this case.

Table 4 shows the results of decomposition.[8] Overall, the annual compound rates of growth of international students between 2004 and 2016 are well-predicted in the sense that an average predicted change for these 16 bilateral flows is nearly similar to an actual change (3.73% actual, 3.32% predicted). Directions of predicted and actual changes are similar, except for Australia-Malaysia, Canada – Japan, Japan-Malaysia, and UK-Korea. Overall, the decomposition reveals that GDP of an importing country and visa regime between an exporting country and an importing country are the most important contributors for the changes in the bilateral flow of international students. The OECD wages perceived by importers is also important, except for Japan (as a destination), which has experienced stagnant wages. Demographic changes in Asian countries are important for China, Malaysia and Japan (as an importer). Other time-varying variables are less important because, either their elasticity is small or the change in the variable is limited or both.

<Table 4 about here>

Looking at salient elements, for Australia, Canada and the US, visa regimes, income growth of importers, and wage growth have driven the changes in the number of international students they host. Importers' income growth and visa regimes play an important role for the change for the UK destination. Changes in the number of international students are in general over-predicted for the US and to a lesser extent the UK. However, a change in the number of

[8] The annual rates of change of top100 for Canada and US are zero because the number of top100 universities in 2004 does not differ from that in 2016, while showing some variations between 2004 and 2016.

international students flows between US and China is very well predicted.

For importers, China has increased its imports from the four exporters from 2004 to 2016. Its changes in the number of international students are estimated to have increased by about 10%, driven by a liberalization of visa regimes and GDP growth, and this despite of a decrease in college-age population. Improvements in visa regime, GDP, and population in India also lead to a large increase in imports for India (8%). Korea shows a moderate increase in total higher education imports over the period (2%), despite a large increase in students going to Canada and to a lesser extent Australia. The decomposition under-predicts actual changes in Korea's imports for the key destinations shown in the table. The flow of students to Japan has sharply decreased driven by stagnant Japanese wages, and the reduced capacity in Japan. Finally, the decomposition shows that Japan has reduced its imports from the four exporters consistently with the actual changes, partly driven by the contraction of the college-age population.

Concluding remarks

This growth of the flows of foreign students coming to OECD countries has been remarkable in the last two decades with more than a doubling of foreign students coming to OECD countries to enroll and study. The lion share of these students is from Asia. The growth has affected most OECD countries positively but with increasing market share for Australia, the UK, France, Korea, Canada, and NZ, and more recently declining market shares for the US and Japan (OECD, 2018). Almost all countries have experienced strongly increasing enrollment of foreign students despite the increased competition among OECD countries for these students. The US and UK still dominate the markets but with a large competitive fringe made of other OECD countries. Further, some Asian countries like China are experiencing a demographic transition with a shrinking population in college-age. This is affecting exports of higher education, especially in the US, which has historically received a large share of Chinese students. US Universities will have to look for foreign students in other countries like Malaysia to make up for the change.

Despite the controversy on "commoditization" of higher education (Altbach and Knight, 2007; and Knight, 2015) the growth has been phenomenal. Our results suggest that the growth has principally been fueled organically by rising income and changes in demographics in some importing countries like India and Indonesia, decreasing transaction costs to enroll and cross borders (our visa proxy shows increasing mobility across countries). Wages in OECD countries provide a pull and influence foreign students to come. Distance remains a strong impediment, which benefits Japan, Korea, and Turkey as host countries. Our elasticity to distance estimates appears robust across estimations.

Common language is a cultural factor, which strongly benefits especially Anglo-Saxon universities (US, Canada, UK, Australia, NZ, and Ireland) with their connection to large export markets in Hong Kong, India, Israel, Pakistan, the Philippines, and Singapore. The strong effect of common language was a key result, emphasizing transaction costs in studying in a foreign language. Communality in religion appears not to matter, but we found that countries with larger populations of Muslim international students flows experienced reduced flow for several years following the tragedy of September 11, 2001.

In our analysis, we cannot address specific trade or education policy issues directly because we have gross measures of trade costs. Nevertheless, we find that visa restrictions have a significant role in constraining the consumption abroad of higher education. The policy prescription if any is for Asian (and other) countries with limited international mobility to increase the ease of access to OECD markets for their students.

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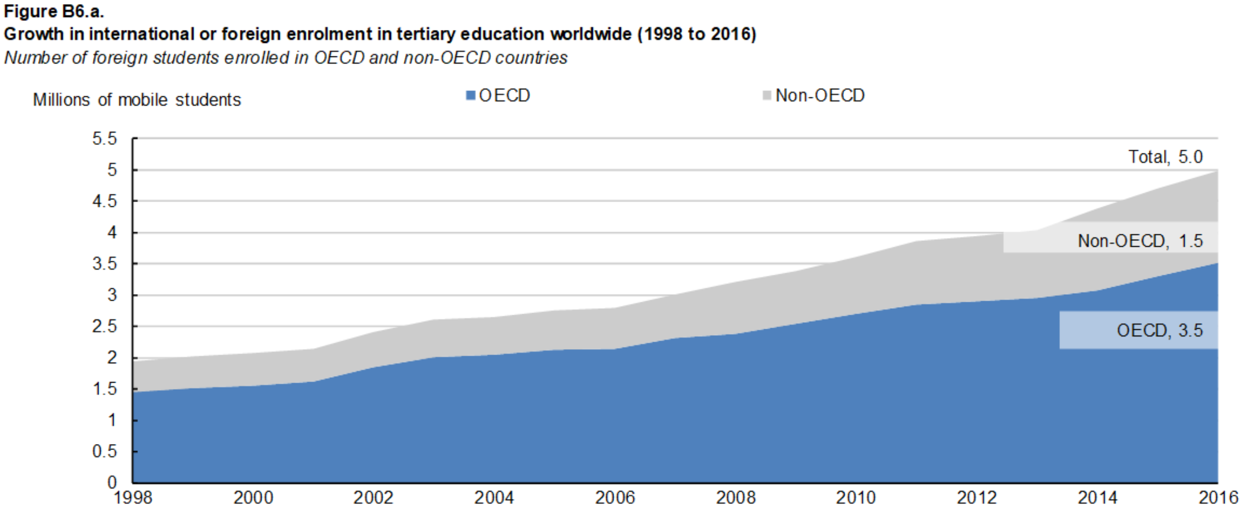
Figure 1. Growth of enrollment of foreign students



Note: The data sources use similar definitions, thus making their combination possible. Missing data were imputed with the closest data reports to ensure that breaks in data coverage do not result in breaks in time series.

Figure 2. Distribution of international students by region of origin

Country	Total tertiary	Short-cycle tertiary	Bachelor's or equivalent	Master's or equivalent	Doctoral or equivalent
Asia	55	66	55	57	42
Europe	24	14	25	22	32
Africa	8	7	8	9	10
Latin America & Carribean	5	5	5	6	8
North America	3	2	3	3	4
Oceania	1	1	1	0	1
Rest of the World (non allocated	3	6	4	3	3

	Total tertiary education	Short-cycle tertiary	Bachelor's or equivalent	Master's or equivalent	Doctoral or equivalent
Total	3,521,004	206,200	1,751,923	1,320,635	242,246
Asia	1,946,054	135,408	960,529	749,351	100,765

Table 1. Country list in the OECD database

OECD Exporters	Asian Importers	
Australia	United Arab Emirates	Oman
Austria	Afghanistan	Pakistan
Belgium	Armenia	Palestine, State of
Canada	Azerbaijan	Philippines
Chile	Bangladesh	Qatar
Czech Republic	Bahrain	Russian Federation
Denmark	Brunei Darussalam	Saudi Arabia
Estonia	Bhutan	Singapore
Finland	China	Syrian Arab Republic
France	Cyprus	Tajikistan
Germany	Georgia	Thailand
Greece	Hong Kong, China	Timor-Leste
Hungary	Indonesia	Turkey
Iceland	Israel	Turkmenistan
Ireland	India	Uzbekistan
Israel	Iraq	Viet Nam
Italy	Iran, Islamic Republic of	Yemen
Japan	Jordan	
Korea	Japan	
Luxembourg	Kyrgyzstan	
Mexico	Cambodia	
Netherlands	North Korea	
New Zealand	Korea, Republic of	
Norway	Kuwait	
Poland	Kazakhstan	
Portugal	Laos	
Slovak Republic	Lebanon	
Slovenia	Sri Lanka	
Spain	Macao	
Sweden	Malaysia	
Switzerland	Maldives	
Turkey	Mongolia	
United Kingdom	Myanmar	
United States	Nepal	

Table 2. PPML specifications regression results with 3 proxies of network effects

	(1)	(2)	(3)
	PPML	PPML	PPML
Capacity proxy OECD college-age pop	0.209	0.375	2.354^{***}
	(0.465)	(0.478)	(0.720)
University reputation	0.0183	0.0195	0.0229
	(0.0174)	(0.0171)	(0.0180)
Ln OECD wage	2.699^{***}	2.566^{***}	1.698^{*}
	(0.801)	(0.834)	(0.939)
Ln network migration WB	0.239^{***}		
	(0.0483)		
Ln network DLM total		0.387^{***}	
		(0.0579)	
Ln network Marfouk			0.436^{***}
			(0.0658)
Ln distance	-1.027^{***}	-0.784^{***}	-0.767^{***}
	(0.154)	(0.146)	(0.154)
Common language	1.228^{***}	1.072^{***}	1.011^{***}
	(0.265)	(0.256)	(0.277)
Contiguity	0.0634	0.262	-0.113
	(0.457)	(0.491)	(0.627)
Colonial link	-0.123	-0.336	-0.120
	(0.235)	(0.252)	(0.354)
Ln religious dissimilarity	-0.0758	-0.0926	0.0460
	(0.105)	(0.101)	(0.143)
Ln visa free	1.035^{***}	1.028^{***}	1.021^{***}
	(0.262)	(0.257)	(0.269)
Ln real exchange rate	-0.125	-0.136	-0.165^{*}
	(0.0828)	(0.0834)	(0.0993)
Ln gdp per capita Asia	0.744^{***}	0.745^{***}	0.630^{***}
	(0.222)	(0.212)	(0.215)
Ln Asia college-age population	0.760^{**}	0.739^{**}	0.535^{*}
	(0.300)	(0.294)	(0.303)
Foreign data correction	0.373^{***}	0.389^{***}	0.368^{***}
	(0.0714)	(0.0713)	(0.0903)
Constant	-41.23^{***}	-41.44^{***}	-39.72^{***}
	(9.365)	(9.176)	(12.16)
N	21238	16898	14321
R^2	0.927	0.925	0.924

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3. The effect of 9/11 on Asian students enrollment in OECD countries

PPML estimation with Muslim* time

Capacity proxy college pop	0.266	pctMus x 2002	-0.271**
	(0.464)		(0.106)
University reputation	0.0210	pctMus x 2003	-0.489***
	(0.0173)		(0.126)
Ln OECD wage	2.723***	pctMus x 2004	-0.786***
	(0.742)		(0.215)
Ln network migrants WB	0.239***	pctMus x 2005	-0.841***
	(0.0482)		(0.227)
Ln distance	-1.029***	pctMus x 2006	-0.815***
	(0.154)		(0.234)
Common language	1.226***	pctMus x 2007	-0.646***
	(0.265)		(0.240)
Contiguity	0.0759	pctMus x 2008	-0.593**
	(0.447)		(0.256)
colony	-0.123	pctMus x 2009	-0.555**
	(0.235)		(0.271)
Ln religious dissimilarity	-0.0759	pctMus x 2010	-0.561*
	(0.106)		(0.290)
Ln visa free	1.108***	pctMus x 2011	-0.529*
	(0.252)		(0.296)
Ln real exchange rate	-0.157*	pctMus x 2012	-0.516*
	(0.0875)		(0.313)
Ln gdp per capita Asia	0.661***	pctMus x 2013	-0.469
	(0.229)		(0.326)
Ln Asia college age population	0.811**	pctMus x 2014	-0.464
			(0.347)
	(0.338)	pctMus x 2015	-0.450
Foreign data correction	0.357***		(0.366)
	(0.0702)	pctMus x 2016	-0.399
pctMus x 2001	-0.134*		(0.377)
	(0.0686)	_cons	-42.57***
			(9.503)

N	21238
R^2	0.926

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4. Decomposition of trade flows over time (between 2004 and 2016)

Exporter	Importer	OECD capacity	Reputation	Visa regime	Real exchange rate	Asian GDP per capita	Asian college population	OECD wage	Foreign correction	Actual changes	Predicted change	(actual - predicted)
Australia	China	0.20%	0.28%	10.86%	0.31%	5.87%	-1.59%	2.32%	0.00%	10.60%	10.28%	0.32%
Australia	India	0.20%	0.28%	8.56%	-0.03%	4.14%	0.59%	2.32%	0.00%	8.30%	8.09%	0.21%
Australia	Japan	0.20%	0.28%	5.13%	-0.37%	0.50%	-1.16%	2.32%	0.00%	-4.58%	-1.07%	-3.51%
Australia	Korea	0.20%	0.28%	5.93%	-0.13%	2.02%	-0.38%	2.32%	0.00%	3.37%	2.28%	1.09%
Australia	Malaysia	0.20%	0.28%	5.21%	-0.03%	2.04%	1.16%	2.32%	0.00%	-0.38%	3.21%	-3.59%
Canada	China	0.07%	0.00%	10.68%	0.45%	5.87%	-1.59%	3.77%	0.00%	15.68%	11.27%	4.40%
Canada	India	0.07%	0.00%	8.37%	0.10%	4.14%	0.59%	3.77%	0.00%	21.16%	9.08%	12.08%
Canada	Japan	0.07%	0.00%	4.94%	-0.24%	0.50%	-1.16%	3.77%	0.00%	1.35%	-0.08%	1.43%
Canada	Korea	0.07%	0.00%	5.75%	0.01%	2.02%	-0.38%	3.77%	0.00%	9.49%	3.27%	6.22%
Canada	Malaysia	0.07%	0.00%	5.03%	0.10%	2.04%	1.16%	3.77%	0.00%	5.39%	4.20%	1.18%
Japan	China	-0.32%	-0.14%	10.54%	0.68%	5.87%	-1.59%	0.42%	-2.87%	0.04%	4.62%	-4.58%
Japan	India	-0.32%	-0.14%	8.23%	0.34%	4.14%	0.59%	0.42%	-2.87%	6.95%	2.43%	4.52%
Japan	Korea	-0.32%	-0.14%	5.61%	0.24%	2.02%	-0.38%	0.42%	-2.87%	-4.51%	-3.38%	-1.13%
Japan	Malaysia	-0.32%	-0.14%	4.89%	0.34%	2.04%	1.16%	0.42%	-2.87%	1.53%	-2.45%	3.98%
UK	China	0.03%	-0.28%	10.63%	0.70%	5.87%	-1.59%	0.38%	0.00%	4.82%	7.76%	-2.94%
UK	India	0.03%	-0.28%	8.32%	0.35%	4.14%	0.59%	0.38%	0.00%	1.00%	5.56%	-4.56%
UK	Japan	0.03%	-0.28%	4.89%	0.01%	0.50%	-1.16%	0.38%	0.00%	-5.97%	-3.60%	-2.37%
UK	Korea	0.03%	-0.28%	5.70%	0.26%	2.02%	-0.38%	0.38%	0.00%	2.82%	-0.25%	3.07%
UK	Malaysia	0.03%	-0.28%	4.98%	0.35%	2.04%	1.16%	0.38%	0.00%	2.97%	0.68%	2.28%
US	China	0.10%	0.00%	10.46%	0.42%	5.87%	-1.59%	1.98%	0.00%	9.69%	9.26%	0.43%
US	India	0.10%	0.00%	8.15%	0.07%	4.14%	0.59%	1.98%	0.00%	4.09%	7.07%	-2.98%
US	Japan	0.10%	0.00%	4.72%	-0.27%	0.50%	-1.16%	1.98%	0.00%	-7.48%	-2.09%	-5.39%
US	Korea	0.10%	0.00%	5.53%	-0.02%	2.02%	-0.38%	1.98%	0.00%	1.09%	1.26%	-0.17%
US	Malaysia	0.10%	0.00%	4.81%	0.07%	2.04%	1.16%	1.98%	0.00%	2.03%	2.19%	-0.16%

Appendix table 1. Investigation of endogeneity of OECD college-age population as proxy for capacity and other proxies for the supply of higher educations

	(1) CF	(2) IVPOISSON	(3) PPML	(4) PPML	(5) PPML
Ln OECD pop 15-24	1.010	0.887			
	(0.797)	(0.564)			
Ln OECD total pop			1.516		
			(1.252)		
Ln OECD enrollment				-0.103	
				(0.23)	
Ln OECD pop 15-24 lagged					0.164
					(0.451)
University reputation	0.00493	0.0209	0.0150	0.0164	0.0157
	(0.0210)	(0.0176)	(0.018)	(0.0174)	(0.0178)
Ln OECD wage	2.917***	1.987**	2.291***	2.744***	2.771***
	(0.922)	(0.882)	(0.733)	(0.870)	(0.798)
Ln network migrant WB	0.240***	0.240***	0.239***	0.237***	0.236***
	(0.0561)	(0.0484)	(0.0483)	(0.0486)	(0.0481)
Ln distance	-1.019***	-1.023***	-1.027***	-1.045***	-1.022***
	(0.224)	(0.154)	(0.154)	(0.155)	(0.154)
Common language	1.227***	1.228***	1.229***	1.265***	1.227***
	(0.315)	(0.265)	(0.266)	(0.271)	(0.266)
contiguity	0.0738	0.0728	0.0650	0.0577	0.0750
	(0.802)	(0.457)	(0.459)	(0.458)	(0.456)
Colonial link	-0.122	-0.128	-0.125	-0.127	-0.128
	(0.406)	(0.235)	(0.235)	(0.236)	(0.235)
Ln religious dissimilarity	-0.0802	-0.0828	-0.0778	-0.0814	-0.0701
	(0.154)	(0.106)	(0.105)	(0.107)	(0.105)
Ln visa free	1.148***	1.042***	1.053***	1.036***	1.011***
	(0.264)	(0.260)	(0.259)	(0.269)	(0.260)
Ln real exchange rate	-0.112	-0.143	-0.144*	-0.0922	-0.142*
	(0.0810)	(0.0874)	(0.0875)	(0.0808)	(0.0826)
Ln per capita gdp Asia	0.758***	0.745***	0.728***	0.741***	0.658***
	(0.236)	(0.215)	(0.217)	(0.233)	(0.228)
Ln Asia pop24	0.747**	0.734**	0.739**	0.795***	0.725**
	(0.311)	(0.303)	(0.302)	(0.300)	(0.320)
Foreign correction	0.447***	0.406***	0.361***	0.349***	0.356***
	(0.105)	(0.0758)	(0.0677)	(0.0728)	(0.0676)
residuals	-1.290				
	(0.962)				
Constant	-52.60***	-38.74***	-44.59***	-32.43***	-40.18***
	(14.21)	(8.955)	(10.29)	(10.01)	(9.759)
N	21238	21238	21238	20714	20278
R^2	0.926	0.927	0.927	0.927	0.928

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix Table 2. Truncated OLS and Negative Binomial PML with OECD college-age population as capacity proxy

	(1) Truncated OLS	(2) Truncated OLS $log(c_{ij}+1)$	(3) NBPML	(4) NBPML $(c_{ij}/100)$
Ln OECD college pop	0.158	0.205	0.719**	-0.0880
	(0.215)	(0.185)	(0.284)	(0.279)
University reputation	0.0640***	0.0707***	0.0661***	0.0404***
	(0.0141)	(0.0146)	(0.0167)	(0.0148)
Ln OECD wage	-0.0849	-0.344	-0.269	1.474***
	(0.281)	(0.239)	(0.375)	(0.399)
Ln network Migrant WB	0.294***	0.267***	0.323***	0.239***
	(0.0207)	(0.0194)	(0.0210)	(0.0292)
Ln distance	-1.420***	-1.392***	-1.415***	-1.414***
	(0.110)	(0.107)	(0.124)	(0.123)
Common language	0.678***	0.810***	0.762***	0.884***
	(0.177)	(0.183)	(0.182)	(0.185)
contiguity	-1.272***	-1.267**	-1.220*	-0.987*
	(0.491)	(0.525)	(0.625)	(0.504)
Colonial link	0.876***	0.981***	1.197***	0.832***
	(0.257)	(0.259)	(0.229)	(0.228)
Ln religious dissimilarity	-0.0292	-0.0259	-0.00684	0.0137
	(0.0486)	(0.0447)	(0.0497)	(0.0643)
Ln visa free	-0.0268	0.142	0.0672	0.784***
	(0.136)	(0.131)	(0.165)	(0.135)
Ln real exchange rate	-0.0652***	-0.0747***	-0.0213	-0.0614**
	(0.0252)	(0.0255)	(0.0298)	(0.0304)
Ln per capita gdp Asia	0.588***	0.468***	0.545***	0.504***
	(0.0957)	(0.0823)	(0.101)	(0.102)
Ln Asian pop 15-24	-0.0769	0.00548	0.0821	0.579***
	(0.113)	(0.0965)	(0.139)	(0.129)
Foreign correction	0.374***	0.336***	0.303***	0.306***
	(0.0418)	(0.0370)	(0.0496)	(0.0472)
Constant	9.681***	8.905***	4.028	-19.55***
	(3.683)	(3.065)	(6.016)	(5.468)
N	17810	21238	21238	21238
R^2	0.797	0.809	0.321	0.677

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix table 3. Disaggregated F effects by country

	PPML disaggregated F		
Capacity proxy college pop	0.615	Foreign_FIN	-0.323
	(0.697)		(0.257)
University reputation	-0.0112	Foreign_FRA	0.314^{***}
	(0.0271)		(0.0877)
ln OECD wage	1.884^{**}	Foreign_DEU	1.037^{***}
	(0.843)		(0.288)
Ln network migrant WB	0.239^{***}	Foreign_HUN	0.266^{*}
	(0.0482)		(0.148)
ln distance	-1.028^{***}	Foreign_ISL	-0.309
	(0.154)		(0.234)
common language	1.226^{***}	Foreign_IRL	0.135
	(0.266)		(0.275)
contiguity	0.0556	Foreign_JPN	0.311^{***}
	(0.460)		(0.118)
colonial link	-0.110	Foreign_LUX	-1.184^{***}
	(0.235)		(0.296)
ln religion dissimilarity	-0.0730	Foreign_NLD	0.473
	(0.106)		(0.335)
ln visa free	1.075^{***}	Foreign_NZL	0.128
	(0.260)		(0.263)
ln real exchange rate	-0.128	Foreign_NOR	0.568^{***}
	(0.0834)		(0.189)
ln gdp per capita Asia	0.705^{***}	Foreign_POL	-0.271
	(0.219)		(0.280)
ln Asian pop 15-24	0.738^{**}	Foreign_PRT	-0.212
	(0.295)		(0.262)
Foreign_AUS	0.387^{*}	Foreign_SVK	0.143
	(0.211)		(0.257)
Foreign_AUT	0.339^{*}	Foreign_ESP	0.181
	(0.177)		(0.214)
Foreign_BEL	1.222^{***}	Foreign_SWE	0.369
	(0.214)		(0.295)
Foreign_CAN	-0.0966	Foreign_CHE	0.454^{**}
	(0.217)		(0.201)
Foreign_CHL	1.733^{***}	Foreign_GBR	0.244
	(0.233)		(0.169)
Foreign_CZE	0.753^{***}	Foreign_USA	0.676^{***}
	(0.283)		(0.209)
		Constant	-32.30^{***}
			(9.509)
N			21238
R^2			0.930

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix 1. Data categories used in each year

	Country	1998 -2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013 -2016
(1)	Australia	F	I	I	I	I	I	I	I	I	I	I
(2)	Austria	F	F	F	F	F	F	F	F	F	I	I
(3)	Belgium	F	I	I	I	I	I	I	I	I	I	I
(4)	Canada	F	I	X	I	I	I	I	I	I	I	I
(5)	Chile	F	X	F	X	F	I	I	I	I	I	I
(6)	Czech	F	F	F	F	F	F	F	F	F	F	F
(7)	Denmark	F	I	I	I	I	I	I	I	I	I	I
(8)	Estonia	X	X	I	I	I	I	I	I	I	I	I
(9)	Finland	F	F	F	F	F	F	F	F	F	F	I
(10)	France	F	F	F	F	F	F	F	F	F	F	I
(11)	Germany	F	I	I	I	I	I	I	I	I	I	I
(12)	Greece	F	F	F	F	F	F	X	F	F	F	F
(13)	Hungary	F	F	F	F	F	F	I	I	I	I	F
(14)	Iceland	F	F	F	F	I	I	I	I	I	I	I
(15)	Ireland	F	I	I	I	I	I	I	I	I	I	I
(16)	Israel	X	X	X	X	X	X	X	F	F	F	F
(17)	Italy	F	F	F	F	F	F	F	F	F	F	F
(18)	Japan	F	F	F	F	F	F	F	F	F	F	I
(19)	Korea	F	F	F	F	F	F	F	F	F	F	F
(20)	Luxembourg	F	X	X	F	X	F	I	I	X	I	I
(21)	Netherlands	F	I	I	I	I	I	I	I	I	I	I
(22)	New Zealand	F	I	I	I	I	I	I	I	I	I	I
(23)	Norway	F	F	F	F	F	F	F	F	F	F	I
(24)	Poland	F	F	F	F	F	F	F	F	I	I	I
(25)	Portugal	F	F	F	F	F	I	I	I	I	I	I
(26)	Slovak	F	I	I	I	I	I	I	I	I	I	F
(27)	Slovenia	X	X	I	I	I	I	I	I	I	I	X
(28)	Spain	F	I	I	I	I	I	I	I	I	I	I
(29)	Sweden	F	I	I	I	I	I	I	I	I	I	I
(30)	Switzerland	F	I	I	I	I	I	I	I	I	I	I
(31)	Turkey	F	F	F	F	F	F	F	F	F	F	F
(32)	United Kingdom	F	I	I	I	I	I	I	I	I	I	I
(33)	United States	F	I	I	I	I	I	I	I	I	I	I

1) F: Foreign (Non-Citizen) students, I: International students (non-resident or prior education outside the reporting country), X: none of the categories are not available.