Received: 21 January 2020 | Revised: 9 September 2020 | Accepted: 25 September 2020

DOI: 10.1111/twec.13192

ORIGINAL ARTICLE

The World Economy WILEY

The exports of higher education services from OECD countries to Asian countries: A gravity approach

John Beghin[1,2] | **Byungyul Park**[3]

[1]University of Nebraska-Lincoln, Lincoln, Nebraska, USA

[2]Department of Economics, Iowa State University, Ames, Iowa, USA

[3]Korea Institute for Industrial Economics & Trade, Sejong, Korea

Correspondence
Byungyul Park, Korea Institute for Industrial Economics & Trade, Building C, Sejong National Research Complex, 370, Sicheong-daro, Sejong, Korea.
Email: bypark@kiet.re.kr

Abstract

We analyse 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 university reputations explaining the flow of students. The evolution over time of education capacity, earnings, visa regimes,

[Correction added on 5 October, 2021 after first online publication: Byungyul Park was designated as corresponding author.]

Byungyul Park: Senior authorship is equally shared.

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 the reduction in its college-age population.

KEYWORDS

Asia, higher education exports, OECD countries

1 | 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 that have been very successful at increasing their exports of education services. This trade has more than doubled in the last two decades.[1] About 3.5 million foreign students enrol in OECD countries' universities (OECD, 2018), of which, a majority, nearly 2 million students, comes from Asia (see Figures 1 and 2). As the OECD contains three Asian countries, it is worth noting that the average number of students coming from Asian countries to Japan, Korea and Turkey increased from 1138 in 1998 to 3189 in 2016 for Japan; 33 in 1998 to 1234 in 2016 for Korea; and 302 in 1998 to 950 in 2016 for Turkey.[2]

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).

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. Foreign students contribute disproportionately to tuition revenues in higher education (Loudenback,

[1]This growth of higher education trade has taken place in the context of a phenomenal growth of tertiary enrolment in Asia, increasing by more than 240% between 1998 and 2016, but still lagging on the average tertiary enrolment of OECD countries.

[2]Japan, Korea and Turkey are both origin and destination countries in our data set. However, because of data issue, we do not account for domestic flows of students (e.g. Japanese students studying in Japan and so forth). Complete domestic enrolment is only available for 2006–12.

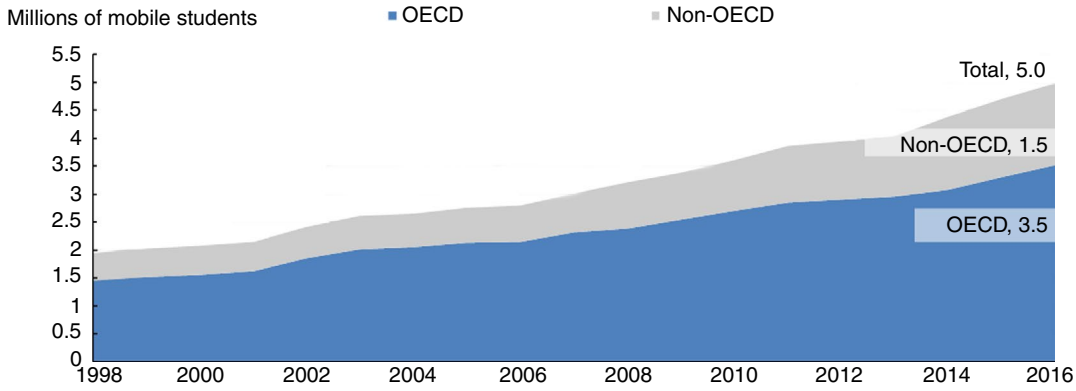

FIGURE 1 Growth of enrolment of foreign students [Colour figure can be viewed at wileyonlinelibrary.com]

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

FIGURE 2 Distribution of international students by region of origin [Colour figure can be viewed at wileyonlinelibrary.com]

2016).[3] 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 enrolment despite this competition among providers. The growth in foreign student enrolment has been fuelled 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 non-pecuniary 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 in easing the decision to study abroad. Our investigation explores these conjectures and brings rationalisation to the rich and contrasting patterns that have emerged in the last 20 years.

[3]For example, foreign students contribute more than $9 billion or about 28% of tuition revenues in US public universities but represent only 12% of enrolment in recent years (Loudenback, 2016).

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 liberalising foreign investment regimes in higher education in importing countries (Knight, 2002). The GATS sets up principles and guidelines to progressively liberalise services. In higher education, it is less clear how this is done. GATS centres on national treatment, market access, most favoured nation and transparency issues. Given the dominance of OECD universities, national treatment and market access are relevant issues for OECD universities trying to establish campuses in non-OECD markets, not the opposite.

Knight (2006) identifies the following minor trade liberalisation issues for the 'consumption abroad' segment 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 subsidise a restricted number of students as governments recognise the multiple benefits of having better-skilled labour force (Institute for International Education, 2011).

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. Visa regimes have been liberalised 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. Becker, 1964; Campbell & Siegel, 1967; Schultz, 1961; Willis & Rosen, 1979). 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. Beine et al., 2014; Campbell & Siegel, 1967; Perkins & Neumayer, 2014).

There is also a large political science, sociological and education management literature looking at the globalisation of higher education, often from a critical perspective of the 'commoditisation' of higher education (e.g. Altbach & Knight, 2007; Tilak, 2011). Education scholars 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 (Abbott & Silles, 2016; Beine et al., 2014; Perkins & Neumayer, 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 non-pecuniary benefits as proxied by university ranking. They apply the model to 13 destinations countries for years 2004–2007 but fixing many variables to a given year. The latter investigation is the most related to our investigation, although it uses a limited panel, and a migration model rather than a bilateral trade flow model leading to account for fewer transaction and trade costs such as trade costs related to visas and foreign exchange.

In the survey-based education management literature, Binsardi and Ekwulugo (2003) analyse students' perceptions of the UK education system. Mazzarol and Soutar (2002) survey foreign students in Australian universities to discover push-and-pull factors influencing them to come to Australia. Daily et al. (2010) analyse students' motivations and decisions to come to U.S. business schools. 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 analyse exports of higher education services and their economic determinants. In addition, our analysis takes place in a larger global context than previous investigations, using a much larger panel data set. Finally, we account for a more comprehensive set of transaction costs than in previous investigations. We then use our parameter 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. We also extend our analysis to look at the impact of the 9/11 terrorist attack in the US on the flow of students coming from countries with large Muslim populations.[4]

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 enrol 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 formalised 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 with distance and language.

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 characterise capacity of the tertiary education sector. As reported in an appendix, 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 specification used, the panel data used and a series of diagnostic tests. We follow with a presentation of the regression results, the decomposition of

[4]As explained later, our estimated equation can be used to analyse shocks affecting flows of foreign students, which can be translated in terms of income shocks, changes in exchange rates and travel restrictions, and demographic changes.

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 and the investigation of potential endogeneity of higher education capacity in OECD countries. We draw some implications for service trade policy. An appendix presents additional results on endogeneity tests and robustness checks.

2 | A SECTORAL APPROACH

The approach parallels the gravity equation of Anderson (1979) and Anderson and Van Wincoop (2003), but with distinct features. First, we start from a simple human capital approach (Willis & Rosen, 1979) to the consumption of higher education considered a tradable good. Then, we make use of the result established by Anderson et al. (1989) mapping discrete choices into CES preferences. The latter authors characterise 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.[5] We also use a sectoral approach to the gravity equation rather than an aggregate GDP, as suggested in Anderson, 1979 (his footnote 14).

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 stylised facts explained in the introduction.

Foreign students in country *j* choose a university training consumption level in country *i* (destination and numbers of years) that optimises the following choice $c_{ij} = \text{Max}(V_{1j}, V_{2j}, ..., V_{mj})$ 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 et al. (1989), to characterise these higher education discrete choices as coming from maximising utility maximisation with CES preferences. Assume agents in country *j* have homothetic assumed CES preferences and choose to purchase higher education

[5]The authors spell out conditions sufficient to reconcile a class of models including the logit and the CES for a representative consumer and characteristic approaches to product differentiation. 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 (McFadden 1978 and 1981; and Feenstra, 2004).

services in country i to maximise 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 maximise utility.

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

subject to income constraint.

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

where β_{ij} is the taste parameter for perceived returns, quality and reputation of higher education services in country i by consumer j (β_{ij}= β_{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.

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

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

Index i covers m OECD countries. Because we follow a sectoral approach, we can safely adopt the assumption of specialisation 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 is predetermined and investigate the potential endogeneity of the supply in the empirical investigation. We have an equilibrium condition equating this capacity with the sum of demands for higher education services from all countries:

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

Equation (4) can be solved for scaled price $p_i^{-\sigma}$ as a function of capacity C_i, 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

$$c_{ij} = C_{i0}\left(\frac{\beta_{ij} t_{ij}^{-\frac{\sigma}{1-\sigma}}}{P_j P_i}\right)^{(1-\sigma)} (pop_j y_j), \tag{5}$$

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 capacity of higher education in i, C_i, 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.

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, and 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:

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

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

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

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; and 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 refer to foreign students in year k, as opposed to data on international (non-resident) students as explained in the Data section. Our data set 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 $I = exp\left(\lambda' X\right)$, 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, $\alpha = I/F$. Then, we have: $F = I/\alpha = \exp\left(\lambda' X - \ln(\alpha)\right)$. 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 ($E(y|x) \propto V(y|x)$). 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 & Tenreyro, 2006, 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 $V\left(y_i|x\right)$ 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 & Tenreyro, 2006). Heteroscedasticity often increases with the conditional mean, and PPML addresses this potential heteroscedasticity. Trade data are characterised 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 data set, we use clustered errors based on the bilateral distance variable.

The potential endogeneity of variable C_{ik} is approached as follows. We use a control function with PPML to endogenise 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 & Santos 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 & 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).

3 | DATA AND SOURCES

3.1 | Dependent variable

For our dependent variable, we use OECD data on international student enrolment covering 51 Asian countries and 34 OECD countries for years 1998–2016. 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 enrol in their current level of education* (OECD, 2018).

There are two large data sets for international student 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 US only reported the number of international students while UK reported the number of both 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.[6]

Because of data gap issues for both the enrolment and explanatory variables, we drop Mexico, North Korea and Palestine. In principle, we have (34 OECD × 51 Asia × 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

[6]If both non-resident and prior education categories are available, the number of students in the non-resident category is used.

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	
Slovakia	Lebanon	
Slovenia	Sri Lanka	
Spain	Macao	
Sweden	Malaysia	
Switzerland	Maldives	
Turkey	Mongolia	
UK	Myanmar	
US	Nepal	

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%. Summary data information is shown in Table 2.

TABLE 2 Summary Statistics (rounded to the second decimal)

	Obs.	Non-zero Obs.	Mean	*SD*	Min	Max
Foreign students	25,625	19,921	842.04	6451.93	0	309,837
Log(OECD population college age)	25,625	25,625	7.51	1.48	3.75	10.7
Top 100 university ranking	25,625	12,583	3.30	9.81	0	57
Log(wage)	24,774	24,774	10.54	0.33	9.62	11.07
Log(network) migration	25,625	22,032	5.99	3.00	0	14.51
Log(distance)	25,625	25,625	8.72	0.58	4.71	9.86
Common language	25,625	815	0.03	0.18	0	1
Contiguity	25,625	200	0.01	0.09	0	1
Colonial ties	25,625	666	0.03	0.16	0	1
Log(religion dissimilarity)	25,625	25,625	−0.53	1.44	−9.85	0.66
Log(bilateral visa regimes)	25,625	25,625	8.71	0.75	6.44	10.33
Log(real exchange rate)	25,625	25,625	2.12	3.67	−8.86	10.27
Log(GDP per capita Asia)	25,625	25,625	6.93	2.66	1.80	12.56
Log(population college age)	25,625	25,625	7.81	1.97	4.00	12.40

3.2 | 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*. 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 1000 people as an instrument for the college-age population. We also use total population per OECD country and total tertiary education enrolment 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 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 (n.d.). 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 Shanghai Ranking 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 300 and 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 (Beine et al., 2014; Marginson, 2006). The indicator is not without problem because it conflates the size of the sector and quality of the system. Beine et al. normalised the ranking by the number of students enrolled in the country, which seems to us a bit peculiar given the non-rival nature of the reputation effect, although there is some logic to it. From a student choice perspective, a system with 1% on institutions in the top 100 may be different from one with 10% of institutions in the top 100. Hence, some normalisation may be legitimate. We try both un-normalised and normalised reputation scores for top 100, 300 and 500 universities.

For the OECD earning variable (*E*), we use the OECD Employment database, which provides wage 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 data set is for 2000 and is time-invariant, which is a major drawback. The advantage is that the variable is available for many countries and minimises the loss of observations. Second, we use the Docquier, Lowell, and Marfouk (DLM) data set available from Marfouk's website (http://www.abdeslammarfouk.com/dlm-database.html). This data set 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.[7] The data are for 2000 (no time variation). The total number of observations is 16,898. The third source comes from the Brucker, Capuano and Marfouk (BCM) data set (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

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

5-year intervals. 1995 values are used for 1998–1999, 2000 values are used for 2000–2004, 2005 values are 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 & 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, and then Portuguese, Greek and Turkish languages. Colonial ties originate with the UK, France and then Turkey, Portugal, Greece, Spain and the US. Colonial ties capture some cultural familiarity and likely network effects from the colony's population in the former colonising 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 variable between origin and destination countries. We do so using the Religious Diversity Index Scores from the Pew Research Center.[8] 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 & Partner's Passport Index to capture transaction cost linked to visas[9]. 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 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 on 2004 prices. The data come from the World Bank WDI database. Exchange rates and GDP deflators

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

[9]We check whether 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 non-immigrant visa (F1) issue of the US 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).

were described before. Population data focus on the population in or near college age (15–24 years) 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.

4 | 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 US 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 3. 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 3 (see last column). The three runs present results for three proxies of migrants' network effects and with varying data sets as explained in the Data section. The third column shows results for the smaller of the three data sets 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.

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 variable bias.[10] We also use another instrumental variable approach using the IVPOISSON command in Stata considering

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

TABLE 3 PPML results with 3 proxies of network effects.

	(1)	(2)	(3)
	PPML	**PPML**	**PPML**
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 bilateral visa regimes	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	21,238	16,898	14,321
R^2	0.927	0.925	0.924

Standard errors in parentheses.

*$p < 0.10$, **$p < 0.05$ and ***$p < 0.01$.

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 enrolment and lagged college-age population). However, none of these proxies was significant. The detailed results of the endogeneity investigation are shown in Table A1 in Appendix A.

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, normalised or not, 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 data set. 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 3 and Table A1 in Appendix A. The implied elasticity is high between 1.7 and 2.7 in Table 3, and it persists in the PPML runs in the 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 0.24–0.43, 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 data set for 2007.

As found in many investigations of merchandise trade, distance matters significantly for exports in education services with a response between −0.77 and −1.02, depending on the specification. Again, all PPML runs confirm the negative role of distance. These values in Table 3 are near the median of estimates analysed in Disdier and Head (2008) (around −0.9), and larger than magnitudes found by Beine et al. (2014).

Common language is also important with a significant response 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 student flows, in line with results of existing papers (Beine et al., 2014; Perkins & Neumayer, 2014; Abbott & Silles, 2016). 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 (0.63–0.745). The population of college age shows a comparable magnitude for its elasticity with the range (0.535–0.760) with a small loss of significance in column 3. These two results hold through all the PPML runs. The income shifter is the major driver 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 analysed. Below, we look at the recent development in China's demographic and income to analyse the projected flow of Chinese students in the US in 2017. This serves of informal validation of the estimated bilateral export equation.

Lastly, the coefficient of $Foreign_{it}$ is significantly positive in all PPML runs. Using the first estimation in column 1 of Table 3, 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 OECD (2007).

4.1 | Prediction of Chinese student flows to the US for 2017

China is the largest buyer of US higher education services, and the US is the first destination for Chinese students. This reciprocal privileged relationship has experienced remarkable growth until recent years. It is worth decomposing the change to see what elements determined the maturation of the flow of students. Using the available variables (visa, top 100 ranking, 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 & Belkin, 2018). The predicted decrease is mostly driven by the decrease in college-age population of China despite a decrease in real exchange rate and an increase in visa regime and GDP of China. Furthermore, the number of students from China to the 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.

4.2 | *The effect of 9/11*

The aftermath of the US tragedy of 11 September 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 & 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 4 shows the estimated effect of 9/11 event from 2001 onwards. 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 onwards. The negative impact of 9/11 on trade in education appears to be insignificant from 2011 onwards, indicating that the effect of 9/11 has persisted almost 8 years but has subsided since 2011.

5 | 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 Table A2 in Appendix A for two proxies of OECD tertiary education capacity and using the WB network proxy. Santos 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 heteroscedasticity. 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 enrolment 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 rationalised properly.

The NBPPML results are shown in columns (3) and (4) of Table A2 in Appendix A. 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 enrolment (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 A). We allow for country-specific effect for the remaining 27 countries. Results are reported in Table A3 in Appendix A. 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

TABLE 4 Effects of 9/11 on Asian students' enrolment in OECD countries

OECD college-age pop	0.266	pctMus × 2003	−0.489***
	(0.464)		(0.126)
University reputation	0.0210	pctMus × 2004	−0.786***
	(0.0173)		(0.215)
Ln OECD wage	2.723***	pctMus × 2005	−0.841***
	(0.742)		(0.227)
Ln network migrants WB	0.239***	pctMus × 2006	−0.815***
	(0.0482)		(0.234)
Ln distance	−1.029***	pctMus × 2007	−0.646***
	(0.154)		(0.240)
Common language	1.226***	pctMus × 2008	−0.593**
	(0.265)		(0.256)
Contiguity	0.0759	pctMus × 2009	−0.555**
	(0.447)		(0.271)
colony	−0.123	pctMus × 2010	−0.561*
	(0.235)		(0.290)
Ln religious dissimilarity	−0.0759	pctMus × 2011	−0.529*
	(0.106)		(0.296)
Ln bilateral visa regimes	1.108***	pctMus × 2012	−0.516*
	(0.252)		(0.313)
Ln real exchange rate	−0.157*	pctMus × 2013	−0.469
	(0.0875)		(0.326)
Ln GDP per capita Asia	0.661***	pctMus × 2014	−0.464
	(0.229)		(0.347)
Ln Asia college-age population	0.811**	pctMus × 2015	−0.450
	(0.338)		(0.366)
Foreign data correction	0.357***	pctMus × 2016	−0.399
	(0.0702)		(0.377)
pctMus × 2001	−0.134*	Constant	−42.57***
	(0.0686)		(9.503)
pctMus × 2002	−0.271**		
	(0.106)		
		N	21,238
		R^2	0.926

Standard errors in parentheses.

*$p < 0.10$, **$p < 0.05$ and ***$p < 0.01$

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.

6 | DECOMPOSITION

Following Heien and Roheim 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, the UK and the US) 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 equation (7), the annual compound rate of growth of international students ($\hat{r}$) between two points can be derived as:

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

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 5 shows the results of decomposition.[11] 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 are 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.

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 in the change for the UK destination. Changes in the number of international students are in general overpredicted for the US and to a lesser extent the UK. However, a change in the number of international student 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 liberalisation of visa regimes and GDP growth, despite 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

[11]The annual rates of change of top 100 for Canada and the US are zero because the number of top 100 universities in 2004 does not differ from that in 2016, while showing some variations between 2004 and 2016.

TABLE 5 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%

imports over the period (2%), despite a large increase in students going to Canada and to a lesser extent Australia. The decomposition underpredicts 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.

7 | 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. 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 with declining market shares for the US and Japan (OECD, 2018). Most countries have experienced strongly increasing enrolment of foreign students despite the competition for these students. The US and UK still dominate the market but with a large competitive fringe of other OECD countries. Further, some Asian countries such as 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 the largest share of Chinese students. U.S. universities will have to find students in other countries. This challenge will eventually spill over to other exporters. This maturation of the higher education export market will eventually affect all importers and exporters. Demographic transition will take place in most Asian countries, and that will induce a major reduction in export demand for higher education services, holding other factors constant.

Our results suggest that the recent growth has principally been fuelled organically by rising income and changes in demographics in some importing countries such as India and Indonesia, decreasing transaction costs to enrol 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. Travel restrictions motivated by pandemics or other global shocks could also compromise this vibrant export market. As our results on visa regimes suggest, travel restrictions could have a commensurate effect on higher education exports both from the destination and from the origin countries.

Common language strongly benefits especially Anglo-Saxon universities (the US, Canada, the UK, Australia, NZ and Ireland) with their connection to large export markets in Hong Kong, India, Israel, Pakistan, the Philippines and Singapore. Communality in religion appears not to matter, but we found that countries with larger populations of Muslim international student flows experienced reduced flow for several years following the tragedy of 11 September 2001.

Our analysis has several limitations. Data on networks were incomplete and lack variation. We also limited our analysis to Asian students and did not consider students from other countries. Several determinants only exhibited cross-section variation (such as distance). 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 is for Asian countries (and other) with limited international mobility to increase the ease of access to OECD markets for their students. The current global pandemic crisis has dramatically restricted travel and entry in

many OECD countries and compromised higher education exports. These travel restrictions will persist until the pandemic subsides substantially in source and destination countries.

ACKNOWLEDGEMENTS

We thank Associate Editor Sir David Greenaway and an anonymous referee for insightful comments, which have improved our original manuscript. Without implicating them, we also thank Anne-Celia Disdier, Zheng Li and João Santos Silva for helping us define our estimation strategy.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ORCID

John Beghin https://orcid.org/0000-0002-8403-3277
Byungyul Park https://orcid.org/0000-0001-9716-0518

REFERENCES

Abbott, A., & Silles, M. (2016). Determinants of international student migration. *The World Economy*, *39*(5), 621–635.

Altbach, P. G., & Knight, J. (2007). The Internationalization of higher education: Motivations and realities. *Journal of Studies in International Education*, *11*(3–4), 290–305.

Anderson, J. E. (1979). A theoretical foundation for the gravity equation. *American Economic Review*, *69*(1), 106–116.

Anderson, J., & van Wincoop, E. (2003). Gravity with gravitas: A solution to the border puzzle. *The American Economic Review*, *93*(1), 170–192.

Anderson, S. P., De Palma, A., & Thisse, J. F. (1989). Demand for differentiated products, discrete choice models, and the characteristics approach. *The Review of Economic Studies*, *56*(1), 21–35.

Bashir, S. (2007). *Trends in International Trade in Higher Education: Implications and Options for Developing Countries* (World Bank Education Working Paper Series No. 6). Retrieved from World Bank Education website: http://documents.worldbank.org/curated/en/828431468762899837/Trends-in-international-trade-in-higher-education-implications-and-options-for-developing-countries

Becker, G. S. (1964). *Human capital: A theoretical and empirical analysis, with special reference to education*. University of Chicago Press.

Beine, M., Noel, R., & Ragot, L. (2012). *The determinants of international mobility of students* (CESifo Working Paper Series No. 3848). Retrieved from CESifo website: https://www.cesifo.org/en/publikationen/2012/working-paper/determinants-international-mobility-students

Beine, M., Noel, R., & Ragot, L. (2014). The Determinants of International Mobility of Students. *Economics of Education Review*, *41*, 40–54.

Besley, D. A., Kuh, E., & Welsch, R. E. (2004). *Regression diagnostics: identifying influential data and sources of collinearity*. John Wiley and Sons.

Binsardi, A., & Ekwulugo, F. (2003). International marketing of British education: Research on the students' perception and the UK market penetration. *Marketing Intelligence & Planning*, *21*(5), 318–327.

Cameron, A. C., & Travedi, P. K. (2013). *Regression analysis of count data*. Cambridge University Press.

Campbell, R., & Siegel, B. N. (1967). The demand for higher education in the United States, 1919–1964. *The American Economic Review*, *57*(3), 482–494.

CEPII. The CEPII Geodist database. http://www.cepii.fr/CEPII/en/bdd_modele/presentation.asp?id=6

Daily, C. M., Farewell, S., & Kumar, G. (2010). Factors influencing the university selection of international students. *Academy of Educational Leadership Journal*, *14*(3), 59–75.

Disdier, A.-C., & Head, K. (2008). The puzzling persistence of the distance effect on bilateral trade. *The Review of Economics and Statistics*, *90*(1), 37–48.

Feenstra, R. C. (2004). *Advanced international trade: Theory and evidence*. Princeton University Press.
Hackman, M., & Belkin, D. (2018). U.S. Grip on the Market for Higher Education is Slipping. *Wall Street Journal*. Retrieved from https://www.wsj.com/
Halvorsen, R., & Palmquist, R. (1980). The interpretation of dummy variables in semilogarithmic equations. *The American Economic Review*, *70*(3), 474–475.
Heien, D. M., & Roheim Wessells, C. (1988). The demand for dairy products: Structure, prediction, and decomposition. *American Journal of Agricultural Economics*, *70*(2), 219–228.
Henley & Partners. Passport Index. Available at: https://www.henleypassportindex.com/passport-index
Institute for International Education. (2011). *Student mobility and the internationalization of higher education. National policies and strategies from six world regions*. A Project Atlas Report. Institute for International Education.
King, G. (1988). Statistical models for political science event counts: bias in conventional procedures and evidence for the exponential Poisson regression model. *American Journal of Political Science*, *32*, 838–863. https://doi.org/10.2307/2111248.
Knight, J. (2006). *Higher education crossing borders: A guide to the implications of the general agreement on trade in services (GATS) for cross-border education*. A Report Prepared for the Commonwealth of Learning and UNESCO. Printed in France.
Knight, J. (2002). Trade creep: Implications of GATS for higher education policy. *International Higher Education*, *28*. https://doi.org/10.6017/ihe.2002.28.6658
Loudenback, T. (2016). International students are now 'subsidizing' public American universities to the tune of $9 billion a year. *Business Insider* September 16.
Marginson, S. (2006). Dynamics of national and global competition in higher education. *Higher Education*, *52*, 1–39.
Mayer, T., & Zignago, S. (2011). *Notes on CEPII's distances measures: The GeoDist database* (CEPII Working Paper No. 2011-25). Retrieved from CEPII website: http://www.cepii.fr/CEPII/en/publications/wp/abstract.asp?NoDoc=3877
Mazzarol, T., & Soutar, G. N. (2002). "Push-pull" factors influencing international student destination choice. *International Journal of Educational Management*, *16*(2), 82–90.
McFadden, D. (1978). Modeling the choice of residential location. In A. Karlqvist, L. Lundqvist, F. Snickars, & J. Weibull (Eds.), *Spatial interaction theory and planning models*. (75–96). North Holland.
McFadden, D. (1981). Econometric Models of Probabilistic Choice. In C. F. Manski, & D. McFadden (Eds.), *Structural analysis of discrete data with econometric applications*. (198–272). MIT Press.
McMahon, M. E. (1992). Higher education in a world market. An historical look at the global context of international study. *Higher Education*, *24*, 465–482.
Naidoo, V. (2007). Research on the flow of international students to UK universities Determinants and implications. *Journal of Research in International Education*, *6*(3), 287–307. https://doi.org/10.1177/1475240907083197.
Neiman, B., & Swagel, P. (2009). The impact of post-9/11 visa policies on travel to the United States. *Journal of International Economics*, *78*, 86–99.
Neumayer, E. (2011). On the detrimental impact of visa restrictions on bilateral trade and foreign direct investment. *Applied Geography*, *31*, 901–907.
OECD. (2018). Education at a Glance Database. http://stats.oecd.org. See Source section for more information and Annex 3 (www.oecd.org/education/education-at-a-glance-19991487.htm).
Perkins, R., & Neumayer, E. (2014). Geographies of educational mobilities: Exploring the uneven flows of international students. *The Geographical Journal*, *180*(3), 249–259.
Rosenzweig, M. (2008). *Higher education and international migration in Asia: Brain circulation*. Annual World Bank conference on development economics (pp. 59–100).
Santos Silva, J. M. C., & Tenreyro, S. (2006). The Log of Gravity. *The Review of Economics and Statistics*, *88*(4), 641–658.
Santos Silva, J. M. C., & Tenreyro, S. (2011). Further simulation evidence on the performance of the Poisson pseudo-maximum likelihood estimator. *Economics Letters*, *112*(2), 220–222.
Schultz, T. W. (1961). Investment in human capital. *The American Economic Review*, *51*(1), 1–17.

Shanghai University Ranking. Academic Ranking of World Universities. Published by ShanghaiRanking Consultancy, available online at: http://www.shanghairanking.com/index.html

The World Bank(n.d.). *World Development Indicators*. The World Bank. Available online at: https://data.worldbank.org/

Thibault, F. (2015). Structural gravity and fixed effects. *Journal of International Economics*, *97*(1), 76–85.

Tilak, J. B. G. (2011). *Trade in higher education: The role of the General Agreement on Trade in Services (GATS)*. UNESCO: International Institute for Educational Planning. Fundamentals of Educational Planning No 95.

Wei, H. (2013). An empirical study on the determinants of international student mobility: a global perspective. *Higher Education*, *66*(1), 105–122.

Willis, R. J., & Rosen, S. (1979). Education and Self-Selection. *Journal of Political Economy 87* (5), Part 2 (Oct): S7-S36.

Windmeijer, F., & Santos Silva, J. M. C. (1997). Estimation of count data models with endogenous regressors: An application to demand for health care. *Journal of Applied Econometrics*, *12*(3), 281–294.

Wooldridge, J. M. (1997). Quasi-Likelihood Methods for Count Data. In M. H. Pesaran, & P. Schmidt (Eds.), *Handbook of applied econometrics, volume II: Microeconometrics*. (321–368). Blackwell Publishers.

How to cite this article: Beghin, J., & Park, B. Y. (2022). The exports of higher education services from OECD countries to Asian countries: A gravity approach. *The World Economy*, 45, 1050–1080. https://doi.org/10.1111/twec.13192

APPENDIX A

TABLE A1 Investigation of endogeneity of OECD college-age population as proxy for capacity and other proxies for the supply of higher education

	(1)	(2)	(3)	(4)	(5)
	CF	IVPOISSON	PPML	PPML	PPML
Ln OECD pop 15–24	1.010	0.887			
	(0.797)	(0.564)			
Ln OECD total pop			1.516		
			(1.252)		
Ln OECD enrolment				−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 bilateral visa regimes	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 pop 24	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)

(Continues)

TABLE A1 (Continued)

	(1)	(2)	(3)	(4)	(5)
	CF	**IVPOISSON**	**PPML**	**PPML**	**PPML**
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	21,238	21,238	21,238	20,714	20,278
R^2	0.926	0.927	0.927	0.927	0.928

Standard errors in parentheses.

*$p < 0.10$, **$p < 0.05$ and ***$p < 0.01$.

TABLE A2 Truncated OLS and Negative Binomial PML with OECD college-age population as capacity proxy

	(1)	(2)	(3)	(4)
	Truncated OLS	**Truncated OLS** $log\,(c_{ij}+1)$	**NBPML**	**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 bilateral visa regimes	−0.0268	0.142	0.0672	0.784***
	(0.136)	(0.131)	(0.165)	(0.135)

(Continues)

TABLE A2 (Continued)

	(1)	(2)	(3)	(4)
	Truncated OLS	**Truncated OLS** $log\ (c_{ij}+1)$	**NBPML**	**NBPML** $(c_{ij}/100)$
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	17,810	21,238	21,238	21,238
R^2	0.797	0.809	0.321	0.677

Standard errors in parentheses.

*$p < 0.10$, **$p < 0.05$ and ***$p < 0.01$.

TABLE A3 Disaggregated effects of foreign students by country

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 bilateral visa regimes	1.075***	Foreign_NZL	0.128
	(0.260)		(0.263)

(Continues)

TABLE A3 (Continued)

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			21,238
R^2			0.930

Standard errors in parentheses.

*$p < 0.10$, **$p < 0.05$ and ***$p < 0.01$.

TABLE A4 Data categories used in each year.

Country	1998–2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013–2016
Australia	F	I	I	I	I	I	I	I	I	I	I
Austria	F	F	F	F	F	F	F	F	F	I	I
Belgium	F	I	I	I	I	I	I	I	I	I	I
Canada	F	I	X	I	I	I	I	I	I	I	I
Chile	F	X	F	X	F	I	I	I	I	I	I
Czech	F	F	F	F	F	F	F	F	F	F	F
Denmark	F	I	I	I	I	I	I	I	I	I	I
Estonia	X	X	I	I	I	I	I	I	I	I	I
Finland	F	F	F	F	F	F	F	F	F	F	I
France	F	F	F	F	F	F	F	F	F	F	I
Germany	F	I	I	I	I	I	I	I	I	I	I
Greece	F	F	F	F	F	F	X	F	F	F	F
Hungary	F	F	F	F	F	F	I	I	I	I	F
Iceland	F	F	F	F	I	I	I	I	I	I	I
Ireland	F	I	I	I	I	I	I	I	I	I	I
Israel	X	X	X	X	X	X	X	F	F	F	F
Italy	F	F	F	F	F	F	F	F	F	F	F
Japan	F	F	F	F	F	F	F	F	F	F	I
Korea	F	F	F	F	F	F	F	F	F	F	F
Luxembourg	F	X	X	F	X	F	I	I	X	I	I
Netherlands	F	I	I	I	I	I	I	I	I	I	I
New Zealand	F	I	I	I	I	I	I	I	I	I	I
Norway	F	F	F	F	F	F	F	F	F	F	I
Poland	F	F	F	F	F	F	F	F	I	I	I
Portugal	F	F	F	F	F	I	I	I	I	I	I
Slovak	F	I	I	I	I	I	I	I	I	I	F
Slovenia	X	X	I	I	I	I	I	I	I	I	X
Spain	F	I	I	I	I	I	I	I	I	I	I
Sweden	F	I	I	I	I	I	I	I	I	I	I
Switzerland	F	I	I	I	I	I	I	I	I	I	I
Turkey	F	F	F	F	F	F	F	F	F	F	F
UK	F	I	I	I	I	I	I	I	I	I	I
US	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 available.