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International Student Mobility and High-Skilled Migration: The Evidence

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Abstract

Using information from the UNCTAD, we construct a new balanced panel database of bilateral international student mobility for 150 origin countries, 23 host countries, and the years 1970–2000. We match these data with information on bilateral stocks of international migrants by educational attainment from census data, available for 1990 and 2000. We estimate a theory-founded gravity model by conditional fixed effects Poisson Pseudo Maximum Likelihood to investigate the question: To what extent do countries that attract foreign students benefit from an increased stock of educated foreign workers? We find that, on average, an increase of students by 10 percent increases the stock of tertiary educated workers in host countries by about 0.9 percent. That average effect is, however, entirely driven by Anglo-Saxon countries. On average, our results imply a student retention rate of about 70 percent. These results suggest that the costs of educating foreign students are at least partly offset by increased availability of foreign talent.

JEL Code: F22, H41, I25.
Keywords: Migration, education, international student mobility, brain drain, panel data, Poisson model.

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1 Introduction

There is little doubt that the long-run growth perspectives of industrialized countries crucially depend on their ability to continuously develop new and better products and to improve production processes. This capacity, in turn, is shaped by the quality of the educated work force. Human resource recruiters have long understood this. Business consultants talk about a "*war of talent*" (Chanbers et al., 1998). Awareness is growing, that a successful position in the "global competition for talent" (OECD, 2009) is important.

The increasing mobility of highly educated workers puts strains on the workings of higher education systems, in particular if they are publicly financed. Countries that finance universities but see their graduates move to jobs in other countries have incentives to cut back spending as other countries reap the benefits. This is even more so if part of the student body is foreign. On the other hand, attracting talented foreign students and retaining them after graduation is an important strategy in the global competition for talent (Tremblay, 2005). However, to what extent imports of university students lead to a subsequent increase in the highly educated foreign workforce is an empirical question that has not received much attention so far.

Recent data published by the OECD (2011) shows that the number of international students has increased dramatically from 0.8 million in 1975 to 2.1 million in 2000 and 3.7 million in 2009. OECD countries attract a fairly stable 76 percent of this flow, about half that share goes to EU countries. Student flows are strongly concentrated in few destinations: The top 5 destinations (US, UK, Germany, France and Australia) attract about 50 percent of all international students. On average, about 6.2 percent of all students are international students, but there is strong heterogeneity across destinations: in Australia, more than 20 percent of all students are international; that share is about 15 percent in places such as UK, Austria or Switzerland. Survey results indicate that about 30 percent of international students wish to remain in their country of graduation after completion of their degree; but again, there is strong heterogeneity in that number. While the data situation on country-level international student stocks is satisfactory, there is much less detail available on student flows by country of destination *and* origin.

Information on the stocks of high skilled migrants across countries compiled by Docquier et al. (2008) reveals that the distribution of highly educated migrants across countries is similarly concentrated as the stock of students. The data also shows a strong increase in the stock of tertiary educated individuals living abroad, from 12.5 million in 1990 to 20.5 million in 2000.

In this paper we present a new database on bilateral student mobility covering the years 1970 through 2000, mostly obtained from printed UNESCO Statistical Yearbooks (and in more recent years, from electronic UNESCO data bases). The data cover 23 host countries and 150 destination countries. Matching these data with information about bilateral stock of immigrants with age 25 or higher by educational attainment for the years 1990 and 2000 from Docquier et al. (2008), we study how international bilateral student mobility affects stocks of highly educated foreign workers. Since the student data have patchy coverage for certain host countries, in our regressions, we work with averages typically constructed over ten years prior to 1990 and 2000, but we conduct extensive sensitivity checks with respect to this choice.

The Docquier et al. (2008) data allows us to conduct our analysis in a panel setup. The short time dimension notwithstanding, the availability of within country-pair variation makes it possible to control for unobserved heterogeneity in countries' ties that affect both, the stock of workers and those of migrants. Moreover, since we observe stocks from each destination country in 23 host countries, we can control for destination country specific variables by using time-variant country dummies. The same is feasible for host countries. Existing studies look at single host countries only, so that this comprehensive dummy variable strategy is not applicable. We base our econometric strategy on a theory-founded gravity model for bilateral migration which shows that carefully controlling for multilateral resistance terms is crucial to obtain consistent estimates of average effects. Finally, unlike most of the existing literature, we employ a Poisson Pseudo Maximum Likelihood estimation. Compared to the more conventional log-linear specification, this has the advantage that we can deal with zero immigrant stocks (which exist in the data), and with heteroscedasticity in the disturbances.

We report the following findings. (i) To combat omitted variables bias, it is crucial to use a comprehensive set of country × year dummies in the model. When this is done, the room for remaining omitted variable bias becomes very small, so that our estimates can be interpreted as causal. In the log linear model, the effect of student mobility falls by a factor of 12, but remains statistically significant at the 5 percent level. (ii) There are substantial problems related to heteroscedasticity in the disturbances and to aggregation bias in the data: using the PPML model, if the heterogeneity in educational levels of migrants is disregarded, student mobility has no measurable effect on foreign worker stocks. Looking at tertiary educated migrants only, such an effect does, however, exist, and is statistically significant at the 5 percent level. (iii) The elasticity of student stocks on stocks of highly educated foreigners is about 0.09 so that doubling the number of foreign students is associated to an increase in the stock of tertiary educated foreign workers of 5.7 percent. Evaluated at the average for EU countries, this scenario yields a retention rate of about one third. (iv) Student mobility triggers higher migration of less than university educated migrants, in particular of agents with secondary education, but the estimated elasticities are smaller than those obtained for the stock of high skilled workers. (v) Importantly, the sample average is driven by Anglo-Saxon countries, among which the elasticity of high-skilled migrant stocks with respect to international students is about 0.12.

There are several reasons why one may expect student mobility to affect the stock of migrants in later periods. First, young persons who study abroad may decide to stay in that foreign country after graduation, or be more likely to return there after a intermittent spell in the home or a third country. This argument, of course, may explain stocks of highly educated migrants, but not of persons with less than university education. Second, it is possible that the presence of the first mechanism entails migration of secondary and primary educated persons. If a former student decides to work after graduation in the foreign country, she may facilitate the migration of other workers from her home country, e.g., when she has family members join her, or when she sets up an enterprise which has business ties to her home country.

Our work is closely related to a recent paper by Dreher and Poutvaara (2011). These authors use panel data for 78 countries of origin to study the effect of student flows into the USA on migration. They find an elasticity of migration with respect to student mobility around 0.094, which is very similar to what we find. The strength of their approach is that they work with yearly data from 1971 to 2001 while we have only two observations per country pair. The disadvantage of their study lies in the fact that they (i) only observe total immigration and have no breakdown according to education classes; this invites aggregation bias, and blurs their 'brain gain' argument; (ii) they focus on a single host country; this makes it impossible to control for that country's unobserved multilateral resistance term as mandated by theory; (iii) they employ a log-linear model which cannot deal with zero migration stocks that do, however, exist even in the US data.[1] Our model complements survey exercises on the propensity to stay after graduation, see for example Baruch et al. (2007).

Our work is also very much related to gravity estimates of bilateral migrations stocks. Important contributions to this body of research are Hatton (2003), Mitchell and Pain (2003), Clark, Hatton and Williamson (2007), Pedersen, Pytlikova and Smith (2008), Beine, Docquier and Ozden (2009) or Grogger and Hanson (2011). These papers do not address student mobility, they use a different motivating theory, and they do not use Poisson techniques for estimation purposes.

[1]Zeros (or missings) amount to about 20 percent of the migration data.

Finally, our work also relates to a large, mainly theoretical, literature that discusses the role of national higher education systems in a world with mobile students and workers. It is well known that international (or interregional) mobility of educated workers may cause an underinvestment in local public education when political entities independently decide on spending to maximize local welfare, see Justmann and Thisse (2000) or Demange et al. (2008) for excellent examples. Lange (2009) has shown that this can reverse if students are mobile, too. Then, countries have an incentive to overinvest to attract students who, in turn, have a certain probability to stay in the country in which they graduate. Clearly, that probability is crucial for the policy maker. In this paper, we try to assess empirically how big that likelihood is. While there is substantial theoretical work on the provision of public education under interregional mobility, there is a clear scarcity of empirical work.

The paper is organized as follows. The following section 2 describes the data. Section 3 sketches a simple multi-country migration model that yields a gravity equation and discusses its consistent estimation. Section 4 presents our baseline results, while section 5 discusses robustness checks. The final section 6 concludes.

2 Data

2.1 Bilateral migration data

The data on international migration used in this paper is based on the data set provided by Docquier and Marfouk (2006). They developed a data set on migration to OECD countries by educational level for 174 countries of origin for the year 1990, and 195 countries for the year 2000.

This data set has been updated by Docquier et al. (2008).[2] They use new sources, homogenize the concepts for both years 1990 and 2000, and construct new stocks and rates

[2] the data set is available on http://perso.uclouvain.be/frederic.docquier/oxlight.htm .

of bilateral emigration by level of education.[3] The resulting data, which is used in this paper, refers to the years 1990 and 2000 for 195 sending and 31 host countries. The sample shows the number of migration measured as stock in general as well as more detailed by educational attainment: Low skilled migrants attained less than upper secondary education, medium skilled migrants completed upper secondary education and high skilled migrants are those with all post-secondary education levels, even those with only one year of US college. The data set only takes into account OECD nations as receiving countries.[4] Furthermore in this data set migration is defined as foreign-born adult migrants that are 25 and older. Hence, students as temporary migrants are not included. However, as data considers immigrants independently of their age of entry, it does not appear where education has been acquired. Beine et al. (2007) use the age of entry as a proxy for where education has been attained. Even though the rates calculated without age-of-entry restriction are higher than the corrected rates, the correlation between the two rates is very high. Hence, empirical work is "likely to be robust to the choice of corrected or uncorrected skilled emigration rates" (Beine et al., p. 253, 2007).

2.2 Data Sources

The main explanatory variable -the stock of students from abroad which study in a foreign host country- is taken from the UNESCO Institute for Statistics (UIS). The data shows the annual stock of foreign students enrolled in institutions at the tertiary level since 1950. For the years prior to 1998, data only is available as hard copy in the UNESCO Statistical Yearbooks; for the years after 1998 data is available at the UNESCO homepage.[5] As most host countries are covered more consistently starting from the year 1970, the sample

[3]Furthermore, they introduce a gender breakdown. As data on student exchange is only available in general and not by gender, this dimension is not taken into account for the empirical work of this paper.

[4]Even though the number of high skilled immigrants in other than OECD-countries is expected to be low and skilled migration to OECD countries covers about 90 percent of the total number, high skilled migration from some developing countries probably will be underestimated.

[5]For the years 1997 and 1998 unfortunately is no data available.

begins in 1970. As for the dependent variable -immigrants- data is only available for 31 host countries and the student data unfortunately only overlaps 26 countries of these, the sample is restricted to 26 host countries.[6] With respect to the country of origin, data is almost available for all countries.

For most years, data belongs exclusively to one certain year. In some cases, however, the number of students refer to a academic year, e.g. 1994/1995. Therefore we generate two different data sets: our preferred data set consists of data where the number for a academic year is attached to the second year, hence in the example to 1995. This makes sense as a semester always ends in the second year. Furthermore we generate a second data set to check for robustness. For this data set the number is allocated to the first year, which would be in the example 1994. If, however, data is already available explicitly for one of the two years, this number is kept in the data set and the data referring to the academic year is not taken into account.

Data on cultural and geographical proximity are taken from the CEPII gravity data set developed by Head et al. (2010). The data set covers the years 1948 to 2006 and 224 countries. For our data set we only use data for the years 1990 and 2000.

Data on GDP, population and unemployment come from the *World Development Indicators* database.

2.3 Descriptive Statistics

As the resulting data set spans the years 1970 to 2000, due to secessions, reunifications and dependency changes, various countries are not consistent over the considered period. To make the data comparable, assumptions have to be made. While data as GDP, population and the number of students can be aggregated, it is more complicated for data such as dummies on regional trade agreement, common currency,etc.; hence, data described in

[6]After balancing the data set, the sample is restricted to 23 destination countries.

the CEPII data set. Therefore most decisions on whether aggregating countries or not are oriented on the CEPII data set in order to maintain as many countries as possible in the resulting data set: If data in the CEPII data set is only available individually while it is aggregated in the other data sources, data is not taken into account for our data set. If data in the CEPII data set is available only aggregated, data will be aggregated for the whole data set.

Combining these data according to the described decision rules results in a data set of 26 countries of origin and 159 destination countries.[7] The sample spans the period 1970 to 2000 for the dependent variable on student exchange; the other variables are considered for the years 1990 and 2000. Table 11 in chapter 7 shows the countries of origin as well as the host countries that are represented in the sample.

Before we investigate the causal effect of student mobility on the stock of high skilled migrants first it is interesting to see how the number of foreign students and the number of migration developed over years.

Table 1 presents the annual average number of students in a destination country for periods of ten years as well as the number of migrants in the year 1990 and 2000. While in the 70s a country had an average stock of almost 40,000 students, the average annual number in the 90s is about 82,000, and therefore more than two times bigger. But also the number of migrants increased: while a country in 1990 on average had a stock of total migrants of about about 1.4 millions, ten years later the number was by about 41 percent higher at almost 2 million migrants. In the case of our group of interest, the high skilled migrants, the pattern is even more dramatically: From 1990 to 2000 the stock of high skilled migrants in a country increased from about 425,000 to 693,000, which is an increase of around 63 percent.

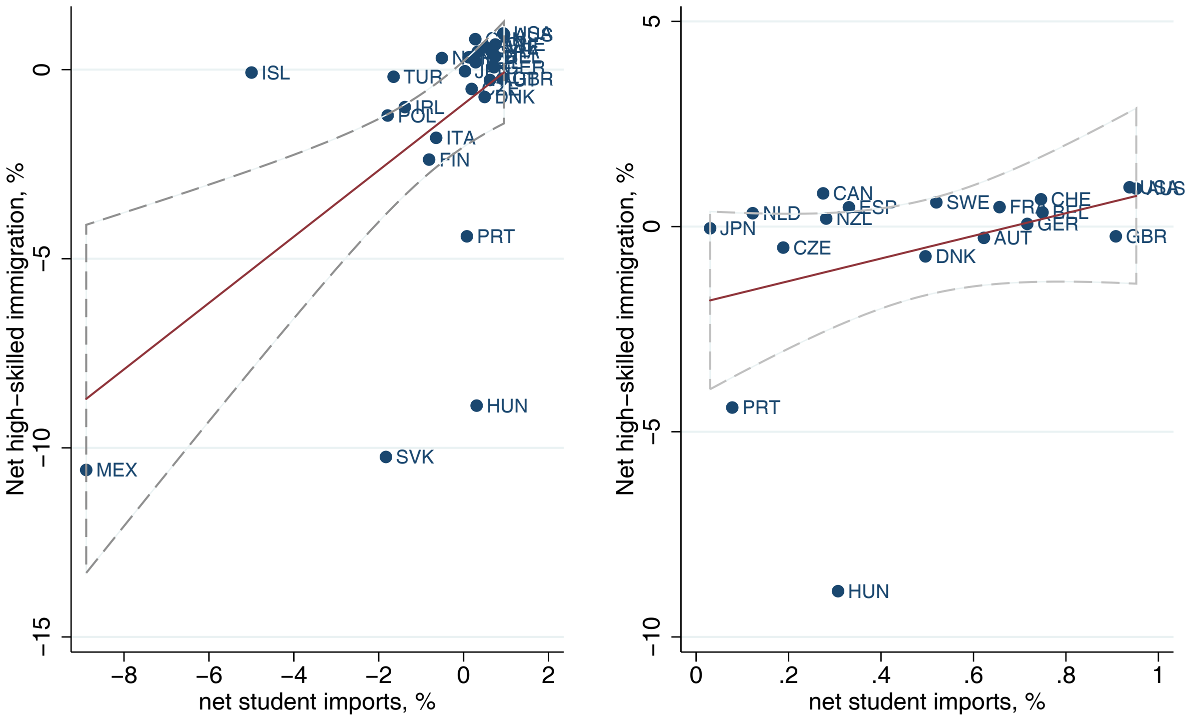
[7] However, these countries are only covered in the unbalanced data set. The balanced version only contains 23 countries of origin and 150 countries of destination.

Table 1: Average annual numbers for a host country

Year	1970-1979	1980-1989	1990-1999	1990	2000
Students	39,499	55,830	81,696		
Migrants				1,388,598	1,962,120
High skilled migrants				424,980	693,199

2.4 A first glance at the data

The patterns shown in table 1 suggest that there is a high correlation between student migration and later migration in general as well as for the highly skilled.



Note: Left−hand panel shows all available host countries; right−handel panel only those with non−negative net student inflows. Variables are expressed as percentage of inflows. Linear regression fitted, with 95% confidence intervals.
All data for year 2000.

Figure 1: Correlation between net student and high-skilled immigrant stocks

Figure 1 plots net student imports at the country level against net immigration of high skilled workers. Both measures are normalized by gross inflows for the year of 2000. The left-hand panel shows that most reporting host countries are net importers of both, students and high-skilled immigrants. That is, a brain gain or a brain drain of a country manifests itself already in student mobility. There are, however, some notable exceptions: Hungary, for example, is a net importer of students but, in 2000, the net loss of educated workers amounts to about 9 percent of the gross inflow of high-skilled individuals. Also, Portugal is a net importer of students but a net exporter of talent. Fitting a linear regression to the data reveals a strong and statistically significant positive correlation between the two variables. The right-hand side diagram looks at net importer of students only. There is substantial heterogeneity in terms of net student mobility, but less so in terms of net migration. Countries such as UK or USA have net imports of students that are almost identical to total imports of students, while Japan or the Netherlands have much more balanced positions. In this subsample, there is a positive link between net migration of talent and net student mobility, too, but the relation is only moderately statistically significant.

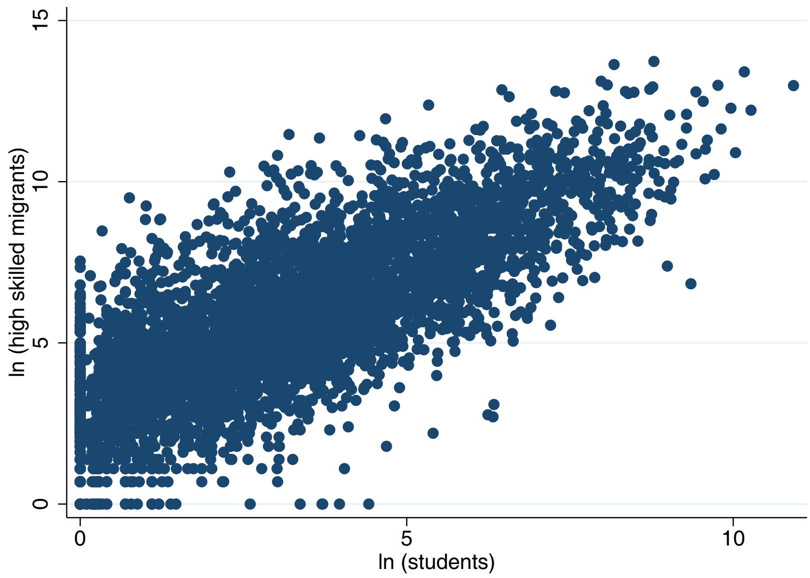


Figure 2: Bilateral gross stocks of students versus stocks of highly-educated migrants

While 1 looks at monadic data (i.e., bilateral stocks cumulated over all source countries), figure 2 provides a scatter plot of the raw bilateral data. The average stock of students over the period 20 years to 1 year prior to measuring the stock of high skilled migrants is correlated with the total stock of highly educated workers in the years of 1990 and 2000. There is a very clear and fairly strong positive association between the two variables; the slope of the relationship appears larger than unity. While figures 1 and 2 provide interesting illustrations, they only show raw correlations. We will see later that controlling for a wide range of determinants of high-skilled mobility, the link between students and workers becomes much weaker, and even disappears for a wide subsample of countries.

3 Model and empirical strategy

3.1 A stylized theoretical framework

We wish to investigate the link between student mobility and migration. For that purpose, we need a simple model of migration choice that aggregates to the bilateral country level and that can be implemented empirically. To keep things simple, we differentiate between three education classes, low, medium, and high, indexed by $s \in \{L, M, H\}$.

While much modeling attention has been devoted to modeling bilateral trade flow equations on the aggregate level ('the gravity literature'), there has been much less work on worker flows; recent exceptions are Beine, Docquier and Ozden (2009) or Grogger and Hanson (2011). Here, we follow the recent model by Anderson (2011). In contrast to a firm's decision to export, the decision to migrate is a discrete choice from a set of possible destinations. The flow costs of migration are destination-specific, but they may also have an idiosyncratic component reflecting the costs or utility from the move.

Let w_s^i denote the real wage paid in country i to a worker of education s. The systematic flow costs of migration are captured by an iceberg discount factor $\zeta_s^{ji} \leq 1$,[8] so that the effective net wage is reduced: $w_s^i \zeta_s^{ji} \leq w_s^j$. The diminution factor ζ_s^{ji} may be education-specific (e.g., lower for highly educated workers due to their knowledge of languages), and also incorporates geographical frictions such as captured by distance. Worker h

[8]Whether these costs are flow costs or fixed costs does not make a difference in the present setup.

idiosyncratic utility component is ϵ_s^{jih}; that shock is unobserved to the econometrician. In these derivations we view ϵ_s^{jih} as idiosyncratic. In reality, it may also contain the effect of $h's$ prior exposure to country i, possibly through a stay as a student. So, worker h leaves his home country j if $w_s^i \zeta_s^{ji} \epsilon_s^{jih} \geq w^j$ for at least some i. He chooses the country with the highest net wage.

McFadden (1974) shows that, if utility is logarithmic, so that the observable gain from migration is $u_s^{ji} = \ln w_s^i + \ln \zeta_s^{ji} - \ln w^j$, and if $\ln \epsilon$ is distributed according to a type-1 extreme value distribution, then the probability that a randomly drawn individual would chose any specific destination country is given by the multinomial logit form. At the aggregate level, the likelihood of a randomly picked individual to migrate from j to i is given by $\left(w_s^i \zeta_s^{ji}\right) / \left(\sum_k w_s^k \zeta_s^{jk}\right)$. Let N_s^j be the mass of natives educated at level s in j; then the predicted stock of migrants is

$$M_s^{ji} = \frac{w_s^i \zeta_s^{ji}}{\sum_k w_s^k \zeta_s^{jk}} N_s^j. \tag{1}$$

To derive a gravity equation, one needs to factor in the aggregate labor market clearing conditions. Let $L_s^i = \sum_j M_s^{ji}$ denote the total labor supply available to region i and let $N_s = \sum_j N_s^j = \sum_i L_s^i$ denote the world labor supply. Finally, define $W_s^j \triangleq \sum_k w_s^k \zeta_s^{jk}$, the migration-cost weighted wage faced by an $s-$type worker from country j. Then, the labor market clearing condition can be restated as

$$L_s^i = w_s^i \sum_j \frac{\zeta_s^{ji} N_s^j}{W_s^j} \tag{2}$$

which can be solved for the equilibrium wage rate w_s^i that prevails in i for skill s

$$w_s^i = \frac{L_s^i}{\Omega_s^i N_s} \text{ where } \Omega_s^i \triangleq \sum_j \frac{\zeta_s^{ji}}{W_s^j} \frac{N_s^j}{N_s}. \tag{3}$$

We can now substitute out w_s^k from the definition $W_s^j \triangleq \sum_k w_s^k \zeta_s^{jk}$ so that

$$W_s^j = \sum_k \frac{\zeta_s^{jk}}{\Omega_s^k} \frac{L_s^k}{N_s}. \tag{4}$$

The final step consists in using equation (3) to substitute the endogenous wage rate out from (1). This yields Anderson's structural gravity equation of migration

$$M_s^{ji} = \frac{L_s^i N_s^j}{N_s} \frac{\zeta_s^{ji}}{\Omega_s^i W_s^j}. \tag{5}$$

The first term in the gravity equation (5) would represent the bilateral pattern of migration in the complete absence of migration costs (whence, $\zeta_s^{ji} = 1$). Then the distribution of workers across countries would be entirely independent from their respective countries of origin. The second term captures the losses due to migration. Clearly, the higher those losses (the smaller ζ_s^{ji}), the smaller will the flow M_s^{ji} be. However, in a world, where workers can choose from a whole set of destinations, the migration flow does not only depend on the bilateral cost ζ_s^{ji}, but also on multilateral terms Ω_s^i and W_s^j. These resistance indices reflect all bilateral migration costs in the world. The larger W_s^j, the larger is the average net wage that a worker can expect in country j, which reduces emigration incentives out from j. The larger Ω_s^i, the lower are outflows from j to i.

3.2 Empirical model

Equation (5) constitutes the backbone of our empirical model. Since we will work with aggregate bilateral data, we model the discount factor ζ_s^{ji} that reduces the attractiveness of destination i for $s-$type workers from country j as dependent on the likelihood that such a worker has studied in that country prior to the data at which we observe that person as a migrant. Moreover, our data has a time dimension which we will use to identify the effects of international student mobility on migration stocks. Introducing time indices t, we view the discount factor ζ_s^{ji} as a function of several determinants:

$$\zeta_s^{ji}(t) = \Gamma\left[Geo^{ij}, Cult^{ij}, Pol^{ij}(t), MPol_s^i(t), MPol_s^j(t), Stud^{ij}(t-\tau), \nu_s^{ji}, t\right] \tag{6}$$

where Geo^{ij} collects time-invariant geographical determinants of migration costs such as distance or adjacency. $Cult^{ij}$ approximates cultural proximity and contains variables such as common language, common colonizer etc. These variables are identical over s, but they may affect different education classes differently. $MPol_s^i(t)$ is an education class and time-specific control for migration policy in country i. $Pol^{ij}(t)$ controls for the general stance of political ties between countries i and j. $Stud^{ij}(t-\tau)$, where $t \geq \tau$, measures the stock of international students from i in country j at a period (or interval) of time sufficiently far from t in the past so that the current stock of students is not per se accounted for in the stock of migrants. Moreover, ζ_s^{ji} may depend on unobservable bilateral determinants of migration costs, such as historical affinity between countries, preexisting networks of businesses or ethnicities, and so on. The costs also may have a common time trend t.

In our baseline regressions, we define $Stud^{ij}(t-\tau)$ as the bilateral stock of international students averaged over the years $t-\tau$ to $t-1$. Our student data covers a longer time period than the migration data, which comes either from year 2000 or 1990. For that reason, we can use several student stock averages in our migration gravity equations. When we work with 10 year averages, with some abuse of notation, we refer to the first average (defined from $t-1$ to $t-10$) as the first lag and the second average (defined from $t-11$ to $t-20$) as the second lag.

To turn (5) into an estimable expression, we need to specify the error term υ_s^{ji}. We follow Santos-Silva and Tenreyro (2006) and assume that υ_s^{ji} is generated from a Poisson process. We choose this specification, because in the presence of heteroscedastic errors, log-linearizing (5) with a normal disturbance terms and estimating by OLS leads to *inconsistent* estimates. If there are zeros in the data, the disturbance term cannot be normally distributed. And even if there are none, standard OLS cannot deal with additive error structures. For these reasons, we apply the Poisson Pseudo Maximum Likelihood technique.[9]

Besides the problem of heteroscedasticity, estimation of (5) requires information about the multilateral resistance indices Ω_s^i and W_s^j. Omitting them from the model can severely bias the estimates. However the indices cannot be easily constructed from observed data since they involve ζ_s^{ji}, which needs to be estimated. For these reasons, and following the international trade gravity literature (surveyed, for instance, in Anderson and van Wincoop, 2004), we work with destination and source country specific fixed effects.

Embedding (5) into the Poisson model, and substituting a log-linear form of (6) leads to

$$\begin{aligned} M_s^{ji}(t) &= \exp\left\{\alpha_s + \ln \zeta_s^{ji}(t) + \ln L_s^i(t) + \ln N_s^j(t) - \ln \Omega_s^i(t) - \ln W_s^j(t)\right\} + \upsilon_s^{ji} \\ &= \exp\left\{\alpha_s + \gamma_s \ln Stud^{ij}(t-\tau) + \pi_s Pol^{ij}(t) + \nu_s^i \times v_s(t) + \nu_s^j \times v_s(t) + \nu_s^{ji}\right\} + \upsilon_s^{ji}(t) \end{aligned} \tag{7}$$

where the constant $\alpha_s = -\ln N_s$, $\nu_s^i \times v_s(t)$ and $\nu_s^j \times v_s(t)$ are interactions of country dummies with time dummies to control for all country-specific time-variant variables such as the (unknown) multilateral resistance terms, country variables such as $N_s^j(t), L_s^i(t), MPol_s^i(t)$ or any other such variables (GDP per capita, controls for the quality of the university system, etc.). All time invariant bilateral variables are taken care of by the fixed effect ν_s^{ji}; time-variant bilateral policy controls $Pol^{ij}(t)$ remain, and are proxied by joint membership in regional agreements (possibly including provisions on the free mobility of workers) and in GATT/WTO. In terms of interpretation, model

[9]Note that efficiency of the estimator requires that variance of the error term is proportional, not necessarily equal, to the conditional mean. This allows both for under- and over-dispersion. The proportionality assumption is not always realistic; it is, however, not needed for consistency of the estimation. Also, it is important to understand that for the estimator to be consistent it is not necessary that the data follow a Poisson distribution. For that reason the estimator is called a Pseudo Maximum Likelihood estimator.

(7) is similar to a standard log-linear OLS model. As usual, the estimate of γ_s can be interpreted as an elasticity.

While equation (7) is our preferred econometric model, we also estimate versions of it where the term $\nu_s^i \times v_s(t) + \nu_s^j \times v_s(t)$ is replaced by $v_s(t)$ and the bilateral fixed effects take care of the time-invariant components of country-specific variables. For comparison reasons, we also present models where $\nu_s^i \times v_s(t) + \nu_s^j \times v_s(t) + \nu_s^{ji}$ is replaced by $v_s(t)$ and which may therefore suffer from omitted variable bias. Similarly, we provide results from OLS estimation. Clearly, by treating labor as homogeneous and abstracting from education classes, equation (7) can be interpreted to hold on the aggregate. Similarly, by letting $T = 1$, the model describes a cross-section.

4 Results

4.1 OLS versus fixed-effects estimation

Before we show our baseline regressions using the preferred model and distinguishing across education groups, we show that omitted variable bias due to a misspecification of the model can be very large. To that end, we compare the OLS model with Pseudo Poisson Maximum Likelihood (PPML) estimation, accounting for an increasing number of fixed effects.

Table 2 provides the results. Columns (1) to (3) report OLS models, columns (4) to (6) show estimates based on Poisson regressions. Column (1) is a naïve pooled regression, which includes bilateral geographical (such as contiguity or distance) and cultural variables as well as the log of population, GDP per capita, and the unemployment rate, for the destination and origin countries, respectively. The population data replaces $L^i(t)$ and $N^j(t)$, respectively. Unemployment and GDP per capita are often-used proxies of multilateral attractiveness of countries, and therefore also included. Crucially, the unobserved variables $\Omega^i(t)$ and $W^j(t)$ are omitted from the model.

The results reported in (1) confirm well with intuition and with earlier findings in the literature. High unemployment in the origin country increases migration, while high unemployment in the destination decreases it. Higher GDP per capita in the destination countries increases migration by much more than higher GDP per capita in the source country. However, the point estimate is strictly positive in the origin country, too, as a sufficient level of income is required to engage in migration. Both, the stocks of workers in both countries affect bilateral stocks of migrants positively, as predicted by theory. Distance reduces migration stocks, while contiguity and common language increases them. Beyond these bilateral ties, cultural links captured by a common legal system or current colonial ties do not matter separately. Also, regional trade agreements or currency unions do not increase stocks of migrants. The fit of the model is good, adjusted R^2 standing at about 71 percent. Most interestingly for our purposes, the average stock of international students prior to the year of observation has a substantial and positive effect on the stock of migrants. Increasing the number of students by 1 percent leads to slightly more than a 0.5 percent increase in migrants.

Column (2) is more restrictive, in that it identifies all effects on within variation alone. The inclusion of pair-level fixed effects (and their subsequent elimination via the within transformation of the data) matters dramatically for point estimates. Quite visibly, the elasticity of 0.5 obtained in column (1) on the stock of students is massively upward-biased if unobserved bilateral ties (such as related to history or culture) are not appropriately controlled for. The estimate falls by a factor 5 to about 0.1. Note that specification (2) nests time-invariant country effects as well, so that multilateral resistance is accounted for as long as it does not move over time. Monadic variables such as GDP per capita or unemployment lose their relevance, most likely because of the lack of substantial time variation. The logs of population remain statistically significant, but the sign pattern changes relative to column (1). Finally, now, the colonial dummy appears important while it was insignificant before (and of negative sign).

In a last step for the OLS model, column (3) adds destination × year and origin × year effects to control for unobserved multilateral resistance. One additional benefit of replacing all monadic variables with dummies is that the number of observations is maximized; compared to model (1) the number almost doubles. This cuts the student-migrants elasticity by half; not surprisingly, the explanatory power of the model goes up to 98 percent so there is little scope left for additional omitted variable bias. Interestingly, economic union, such as captured by common currency or regional trade agreement starts to matter in an economically and statistically relevant way.

Next, we repeat the exercise presented in regressions (1) to (3) for the Poisson model. The basic message transpiring from column (4) is that, compared to (1), the sign and significance pattern remains unchanged, but point estimates are substantially smaller in the Poisson model for all statistically significant variables. In particular, the elasticity of the student stock on migration is 0.38. Note that the number of observations is potentially higher in the Poisson model because the dependent variable is not in logarithms and, so, zero migration stocks can be included in the regression. To the extent that zeros persist in both years of observations, the pair has to be dropped, of course. However, the effects of first including pair-level fixed effects (column (5)) and then adding country × year effects (column (6)) reduces the elasticity of the student stock quite dramatically. Under Poisson, in both specifications, the effect is not distinguishable from zero. Column (6) presents our most general model with a maximum number of observations (based on a balanced sample of 1966 country pairs).

4.2 Benchmark results for different education classes

Next, we allow for heterogeneity across educational classes. One issue with the aggregate equation shown in Table 2 is that results could suffer from aggregation bias. By focusing on tertiary, secondary and primary educated migrants, our studies distinguishes itself from the work by Dreher and Poutvaara (2011), who only investigate aggregate data. In contrast, we do not run dynamic models since the short time dimension of our data does not allow this, and we use PPML as our preferred estimation technique.

Table 2: **Student mobility and aggregate bilateral migration stocks: Comparison of methods**

Dep. Var.: (Ln) bilateral stock of total migrants						
		OLS			**PPML**	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
ln avg. Stock of students (t-1 to t-10)	**0.530***** **(0.022)**	**0.099**** **(0.036)**	**0.045*** **(0.019)**	**0.381***** **(0.056)**	**0.024** **(0.037)**	**0.017** **(0.017)**
ln POP, destination	0.168*** (0.036)	-2.059* (0.891)		0.134 (0.070)	-1.610* (0.798)	
ln POP, origin	0.531*** (0.030)	1.314*** (0.368)		0.409*** (0.064)	1.900*** (0.288)	
ln GDP per capita, origin	0.076** (0.026)	0.045 (0.095)		-0.081 (0.078)	0.409*** (0.055)	
ln GDP per capita, destination	0.202* (0.088)	0.370 (0.208)		0.323 (0.185)	0.130 (0.154)	
Unemployment rate (%), destination	-0.029** (0.010)	0.001 (0.013)		-0.020 (0.021)	-0.026* (0.011)	
Unemployment rate (%), origin	0.024*** (0.006)	0.005 (0.006)		0.028* (0.013)	0.015 (0.008)	
ln Distance	-0.158** (0.059)			-0.249 (0.185)		
Contiguity (0,1)	0.470** (0.152)			0.953 (0.490)		
Common language (0,1)	0.756*** (0.099)			0.243 (0.221)		
Common legal system (0,1)	0.126 (0.072)			-0.143 (0.207)		
Current colonial relationship (0,1)	-0.551 (0.546)	0.365*** (0.083)	-0.685 (0.652)	-0.104 (0.628)	0.328*** (0.065)	0.204** (0.062)
Regional trade agreement (0,1)	0.211 (0.114)	0.155 (0.154)	0.310*** (0.069)	0.666 (0.447)	0.042 (0.084)	0.150* (0.074)
Common currency (0,1)	-0.205 (0.113)	0.173 (0.108)	0.113* (0.055)	-0.368 (0.304)	0.018 (0.069)	0.201*** (0.060)
Bilateral fixed effects	NO	YES	**YES**	NO	YES	**YES**
Destination x year effects	NO	NO	**YES**	NO	NO	**YES**
Source x year effects	NO	NO	**YES**	NO	NO	**YES**
R-squared	0.707	0.519	0.980			
Number of observations	2092	2092	3882	2449	1528	3932
Number of pairs		1342			764	1966
Wald chi2					1134.968	280250

Note: All regressions use a balanced panel of country pairs (T=2). Robust standard errors in brackets. All Wald Chi2 tests significant at the 1% level.
* p<0.05
** p<0.01
*** p<0.001

Table 3: **Student mobility and bilateral migration stocks by education**

Dep. var.: Bilateral stock of total migrants:		tertiary			secondary			primary	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
ln avg. Stock of students (t-1 to t-10)	0.079*		0.090**	0.001		0.009	-0.002		0.018
	(0.032)		(0.030)	(0.023)		(0.023)	(0.021)		(0.021)
ln avg. Stock of students (t-11 to t-20)		0.084***	0.091***		0.063**	0.063**		0.067**	0.070***
		(0.022)	(0.022)		(0.023)	(0.023)		(0.022)	(0.024)
Current colonial relationship (0,1)	-0.126	-0.086	-0.136	0.535***	0.540***	0.533***	0.406***	0.408***	0.394***
	(0.080)	(0.097)	(0.093)	(0.124)	(0.106)	(0.108)	(0.103)	(0.088)	(0.087)
Regional trade agreement (0,1)	0.039	-0.021	-0.018	0.243*	0.166	0.167	0.299***	0.266**	0.268***
	(0.069)	(0.066)	(0.065)	(0.099)	(0.090)	(0.091)	(0.099)	(0.087)	(0.087)
Common currency (0,1)	0.368***	0.337***	0.354***	0.252**	0.251**	0.253**	0.209***	0.210**	0.213***
	(0.072)	(0.071)	(0.070)	(0.087)	(0.081)	(0.081)	(0.074)	(0.072)	(0.072)
Number of observations	3918	3616	3616	3892	3590	3590	3908	3602	3602
Number of pairs	1959	1808	1808	1946	1795	1795	1954	1801	1801
Wald chi2	2.99e+07	1.93e+09	180262	23894	58186	1.08e+09	688267	9193691	356869

Note: All regressions use a conditional fixed-effects Poisson model on a balanced panel of country pairs (T=2). All regressions include a complete array of interaction terms between country effects and year effects and the following additional pair-specific time-variant dummy variable controls: current colonial relationship, regional trade agreement, common currency. Robust standard errors in brackets. All Wald Chi2 tests significant at the 1% level.
* p<0.05
** p<0.01
*** p<0.001

The first three columns in Table 3 use the level of tertiary educated migrants as the dependent variable. All regressions are conditional fixed-effects Poisson models and contain destination and origin country dummies interacted with year dummies. Column (1) is our preferred specification. It uses an average over the stock of bilateral migrants obtained over ten years prior to the year in which the stock of migrants is measured. We find an elasticity of 0.08, estimated with satisfactory but not excellent precision. The Wald χ^2- statistic of joint significance of all variables is highly significant at the 1 percent level. Colonial ties or trade agreements do not turn out as explanatory determinants of the stock of tertiary educated migrants; the existence of a common currency, in contrast, is economically and statistically relevant: in a currency union, the stock of well educated migrants is about 36.8 percent higher.

The estimated elasticity of 0.08 has the following quantitative implications. A doubling of the international student body leads to an increase in the stock of highly educated foreigners by $(2^{0.08} - 1)\, 100\% = 5.7\%$. Evaluated at sample averages for the year 2000, where the average stock of tertiary educated migrants in selected countries was approximately 752,965 (see Table 4) and the stock of international students was on average 60,410 doubling the student intake increases the stock of foreign high skilled by 42,919 so that the increase in high-skilled workers is about 71 percent of the increase in international students. This number being driven by the huge stock of highly educated migrants in the US, we look at the European average (including UK), and find a retention rate of 33 percent. However, since our empirical exercise identifies only average effects, but there is substantial heterogeneity across countries, these findings are to be interpreted with caution.

Column (2) looks at student mobility between 11 and 20 years before the observed migration stock. Interestingly enough, that distant student exchange has a lasting and statistically significant effect on contemporaneous stocks. The elasticity is 0.084; relative to column (1), coefficients on other covariates are very similar. Column (3) includes both student mobility between 1 and 10 years as well as between 11 and 20 years earlier to the date when the migrant stock is measured. Both student lags are statistically significant, and yield elasticities of around 0.09.[10]

Columns (4) to (6) repeat this exercise for secondary educated workers. The hypothesis is that mobility of students, who move between countries with the purpose to obtain a university degree, increases the stock of highly educated foreigners in the country to the extent that they stay for work. Whether exchange of students triggers increased mobility of less than university educated workers is, however, not clear. There could be knock-on effects, maybe with a lag. Column (4) shows that the first ten-year lag of student mobility does not induce higher stocks of secondary migrants. The picture is similarly when looking at migrans with primary education (column (7)). Interestingly, the second lag of students does affect contemporaneous migration of secondary and primary educated migrants with an elasticity of somewhat above 0.06. Including both the first and the second lag of students simultaneously, we find that that the first lag does not matter, but the second does, again with elasticities between 0.06 and 0.07.

4.3 Heterogeneity across country groups

Next we want to investigate the effect of student migration for selected groups of destination countries. Table 5 provides the results dividing the data set into two destination regions: Anglo Saxon – including the host countries Australia, New Zealand, USA, UK, Canada and Ireland – and a second group consisting of the remaining destination countries. We distinguish between these two groups as English speaking countries have a similar education system at the tertiary level that is organized differently than in most of the other countries: the role of private institutions is much more important, they host most of the world's top universities and the language of instruction is identical to the

[10]Elasticities are statistically significant at the 1 and 0.1 percent level for the first and second lag, respectively.

lingua franca of the world economy. The countries also differ with respect to their immigration policies. However, the extensive use of fixed effects should allow us to control for these determinants of migration.

Again all regressions are conditional fixed-effects Poisson models and contain origin and destination dummies interacted with years. Column (1) to (3) show the results for Anglo-Saxon host countries. Our preferred specification shown in column (1) uses the average over the period ten years to one year prior to the measured stock of high skilled migrants. The estimation provides an elasticity of 0.10 which is statistically significant at the 1 percent level. While a colonial relationship and trade agreements do not induce higher stocks of tertiary educated migrants, common currency does with an elasticity of 0.4, estimated with a statistical significance of 5 percent.

Column (2) shows the estimates for the second lag of students, building an average of student mobility for the period 11 to 20 years prior the observed stock of tertiary educated migrants. The second lag also has an economically and empirically important effect with an elasticity of 0.1. The estimations for the other covariates are similar to the ones in column (1). In column (3) both lags on student mobility -20 to 11 years and 10 to 1 year before regarding the stock of high skilled migrants- are considered simultaneously. Both lags are economically and statistically significant with an elasticity of around 0.2. The coefficient on the first lag even turns to be more significant at the 0.01 percent level. With respect to the other covariates the effects remain similar as in column (1) and (2): again, in a currency union the stock of high skilled migrants is about 35 percent higher whereas colonial ties and trade agreements have no impact.

Column (4) to (6) repeat the results for the remaining countries of the data set.[11] Interestingly the coefficient on the first lag is a lot smaller with an elasticity of about 0.01 and furthermore it is not statistically significant anymore. The estimated coefficient for

[11]The variable controlling for colonial ties is dropped from the sample due to consistency within the group.

trade agreements is, as in the case for Anglo Saxon countries, not statistically significant; also the coefficient for common currency is not significant. In the next column (5) the second lag on student mobility is investigated. Here the coefficient even turns negative but remains not statistically significant. Furthermore the coefficients for trade agreements and membership in a currency union now become statistically significant, both at the 1 percent level. While the elasticity for trade agreement of 0.3 almost halves compared to column (4), the elasticity on currency union increases to 0.2. Column (6) again includes both lags on student migration. The coefficient of the first lag is higher compared to column (4) but remains not significant just as it is the case for the second lag, with an negative elasticity of 0.03. The patterns on regional trade agreement and common currency are the same as in column (5). These results let assume that non Anglo-Saxon countries seem to have a problem keeping high skilled students after graduating in their country while Anglo-Saxon countries seem to be more successful.

5 Robustness checks

In this section we conduct a number of robustness checks. First, we specify dynamic equations, which contain lags of the dependent variable as well as further lags of the student mobility averages. Second, we work with different definitions of the international student variable. We use a slightly different definition of the student mobility averages, and, rather than using averages, we work with yearly student data. Third, we investigate the effect for the unbalanced data sample. Finally, we differentiate between net student importer countries and net student exporters.

5.1 Dynamic equations

Our theoretical model does not include dynamic considerations. However, the results in Table 3 beg the question why the second lag of students turns out relevant for secondary and primary educated migrants but the first lag does not. One hypothesis is that the presence of highly educated workers from a foreign country, possibly formerly students, may lead to an additional inflow of migrants, who need not be highly educated themselves. To test this prediction, we include the lag of tertiary educated migrants into our PPML regressions.[12] Since $T = 2$, with lagged variables in the regression, we can no longer work with pair-fixed effects. So, all regressions shown in the table contain destination and source country dummies, as well as bilateral variables such as the log of distance, dummies for the presence of a common language or a currency union, and so on. The equation has an excellent fit (R^2 of 0.99), leaving minimum space for omitted variables.

[12] Estimates of that equation suffer from a variant of the Nickel Bias when disturbances are serially correlated. There is no obvious way to correct for this in a non-linear setup such as the Poisson framework. Besides, the fact that $T = 2$ limits our possibilities quite considerably. For these reasons, estimates in this section have to be treated with caution and are to be seen as sensitivity checks rather than as baseline results.

Table 4: **Quantitative interpretation of results**

Country	stock of highly educated foreigners	Stock of international students	increase in highly educatd stock	retention rate
Anglo-saxon countries: $\hat{\gamma}_H = 0.094$				
Australia	1,410,611	84,886	126,109	149%
Ireland	107,691	7,108	9,628	135%
New Zealand	198,447	6,830	17,741	260%
United Kingdom	1,079,991	207,086	96,551	47%
United States	9,120,033	380,558	815,331	214%
Average	**2,383,355**	**137,294**	**213,072**	**155%**
Other countries: $\hat{\gamma}_H = 0.028$				
Austria	75,265	24,836	1,474.97	6%
Belgium	173,852	37,153	3,406.98	9%
Denmark	34,977	6,153	685.44	11%
Finland	11,442	3,995	224.23	6%
France	584,257	126,754	11,449.68	9%
Germany	793,426	148,875	15,548.77	10%
Italy	125,896	19,083	2,467.18	13%
Japan	172,452	40,890	3,379.54	8%
Netherlands	334,685	12,269	6,558.82	53%
Poland	17,166	2,359	336.40	14%
Portugal	22,320	10,694	437.41	4%
Spain	274,480	38,725	5,378.98	14%
Sweden	160,110	18,297	3,137.68	17%
Switzerland	237,339	22,865	4,651.13	20%
Turkey	124,850	8,785	2,446.69	28%
Average	**209,501**	**34,782**	**4,105.59**	**12%**
Grand average	**752,965**	**60,410**	**42,918.98**	**71%**

Notes: All data for the year of 2000. Scenario: doubling of stock of international students. Average estimated increase of skilled migrants 8.9% in Anglo-Saxon countries, 1.9% in rest of the world, and 5.7% for the grand average, as implied by our econometric estimates.

Table 5: **Anglo-Saxon versus Non-Anglo-Saxon education systems**

Dep. var.: Bilateral stock of tertiary migrants:	Anglo Saxon			Non Anglo Saxon		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
ln avg. Stock of students (t-1 to t-10)	**0.094***		**0.119*****	**0.012**		**0.028**
	(0.044)		**(0.036)**	**(0.042)**		**(0.041)**
ln avg. Stock of students (t-11 to t-20)		0.111***	0.128***		-0.025	-0.028
		(0.025)	(0.025)		(0.049)	(0.046)
Current colonial relationship (0,1)	-0.138	-0.099	-0.165			
	(0.085)	(0.109)	(0.105)			
Regional trade agreement (0,1)	0.023	0.044	0.046	0.636	0.340**	0.340**
	(0.098)	(0.106)	(0.109)	(0.339)	(0.126)	(0.124)
Common currency (0,1)	0.396*	0.382*	0.349*	0.114	0.193**	0.200**
	(0.156)	(0.167)	(0.164)	(0.089)	(0.072)	(0.070)
Number of observations	1254	1204	1204	2664	2412	2412
Number of pairs	627	602	602	1332	1206	1206
Wald chi2	655355.9	1.96e+08	4.60e+08	102457.6	6.39e+10	1.12e+10

Note: All regressions use a conditional fixed-effects Poisson model on a balanced panel of country pairs (T=2). All regressions include a complete array of interaction terms between country effects and year effects and the following additional pair-specific time-variant dummy variable controls: current colonial relationship, regional trade agreement, common currency. Robust standard errors in brackets. All Wald Chi2 tests significant at the 1% level.

* p<0.05

** p<0.01

*** p<0.001

Table 6: **Dynamic regressions**

	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**
Dep.var. Stock of migrants:	tertiary	second.	second.	primary	primary	tertiary	second.	second.	primary	primary
Lag dep. Var.	0.824***	0.890***	0.836***	0.906***	0.869***	0.823***	0.880***	0.845***	0.900***	0.870***
	(0.020)	(0.016)	(0.030)	(0.021)	(0.026)	(0.020)	(0.016)	(0.030)	(0.021)	(0.026)
Lag stock of tertiary educated			0.079*		0.071*			0.053		0.061
			(0.037)		(0.031)			(0.039)		(0.032)
ln avg. Stock of students (t-1 to t-10)	0.088***	0.056***	0.040*	0.024	0.005	0.085**	0.002	0.000	-0.009	-0.017
	(0.021)	(0.016)	(0.018)	(0.020)	(0.021)	(0.031)	(0.023)	(0.023)	(0.024)	(0.024)
ln avg. Stock of students (t-11 to t-20)						0.005	0.069***	0.057**	0.042*	0.032
						(0.026)	(0.020)	(0.022)	(0.020)	(0.020)
R-squared	0.991	0.991	0.991	0.999	0.999	0.991	0.992	0.991	0.999	0.999
Number of observations	1881	1864	1836	1887	1853	1881	1864	1836	1887	1853
Pseudo log likelihood	-421558.9	-348447.8	-345272.5	-536045.3	-530269.3	-421526	-343899.7	-342445.2	-532860.7	-528573.7

Note: All regressions use a Poisson model with migration stocks from 2000. All regressions include a complete array of destination and origin fixed effects as well as bilateral variables such as log of distance, common language, colonial relationship, regional trade agreement, common currency. Robust standard errors in brackets. T-tests on coefficient of lagged dependent variable to be equal to unity reject in all models.
* p<0.05
** p<0.01
*** p<0.001

Column (1) in Table 6 shows that the bilateral stock of tertiary educated migrants is highly persistent; the coefficient on the lagged stock being 0.82. That coefficient is statistically different from unity at the 0.1 percent level. The first lag of international students is again highly significant and close to the elasticity estimate of 0.09 that we have found before. Columns (2) and (3) turn to secondary educated migrants. Column (2) includes the lagged dependent variable while column (3) additionally contains the lag of the highly educated migrants to disentangle the effect of student exchange from that of a preexisting stock of tertiary educated foreigners. We find that the latter has a positive influence on the stock of secondary educated migrants, with an elasticity of 0.08. Compared to column (2), the effect of the first lag of students is reduced and estimated at lower precision. Our conclusion is that student mobility partly captures the effect of highly educated on secondary educated migrants.

The picture is somewhat different in columns (4) and (5), where we look at primary educated workers. There, it is still true that a lagged stock of tertiary educated workers spurs migration of unskilled workers; the effect of student mobility, however, turns to zero. Columns (6) to (10) also include the second lag of student mobility. It is quite striking that the first lag of student mobility is only relevant for tertiary educated migrants.

5.2 Alternative measurement of international student stocks

Table 7: **Student mobility and bilateral migration stocks by education: Alternative definition of student stock variable**

Dep. var.: Bilateral stock of total migrants:	tertiary			secondary			primary		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
ln avg. Stock of students (t-1 to t-10)	**0.081***		**0.092****	**0.004**		**0.012**	**0.001**		**0.021**
	(0.032)		**(0.030)**	**(0.023)**		**(0.023)**	**(0.021)**		**(0.021)**
ln avg. Stock of students (t-11 to t-20)		0.086***	0.092***		0.063**	0.064**		0.068**	0.071**
		(0.022)	(0.022)		(0.023)	(0.023)		(0.022)	(0.023)
Current colonial relationship (0,1)	-0.129	-0.085	-0.138	0.533***	0.541***	0.532***	0.404***	0.409***	0.392***
	(0.080)	(0.097)	(0.093)	(0.124)	(0.106)	(0.108)	(0.103)	(0.088)	(0.088)
Regional trade agreement (0,1)	0.036	-0.019	-0.018	0.244*	0.167	0.168	0.299**	0.267**	0.269**
	(0.069)	(0.066)	(0.065)	(0.099)	(0.090)	(0.091)	(0.099)	(0.088)	(0.087)
Common currency (0,1)	0.366***	0.339***	0.354***	0.253**	0.251**	0.254**	0.209**	0.211**	0.214**
	(0.072)	(0.071)	(0.070)	(0.087)	(0.081)	(0.081)	(0.074)	(0.072)	(0.072)
Number of observations	3904	3612	3612	3878	3584	3584	3892	3596	3596
Number of pairs	1952	1806	1806	1939	1792	1792	1946	1798	1798
Wald chi2	52478.8	5.68e+09	1.22e+09	26598.59	57971.89	3.04e+09	1454134	1.63e+07	363322.6

Note: All regressions use a conditional fixed-effects Poisson model on a balanced panel of country pairs (T=2). All regressions include a complete array of interaction terms between country effects and year effects and the following additional pair-specific time-variant dummy variable controls: current colonial relationship, regional trade agreement, common currency. Robust standard errors in brackets. All Wald Chi2 tests significant at the 1% level.

* p<0.05

** p<0.01

*** p<0.001

Table 7 investigates the robustness of our results shown in Table 3 for the second data set, where students of an academic year are attached to the first year. Again column (1) to (3) use the level of high skilled migrants as the dependent variable, column (4) to (6) show the results for medium skilled migrants and the last three columns present estimates for low skilled migrants. Compared to Table 3, the results in general remain almost equal and also the number of observations is only slightly smaller. The estimated elasticities for our independent variable of interest, the stock of students, remain -even though in some cases slightly bigger- statistically and economically significant at the same level: for estimations on high skilled migrants the elasticity for the first lag is about 0.08, for the second lag 0.09 and investigating both lags simultaneously the elasticities are 0.09 for both lags. The results for the other groups of migrants, medium and low skilled migrants, are also similar to the ones presented and described in section 4. Hence, the choice of attaching the stock of students to a certain year in the case of study years does not affect the results.

Table 8 analyzes the stability of the effect over time. For that purpose, rather than using averages defined over a longer period, we use student stocks as pertaining to a specific year. Since academic years and calender years do not coincide, and the exact timing of international student mobility is not obvious from reported UNCTAD data, there is some measurement issue here. However, since we are not interested in the contemporaneous effect of student mobility on migration (which could well be a pure accounting relation), we allow for a sufficient time lag between the measurement of the migrant stock and that of the international student body. Table 8 reports regressions containing the first lag of the dependent variable, and the complete array of bilateral variables as well as destination and source country specific fixed effects. Starting with more recent students, we find that the effect on highly educated migration falls as we move back in time with student mobility from an elasticity close to 0.15 to one of 0.05 in 1986. With the exception of one year, all years reported yield coefficients that ar statistically significant at least at the

Table 8: **Year-specific effects**

	Dep.var.:	Stock of highly educated, t=2000				
	International students in	$\hat{\gamma}_H$	s.e.	R2	N	LL
(1)	1995	0.148**	(0.046)	0.976	603	-47546.68
(2)	1994	0.091***	(0.022)	0.996	1295	-288776.3
(3)	1993	0.061**	(0.020)	0.991	1309	-307922.9
(4)	1992	0.062**	(0.019)	0.990	1518	-385931.8
(5)	1991	0.045**	(0.017)	0.990	1510	-385351.6
(6)	1990	0.074***	(0.020)	0.992	1347	-344875.4
(7)	1989	0.027	(0.031)	0.992	1197	-305699.5
(8)	1988	0.062**	(0.021)	0.992	1432	-366995.4
(9)	1987	0.069**	(0.022)	0.996	1156	-245574.3
(10)	1986	0.051*	(0.021)	0.995	1139	-277120.6

Note: Each line corresponds to a separate regression. Each regression includes a full set of destination and origin dummies, the lag of the dependent variable (t-1=1990), time invariant bilateral controls such as the log of distance, contiguity and common language dummies. Additional pair-specific time-variant dummy variable controls are current colonial relationship, regional trade agreement, common currency. Robust standard errors in brackets. All models estimated with Poisson Pseudo Maximum Likelihood.
* p<0.05
** p<0.01
*** p<0.001

5 percent level. We conclude that our practice of averaging ist not crucial for obtaining statistically relevant estimates, but improves coverage and precision.

5.3 Unbalanced data sample

Table 9 checks for robustness of the results presented in table 3 for the unbalanced data sample. The first three columns demonstrate the results for high skilled migrants, column (4) to (6) present the results for medium skilled migrants and column (7) to (9) refer to low skilled migrants. In general, again, the results are almost equal to the ones presented in table 3 and the number of observations raises a bit when the second lag is investigated. The elasticities of our main independent variable, the stock of students, are still statistically and economically significant; the same holds for the elasticities of the other variables.[13] For estimations on tertiary educated migrants, the elasticities for the student lags remain equal: for the first as well as for the second lag the elasticity is 0.08 and when both lags are investigated at the same time, the elasticities, again, both are 0.09. Also the results for the other two migrant groups are almost equal to the results presented before in table 3. Hence, balancing the sample has no changing effect on the results.

[13]In some cases, the significance level falls from 0.1 percent to 1 percent.

Table 9: **Student mobility and bilateral migration stocks by education: Unbalanced data sample**

Dep. var.: Bilateral stock of total migrants:	tertiary			secondary			primary		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ln avg. Stock of students (t-1 to t-10)	0.079*		0.090**	0.001		0.009	-0.002		0.018
	(0.032)		(0.030)	(0.023)		(0.023)	(0.021)		(0.021)
ln avg. Stock of students (t-11 to t-20)		0.084***	0.091***		0.062**	0.063**		0.067**	0.070**
		(0.022)	(0.022)		(0.023)	(0.023)		(0.022)	(0.024)
Current colonial relationship (0,1)	-0.126	-0.085	-0.136	0.535***	0.542***	0.533***	0.406***	0.407***	0.394***
	(0.080)	(0.097)	(0.093)	(0.124)	(0.106)	(0.108)	(0.103)	(0.088)	(0.087)
Regional trade agreement (0,1)	0.039	-0.021	-0.018	0.243*	0.163	0.167	0.299**	0.266**	0.268**
	(0.069)	(0.066)	(0.065)	(0.099)	(0.090)	(0.091)	(0.099)	(0.087)	(0.087)
Common currency (0,1)	0.368***	0.337***	0.354***	0.252**	0.250**	0.253**	0.209**	0.210**	0.213**
	(0.072)	(0.071)	(0.070)	(0.087)	(0.081)	(0.081)	(0.074)	(0.072)	(0.072)
Number of observations	3918	3708	3616	3892	3674	3590	3908	3686	3602
Number of pairs	1959	1854	1808	1946	1837	1795	1954	1843	1801
Wald chi2	2511409	2362753	2221643	4.22e+08	1145601	5.87e+08	1361510	291128.7	356562.2

Note: All regressions use a conditional fixed-effects Poisson model. All regressions include a complete array of interaction terms between country effects and year effects and the following additional pair-specific time-variant dummy variable controls: current colonial relationship, regional trade agreement, common currency. Robust standard errors in brackets. All Wald Chi2 tests significant at the 1% level.
* p<0.05
** p<0.01
*** p<0.001

5.4 Net student importers versus exporters

Table 10 provides results for the two groups, net importers and net exporters of students. The decision on whether a destination country is a net importer or not is made separately for the two years where the stock of migrants is considered - 1990 and 2000. If a destination country received more students aggregated in the period 20 years to 1 year prior to considering the stock of migrants, this country is considered as a net importer. Table 13 in chapter 7 demonstrates the net importing and exporting countries of students for both considered years.

Column (1) to (3) demonstrates the results for net importers; column (4) to (6) the results for net exporters.[14] In column (1) we can see that the effect of the first lag is statistically and economically significant with an elasticity of around 0.1. Colonial ties and trade agreements do not seem to have an impact, whereas a common currency does with an elasticity of 0.3 being statistically significant even at the 0.1 percent level. The second column shows results for the second lag that provides a similar elasticity of 0.1 being statistically significant at the 0.1 percent level. The other covariates provide similar results as in column (1). In column (3) we simultaneously look at the two student lags and find an elasticity of around 0.1 for both lags yielding a statistical significance level of 0.01 percent.[15]

Column (4) to (6) demonstrate results for destination countries that are net exporters of students in the considered period. Different than for net importers, the coefficient for the first lag -10 to 1 year before regarding the stock of high skilled migrants- now turns out to be negative but is not statistically significant. Also, different than for net importers, trade agreements have an economically and statistically significant impact with an elasticity of almost 0.8. The next column demonstrates the effect of the second lag.

[14] All regressions are conditional fixed-effects Poisson models and contain origin and destination dummies interacted with years.

[15] The patterns for the other covariates are similar to the ones provided in the first two columns.

Even though the coefficient now is positive, the estimated elasticity again is not significant. As for the first lag, trade agreements have a positive impact; the elasticity however is only half that big compared to column (4). The last column of the table provides the results estimating the effect of both lags at the same time. Both lags perform similar results as before when investigating the effect separately: the first lag still is negative with an elasticity that is slightly smaller and the second lag remains equal; both are not statistically significant. The impacts of a trade agreement and being member in the same currency union is similar to the ones demonstrated in column (5). These results do especially well for net importers. Even in the case that education for foreign students is financed publicly by the host country, they can expect a positive return on financing them as it has an causal effect on the later stock of high skilled migrants.

6 Conclusions

In this paper we investigate to what extent net imports of students lead to net immigration of high-skilled migrants in later periods. We investigate this question empirically. To that end, we have constructed a data set of bilateral student mobility across 23 host countries and 150 source countries from UNCTAD year books going back to the year of 1970. We use these data in a theory-grounded gravity equation of migration that we estimate with Poisson Pseudo Maximum Likelihood procedures. To ensure consistent estimates, we make extensive use of country fixed effects to dummy out unobserved multilateral resistance terms. Moreover, we partial out bilateral effects to control for unobserved country-pair heterogeneity that may lead to a spurious correlation between stocks of highly educated foreigners and foreign students.

Our findings indicate that the elasticity of the stock of highly educated migrants with respect to the international student body is about 0.09 on average. However, that average hides substantial heterogeneity across country groups: it is driven exclusively by

Table 10: **Robustness Check: Student mobility and bilateral tertiary migration for net importers and net exporters of students**

Dep. var.: Bilateral stock of high skilled migrants:	Net Importer			Net Exporter		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
ln avg. Stock of students (t-1 to t-10)	**0.099****		**0.114*****	**-0.043**		**-0.025**
	(0.037)		**(0.032)**	**(0.068)**		**(0.072)**
ln avg. Stock of students (t-11 to t-20)		0.102***	0.113***		0.030	0.030
		(0.023)	(0.023)		(0.045)	(0.044)
Current colonial relationship (0,1)	-0.138	-0.092	-0.156			
	(0.081)	(0.103)	(0.098)			
Regional trade agreement (0,1)	0.026	0.010	0.018	0.792**	0.360*	0.366*
	(0.061)	(0.061)	(0.059)	(0.304)	(0.158)	(0.166)
Common currency (0,1)	0.337***	0.316***	0.334***	-0.196	0.198	0.181
	(0.079)	(0.078)	(0.076)	(0.231)	(0.114)	(0.110)
Number of observations	2854	2710	2710	790	652	652
Number of pairs	1427	1355	1355	395	326	326
Wald chi2	1.57e+07	73027.11	91510.58	3950696	1.47e+09	1.12e+09

Note: All regressions use a conditional fixed-effects Poisson model on a balanced panel of country pairs (T=2). All regressions include a complete array of interaction terms between country effects and year effects and the following additional pair-specific time-variant dummy variable controls: current colonial relationship, regional trade agreement, common currency. Robust standard errors in brackets. All Wald Chi2 tests significant at the 1% level.
* p<0.05
** p<0.01
*** p<0.001

the Anglo-Saxon countries Ireland, UK, USA, Canada, Australia and New-Zealand. These countries strongly benefit from student mobility: doubling the international student intake would lead to an overproportional increase in the stock of high-skilled foreigners from the respective destination countries. Hence, from a single country perspective, our findings constitute a rationale for public subsidies to higher education. From a world perspective, however, there is the threat of overinvestment in higher education, as countries compete for international talent by making their universities more attractive.

While our results are robust over a number of sensitivity checks, with better data, more precise inference would be possible. However, relative to the existing, mostly survey-based empirical literature, our analysis makes substantial headway: we exploit panel data, use information on high-skilled immigrants, and base our analysis on a very general econometric model. In the future, a better understanding of student mobility itself will make it possible to better deal with remaining endogeneity issues that still do arise in our framework.

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7 Appendix

Table 11: List of Countries

Country	Source	Host	Country	Source	Host
Afghanistan	x		Ecuador	x	
Albania	x		Egypt, Arab Rep.	x	
Algeria	x		El Salvador	x	
Andorra*	x		Equatorial Guinea	x	
Angola	x		Eritrea*	x	
Antigua and Barbuda	x		Ethiopia	x	
Argentina	x		Fiji	x	
Australia	x	x	Finland	x	x
Austria	x	x	France	x	x
Bahamas, The	x		Gabon	x	
Bahrain	x		Gambia, The	x	
Bangladesh	x		Germany[e)]	x	x
Barbados	x		Ghana	x	
Belgium	x	x	Greece	x	x
Belize	x		Grenada	x	
Benin[a)]	x		Guatemala	x	
Bhutan	x		Guinea	x	
Bolivia	x		Guinea-Bissau[f)]	x	
Botswana	x		Guyana	x	
Brazil	x		Haiti	x	
Brunei Darussalam	x		Honduras	x	
Bulgaria	x		Hong Kong SAR, China	x	
Burkina Faso[b)]	x		Hungary	x	x
Burundi	x		Iceland	x	
Cambodia[c)]	x		India	x	
Cameroon[d)]	x		Indonesia	x	
Canada	x	x	Iran, Islamic Rep.	x	
Cape Verde	x		Iraq	x	
Central African Republic	x		Ireland	x	x
Chad	x		Israel	x	
Chile	x		Italy	x	x
China	x		Jamaica	x	
Colombia	x		Japan	x	x
Comoros	x		Jordan	x	
Congo, Dem. Rep.	x		Kenya	x	
Congo, Rep.	x		Kuwait	x	
Costa Rica	x		Lao PDR	x	
Cote d'Ivoire	x		Lebanon	x	
Cuba	x		Lesotho	x	
Cyprus	x		Liberia	x	
Denmark	x	x	Libya	x	
Djibouti*	x		Luxembourg**	x	x
Dominica	x		Macao SAR, China*	x	
Dominican Republic	x		Madagascar	x	

Country	Source	Host	Country	Source	Host
Malawi	x		Senegal	x	
Malaysia	x		Seychelles	x	
Maldives*	x		Sierra Leone	x	
Mali	x		Singapore	x	
Malta	x		Somalia	x	
Mauritania	x		South Africa	x	
Mauritius	x		Spain	x	x
Mexico**	x	x	Sri Lanka	x	
Mongolia	x		St. Kitts and Nevis*	x	
Morocco	x		St. Lucia*	x	
Mozambique	x		St. Vincent and the Grenadines	x	
Myanmar (Burma)	x		Sudan	x	
Namibia*	x		Suriname*	x	
Nepal	x		Swaziland	x	
Netherlands	x	x	Sweden	x	x
New Zealand	x	x	Switzerland	x	x
Nicaragua	x		Syrian Arab Republic	x	
Niger	x		Tanzania	x	
Nigeria	x		Thailand	x	
Norway**	x	x	Togo	x	
Oman	x		Tonga	x	
Pakistan	x		Trinidad and Tobago	x	
Panama	x		Tunisia	x	
Papua New Guinea	x		Turkey	x	x
Paraguay	x		Uganda	x	
Peru	x		United Arab Emirates	x	
Philippines	x		United Kingdom	x	x
Poland	x	x	United States	x	x
Portugal	x	x	Uruguay	x	
Qatar	x		Venezuela, RB	x	
Romania	x		Vietnam[g)]	x	
Rwanda	x		West Bank and Gaza	x	
Samoa	x		Yemen, Rep.[h)]	x	
San Marino	x		Zambia[i)]	x	
Sao Tome and Principe	x		Zimbabwe	x	
Saudi Arabia	x				

a) Includes former Dahomey.
b) Includes former Upper Volta.
c) Includes the former Khmer Rouge as well as the People's Republic of Kampuchea.
d) Includes the former Federal Republic of Cameroon and the United Republic of Cameroon.
e) For years prior to 1990: Germany=West Germany and unknown.
f) Includes former Portuguese Guinea.
g) Considered as one nation for all years.
h) Considered as one nation for all years.
i) Includes former Southern Rhodesia.
* Countries are not included in the balanced data set.
** Countries are not included as destination countries in the balanced data set.

Table 12: **Summary Statistics and Data Sources**

Variable	1990 Mean	1990 Std. Dev.	2000 Mean	2000 Std. Dev.	Data source
ln avg. stock of students (t-1 to t-10)	3.04	2.21	3.44	2.23	UNESCO
ln avg. stock of students (t-11 to t-20)	2.97	2.15	3.04	2.21	UNESCO
ln bilateral stock of total migrants	6.98	2.51	7.52	2.37	Docquier, Lowell and Marfouk (2008)
ln bilateral stock of primary migrants	6.05	2.51	6.38	2.38	Docquier, Lowell and Marfouk (2008)
ln bilateral stock of secundary migrants	5.61	2.39	6.16	2.29	Docquier, Lowell and Marfouk (2008)
ln bilateral stock of tertiary migrants	5.77	2.52	6.42	2.41	Docquier, Lowell and Marfouk (2008)
Bilateral stock of total migrants	14,324.64	80,535.24	20,293.92	148,481.10	Docquier, Lowell and Marfouk (2008)
Bilateral stock of primary migrants	7,016.75	51,913.57	8,793.77	97,244.92	Docquier, Lowell and Marfouk (2008)
Bilateral stock of secundary migrants	2,894.29	16,511.15	4,316.49	25,826.69	Docquier, Lowell and Marfouk (2008)
Bilateral stock of tertiary migrants	4,413.59	24,414.54	7,183.67	39,423.82	Docquier, Lowell and Marfouk (2008)
ln POP, destination	16.93	1.20	16.99	1.20	World Bank Indicators
ln POP, origin	16.08	1.72	16.25	1.72	World Bank Indicators
ln GDP per capita, origin	7.55	1.62	7.75	1.71	World Bank Indicators
ln GDP per capita, destination	9.66	0.76	9.87	0.60	World Bank Indicators
Unemployment rate (%), destination	7.03	3.67	6.92	3.43	World Bank Indicators
Unemployment rate (%), origin	7.98	4.88	8.22	5.51	World Bank Indicators
ln distance	8.56	0.83	8.56	0.83	CEPII
Contiguity (0,1)	0.02	0.15	0.02	0.15	CEPII
Common language (0,1)	0.16	0.37	0.16	0.37	CEPII
Common legal system (0,1)	0.29	0.45	0.29	0.45	CEPII
Current colonial relationship (0,1)	0.00	0.03	0.00	0.03	CEPII
Regional trade agreement (0,1)	0.11	0.31	0.19	0.39	CEPII
Common currency (0,1)	0.00	0.05	0.04	0.20	CEPII

Table 13: **List of net importing and exporting countries of students**

Country	2000		1990	
	Net Importer	Net Exporter	Net Importer	Net Exporter
Australia	x		x	
Austria	x		x	
Belgium	x		x	
Canada	x		x	
Switzerland	x		x	
Denmark	x		x	
Spain		x	x	
Finland		x		x
France	x		x	
United Kingdom	x		x	
Germany	x		x	
Greece		x		x
Hungary	x		x	
Ireland		x	x	
Italy	x		x	
Japan		x		x
Netherlands		x		x
New Zealand	x		x	
Poland		x		x
Portugal		x		x
Sweden	x		x	
Turkey		x		x
United States	x		x	

For every year the net imports and exports for a destination country are calculated based on the data presented in the UNESCO Statistical Yearbooks. The Yearbook shows the stock of students for the 50 principal destination countries by their country of origin, based on the last year for which these numbers are available. The annual data represents about 95 percent of the known total world number.

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