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Abstract: This paper provides evidence on migration of workers within the European Union 15 (EU15), disaggregated by occupation. Using the European Labor Force Survey from 1983-2013, we find that in high-educated occupations, EU15 workers move to EU15 countries where their occupation is relatively more abundant among natives. This is at odds with traditional models of migration. We argue that a different framework is more suitable to analyze migration flows across highly educated high-income countries. In particular, we develop a model with external economies of scale that generates agglomeration of highly educated labor. The main implication of the model is that workers of high-educated occupations migrate to countries that are abundant in labor of their same occupation, in accordance with the data.

Keywords: North-North Migration, Occupation, Agglomeration, European Union
JEL Classification: F12, F15, F22, E2

Resumen: Este documento provee evidencia de migración de trabajadores al interior de la Unión Europea-15 (UE15), desagregada por ocupación. Utilizando la Encuesta de Fuerza de Trabajo Europea de 1983-2013, se encuentra que en ocupaciones de alta educación los trabajadores de la UE15 migran a países de la UE15 en los cuales su ocupación es relativamente más abundante entre los nacionales. Lo anterior no se explicaría a partir de los modelos tradicionales de migración. Por ello, se considera un marco conceptual más adecuado para analizar la migración entre países de ingresos altos y cuya fuerza laboral es altamente educada que consiste en un modelo con economías de escala externas que generan aglomeración de trabajo altamente educado. El resultado principal del modelo es que, en línea con lo observado, los trabajadores de ocupaciones de alta educación migran a países abundantes en trabajadores de su misma ocupación.

Palabras Clave: Migración Norte-Norte, Ocupación, Aglomeración, Unión Europea

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1 Introduction

In light of current selective migration reforms, this paper provides evidence on migration of workers within the European Union 15[1] (henceforth EU15), disaggregated by occupation. We document that foreign-born workers, of high-educated occupations, within this area, live in countries where their occupation is relatively more abundant among natives. This is at odds with traditional models of migration. We build a model with external economies of scale in sectors that are intensive in highly educated labor. This feature generates agglomeration in those sectors and allows for international labor flows between similar countries analogous to those flows observed within the EU15. The main result is that, if a country has a relatively large fraction of native population of a highly educated occupation, this country will attract foreign labor of the same occupation. This is consistent with migration patterns observed in high-educated occupations in our sample of analysis.

The share of total immigrants relative to the population in Europe is now similar to that of the United States (US), a number which was much smaller around 1960 (Dustmann and Frattini, 2012). Regardless of the migratory inflows generated by the decolonization process and the incorporation of Eastern European countries to the European Union (EU), 20% of the immigrants in the EU15 are native from other EU15 countries. Relatively recent policy changes are likely to be behind these numbers. Two examples of these changes are the creation of a free mobility area, established by the consolidation of the Schengen Area in 1995, and the changes in national policies that formalize agreements reached under the framework of the European Higher Education Area (EHEA).

The EHEA is the result of a series of agreements signed between 1999 and 2009, involving changes in national educational policy by the member states.[2] These changes include the transferability of academic credits and the mutual recognition of degrees across the EHAE. While the Schengen Area is just one of many labor free mobility areas (OECD, 2012), the

[1] The EU15 comprised the following 15 countries: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, and the United Kingdom.

[2] All European countries are part of the EHEA.

EHEA represents the first *human capital free mobility area*. For our analysis, this means that, nowadays, skills are more transferable and workers are more mobile within this area, which enhances the importance of the intra EU migration phenomenon. These two types of free mobility policies, of workers and skills, are likely to reinforce each other.

Selective migration policies have gained importance, among industrialized countries, in detriment of traditional quotas and family reunification. These policies favor inflows of highly educated labor. Within the EU, for instance, the United Kingdom considered adopting a point-based immigration scheme where potential immigrants earn points on the basis of their qualifications and skills, among other factors. More recently, the Great Recession brought up concerns that were not present when the free mobility agreements were signed.

Most models that examine migration analyze migration flows from poorer regions, where labor with certain characteristics is abundant, to richer regions, where it is scarce. We relegate the discussion of these models to the next section in relation to their main references, and we refer to this approach as the south-north approach. In this setup, immigrants can have higher expected earnings abroad, because of differences in countries' income levels or because of the relative scarcity of their labor characteristics, such as education, as compared to the host country. We will show that this is not the case among workers of the EU15.

Using data from the European Labor Force Survey, we find suggestive evidence that, EU15 countries with relatively large fractions of native population working in a high-educated occupation, also have relatively large fractions of foreign EU15 labor of the same occupation. We also document that high-educated occupations display concentration patterns in the sense that workers in those occupations tend to cluster in specific countries.

We develop a model with external economies of scale where real wages are strictly increasing in the amount of highly educated workers employed in a country, regardless of their country of origin. Hence, at the individual level, for the most able individuals it is worthwhile to become highly educated and to move to the country where there are more highly educated native workers of their occupation. This is consistent with the migration patterns observed in high-educated occupations in our sample of analysis, which we refer to as north-

north migration patterns. Therefore, by incorporating the previously described agglomeration mechanism, the model we propose in this paper successfully generates the EU15 migration flows and concentration patterns for our sample data.

Economies of scale are key to our results, in that sense similarly to international trade models that aim to explain observed flows across developed countries,[3] the model of this paper highlights the importance of increasing returns to scale to generate migration flows across north countries. This model is based on Chipman (1970) and on Haupt and Uebelmesser (2010). We use the framework of increasing returns to scale of the former in the production of skilled intensive goods, which are external at the firm level, to induce agglomeration of workers with similar characteristics after migration; and, the setup of the latter where workers incur a cost to become highly educated in our general equilibrium environment.

The paper is organized as follows. Section 2 discusses some of the literature in migration related to our paper. Section 3 describes the data and documents patterns of intra-EU15 migration by occupation. Section 4 describes the model and the equilibrium. Section 5 reports and discusses the results. Section 6 concludes.

2 Related Literature

A large proportion of the literature on migration focuses on migration flows from low-income (the south) to high-income (the north) countries. An emblematic case is the Mexico-US migration. In this literature, workers move from poorer regions where usually low-skilled workers are abundant, to richer ones where they are scarce. This labor flow is the result of higher expected earnings abroad, because of differences in countries' income levels and because of the relative scarcity of the migrant's skill level in the host country. We refer to this approach as the *south-north* approach.

Relatively recent policy changes have driven attention to a different labor flow where workers with similar characteristics, usually high-skilled labor, move across high-income

[3] For example the *New Trade Theory* of Krugman (1979).

countries (the north). In parallel to the term south-north, we refer to this as *north-north* migration. These flows, where workers migrate to countries that are similar to their source country and where their labor characteristics –such as skill level– are relatively abundant cannot be explained by the south-north literature because its basic mechanism is contradicted from the beginning. In the remainder of this section we review some of the literature of the south-north approach and point to where it fails to explain and predict the intra-EU15 flows.

Beyond the basic south-north mechanism described above, authors began to modify the standard framework by including additional features as more specific determinants of migration and to the observed heterogeneity (in the performance, earnings, and country of origin of immigrants) of some of these labor flows. Some of these features include differences in income dispersion across countries, heterogeneity of schooling and skills, mobility costs, loss of ability of newcomer-foreign workers, differences in the size of the source and host countries, among others.

A new generation of migration models was born when self-selection of immigrants and brain drain started to gain importance. A seminal work in self-selection of immigrants is Borjas (1987). In his work, self-selection is driven by the correlation between expected earnings across countries –where under the Roy (1951) model, that he applies to analyze migration, the distribution of earnings is driven itself by the distribution of worker's skills and the correlation with those of others–[4] and relative earnings distribution dispersion. He finds that with a strong positive correlation between expected earnings, if the source country has a a more unequal (equal) income distribution there would be negative (positive) self-selection, migrants would be drawn from the lower tail of the income distribution and will underperform abroad.[5] He also documents a negative relation between emigration rates and distance across countries, per-capita income levels at home, and inequality at home. He analyzes migration towards the US from several source countries; however, his results rely on substantial differences on income distributions across countries which are not present in

[4]Roy (1951) looked at how workers select occupations and at the effect of this selection on the distribution of output (and earnings) and productivity across occupations, concluding that the distribution of earnings across occupations depends on the distributions of workers' skills and on the state of technique.

[5]There is a third case, refugee sorting, under low correlation migrants will be below-average at home.

the north-north migration within similar countries.

Urrutia (2001) models migration flows from Mexico and India to the US in a south-north fashion. He extends the analysis by allowing for differences in migration costs due to distance and language barriers, that he models as a fixed cost and as a temporary loss of ability, respectively. By considering these two aspects, Urrutia generates a self-selection pattern that can account for heterogeneity in the performance of immigrants from different source countries, which is observed in the data. His main result is that immigrants from distant countries are more likely to belong to the top abilities distribution. This result goes in the opposite direction to the one we are interested in this paper, where migrants from and to the EU15 move across proximal countries and yet belong to the top abilities distribution for some occupations.

Lopez-Real (2011) incorporates a new source of heterogeneity of workers. In his model, workers are heterogeneous in years of schooling and ability. Lopez-Real finds that self-selection in ability is always positive and that differences in TFP determine whether self-selection in schooling is positive or negative. Nonetheless, his model cannot explain the concentration we document among EU15 countries. Moreover Lopez-Real assumes the host country is a large open economy while the source country is a small open economy. This is not the case for EU15 countries since they are similar in terms of size and openness.

Dustmann and Frattini (2012) provide an overview of immigration to Europe from the Second World War to the early 2010s, concluding that non-EU immigrants are in disadvantage in all countries studied. The authors document the existing disparities between immigrants born in the EU and those born outside of the EU, with special focus on labor markets. Overall, they find that EU immigrants are more similar to the native population than immigrants from elsewhere, for instance in terms of occupational and educational attainment distributions, and employment rates. Hence their observations regarding these characteristics support our evidence that the intra-EU migration flow differentiates itself from the aggregate migration flow to the EU15 in a peculiar way: a large fraction of it mimics the characteristics of the national population, with some exceptions.

The model of this paper is based on Chipman (1970). For our model, the most important feature of his framework is the presence of increasing returns to scale (IRS) in the production of skilled intensive goods, that are external at the firm level. This is the main force that induces agglomeration of workers with similar characteristics after migration. In this paper, we use the aforementioned feature, and the framework of Haupt and Uebelmesser (2010) where workers pay to become highly educated and there are IRS in the economy. But, we consider two sectors with IRS and one with constant returns to scale in a general equilibrium environment, and effort costs. We incorporate features of their model by allowing households to simultaneously choose education and migration in high-education intensive sectors.

3 Data and Empirical Evidence

3.1 Data and Classifications

One of the main limitations of the analysis of migration patterns across different countries is the lack of comparable data. It is often the case that each country uses a different definition of immigrant based on either nationality or country of origin. Harmonized data on migration status and occupation for European countries are available from two sources: the European Labor Force Survey (EU-LFS hereafter), which consists of repeated cross-sections of individuals from 1983-2013; and the Database on Immigrants in OECD Countries (DIOC), which reports aggregate numbers of workers by different demographic and labor market categories based on Census data, with a comprehensive list of variables and countries only for 2001.[6]

In this analysis, we use the EU-LFS and we consider a worker to be immigrant if she was born in a country different from the one in which she works. We also use the 1988 International Standard Classification of Occupations (ISCO-88 hereafter) to classify occupations according to education levels. Finally, we use the wage ranking of occupations of Goos et al. (2014) according to which occupations are ranked by mean European wages, because wage information is not available in the EU-LFS.

[6] A version for 2005 is available, but the information disaggregated by occupation is incomplete for a large part of the countries.

The European Union Labor Force Survey Database

The EU-LFS is a harmonized household sample survey that contains quarterly detailed information on individuals per country for 28 European countries. The data covers the years from 1983 onwards, due to availability of our variables of interest we keep the years of 1996 to 2010, for a total of 31,663,252 observations.

The core variables from the EU-LFS used in the analysis are country of residence, country of birth, educational attainment, employment status, hours worked, and occupation (identified by ISCO-88). Out of the 28 countries available in the EU-LFS, we keep EU15 countries.

The ISCO-88: Description and Relation to Educational Classification

The ISCO-88 is one of the occupational classifications published by the International Labour Office (ILO, 1990). It uses information on national coding for over 80 countries and organizes them into a standard classification of occupations.

Even though each occupation presents a different skill specialization content in terms of tasks, we find convenient that its ordering coincides with its corresponding educational level. In particular, eight of the nine major ISCO-88[7] groups are ordered with reference to education levels[8] defined for ISCO-88 (see Table 8 for a description of each major group). Five out of nine major ISCO-88 groups (4, 5, 6, 7 and 8) have the same average education level (lower or upper secondary education). These five groups, together with Elementary Services (group 9)[9] will be considered *Low-Educated* (LE) in the analysis below. The remaining groups (1-3) include occupations that require tertiary education and therefore will be classified as *High-Educated* (HE). For the analysis of concentration patterns we will consider 26 subgroups at the ISCO 2-digit level, or 26 occupations, from which 11 are classified as High-Educated and 15 as Low-Educated following this criterion (see Table 9).

[7] We exclude Armed Forces (group 0).

[8] The ISCO levels of education are based on the first (1976) version of the International Standard Classification of Education (ISCED). ISCO defines 4 levels of education: 1 for primary education, 2 for lower and upper secondary education, 3 for tertiary education not leading to a university degree, and 4 for tertiary education leading to a university degree.

[9] Elementary Services is the only major group of occupations with primary school as average education level.

3.2 Empirical Analysis

This section is organized in three parts. In the first part, we compare the distribution of native workers, EU15 foreign-born workers, and non-EU15 foreign-born workers across occupations. We show that EU15 immigrants are different from non-EU15 and henceforth we limit the study to foreign-born workers whose country of origin is a EU15 member.

In the second part, we compute the correlation between the occupational distributions of foreign-born workers and that of native-born workers, for each country. We use this correlation to explain the relation between natives and foreigners. Finally, in the third part we compute a proxy for concentration of total workers depending on their occupation. For this measure, we use the educational component of the ISCO-88. A detailed definition and explanation of these measures will be provided below.

North-North Empirical Analysis

We fist provide empirical support to the north-north approach of this paper, where we focus on intra EU15 high-skilled worker related migration. We do so by showing that EU15 immigrants are different from non-EU15 immigrants and more similar to natives in terms of employment across occupations, in particular in top paid occupations where the highest fractions of both EU15 foreigners and natives work.[10]

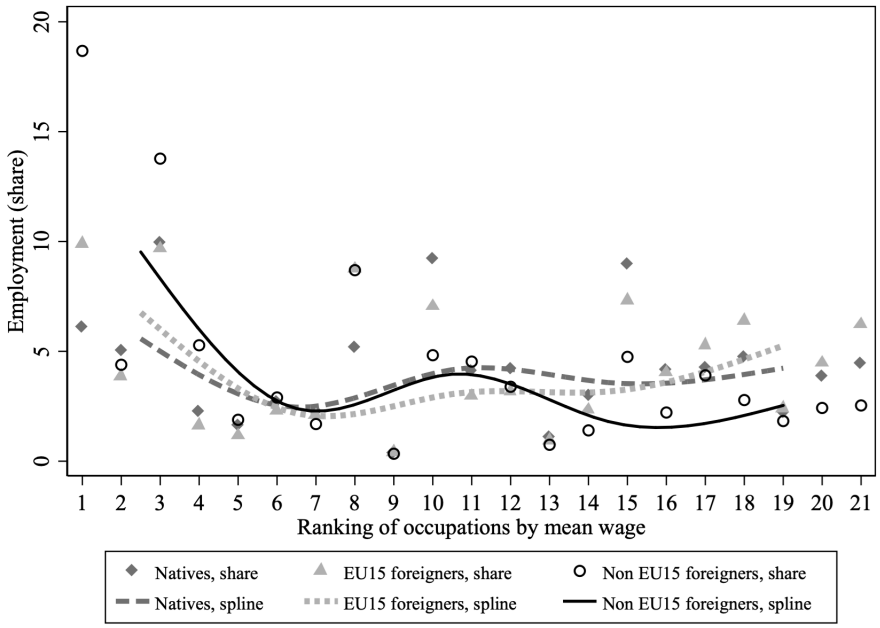
Figure 1 depicts the distribution of employment across occupations and its evolution in time, ordered by their wage ranking, for natives and foreigners. This wage ranking denotes the position of each occupation when occupations are ranked in ascending order according to their mean wage across countries and years, following wage information in Goos et al. (2014).[11] We also use their grouping according to which the eight highest paid occupations are considered *high-paying* and the lowest four as *low-paying*. Regarding the first group, it is worth mentioning that they are also the ones we classified as high-educated occupations.

[10]The fractions of EU15-foreign workers and natives employed in high-paying occupations are 42% and 40%, respectively, whereas that of non-EU15-foreign workers is 23%, see Table 7 in the appendix.

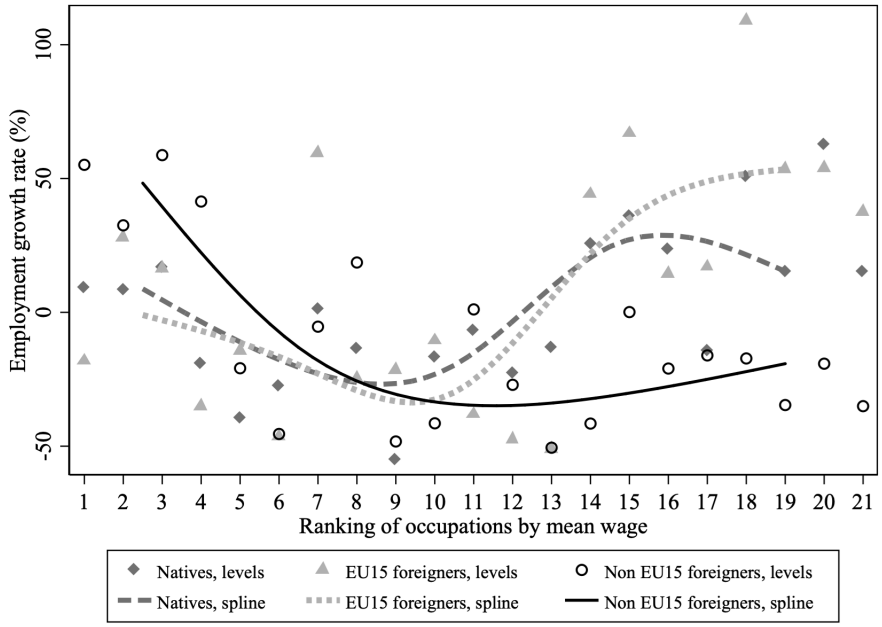
[11]Goos et al. (2014) use wages from the European Community Household Panel and European Union Statistics on Income and Living Conditions.

Figure 1: Employment distribution: Shares (2010) and growth rate (1996-2010)

(a) Employment by migrant status (2010)



(b) Growth rate of employment (1996-2010)



Notes: The ranking of occupations denotes the order of each occupation in the list as determined by their mean wage across 10 European countries and across all years, following wage information in Goos et al. (2014). We restrict the number of countries and occupations (21) to match their wage ranking. Panel (a) plots employment shares by migration category (native-born, born in a EU15 country different to the one of current residency, and born outside the EU15), pooled across countries and their median spline. Panel (b) plots the growth rate of these employment shares from 1996-2010 and its median spline. We obtain these splines by dividing the x-axis in 5 equally spaced intervals, where we calculate the median value of y and then plotting a cubic spline connecting these median values. For more detailed information refer to Table 7 in the appendix.

In the figure we observe that: in general the employment distribution of EU15 immigrants and non-EU15 immigrants are different, and that the distribution of EU15 immigrants is more similar to the one of natives, in particular in these top paid, high-educated occupations.[12]

In panel (a) we observe that, for the highest-paid occupations, the share of EU15 immigrants exceeds that of natives. It is precisely in these occupations, where the highest share of high-educated EU15 workers are concentrated, where wages are higher. Panel (b) shows the evolution of these distributions. Notice that this graph is reminiscent of the polarization literature: employment growth is larger in both tails of the wage distribution and negative in the middle, for natives and EU15 immigrants.[13] We emphasize that, in general, both the share and growth rate of EU15 workers in the top paid (high-educated) occupations exceed that of any other group (i.e. natives and non-EU15 foreigners) and that this paper we will concentrate on these occupations.

We now turn to the distribution of employment across education levels for several host countries, finding that EU15 countries of residence have higher aggregated shares of workers in high-educated occupations. Table 1 presents the fraction of workers in HE occupations for three groups of countries: (i) EU15; (ii) countries that are among the top 5 of both senders of emigrants to any EU15 country and receivers of immigrants from any EU15 country; and (iii) countries that are not in the other groups and where a EU15 country is the top 1 destination of its emigrants. For comparison purposes we use the DIOC-E (2001) database that contains information for non-EU countries. Columns of each panel show the fractions of workers in HE occupations out of all workers in each country for: Natives, Natives and workers born in the EU15 (Nat.& FB-EU15), all workers regardless of migration status (Pop.), respectively.

We emphasize that, in the EU15, the fractions of HE and LE workers are more similar across countries than in the other groups of countries, which is consistent with the north-north framework across similar countries. And, that HE shares in the EU15 are higher than those of non-EU top 5 senders and receivers of EU immigrants (countries above the dashed

[12]These results are in line with previous findings. Other authors, like Dustmann and Frattini (2012), have emphasized differences between EU15 immigrants and other foreigners and their similarities with natives.

[13]See for example panel (a) of Figure 1 of Autor and Dorn (2013) and panel (b) of Figure 1 of this paper.

line in panel (ii)) and than those of almost all non-EU countries where an EU15 is the top 1 destination of its emigrants.

Table 1: Educational Profile (2000), share of workers in HE occupations

(i) *EU15*			
Country	Native	Nat.&FB-EU15	Pop.
Austria	37.7	38.1	36.0
Belgium	41.5	40.9	41.5
Germany	41.0	44.5	38.9
Denmark	37.2	37.4	36.9
Spain	30.1	30.2	29.6
Finland	30.1	37.4	37.4
France	37.8	37.6	37.6
Greece	32.4	32.5	30.0
Ireland	37.0	37.9	38.2
Italy	38.9	39.0	38.6
Luxembourg	42.8	40.6	40.4
Netherlands	49.0	50.1	48.2
Portugal	24.8	25.0	25.6
Sweden	43.9	43.8	42.7
United Kingdom	38.1	38.3	38.9
Average EU15	*38.0*	*38.2*	*37.4*

(ii) *Countries that are both top 5 senders & top 5 receivers of EU15*			
Country	Native	Nat.&FB-EU15	Pop.
Brazil	18.5	18.5	18.6
Ecuador	11.3	11.4	11.6
South Africa	23.0	23.5	23.5
Bulgaria	36.6	36.6	36.6
Poland	32.1	32.1	32.2
Romania	23.8	25.0	24.0
Switzerland	48.3	47.1	46.0

(iii) *EU15 being the top 1 destination*			
Country	Native	Nat.&FB-EU15	Pop.
Mauritius	14.8	16.2	14.7
Senegal	8.3	8.3	8.5
Seychelles	23.8	25.4	24.4
Tanzania	5.4	5.4	5.4
Uganda	6.8	7.0	6.9
Australia	42.0	42.3	42.2

Notes: Columns 2-4 of each panel (i, ii, iii) contain employment shares by migrant status, pooled across countries. Source DIOC-E 2001. Pop. stands for total workers, regardless of country of origin.

Occupational Migration Patterns

"Do people migrate to countries where there are more native workers of their occupation or where there are less?" This subsection addresses this question from an empirical perspective. First, we define the occupational distribution of foreign and native workers in country i as:

$$S_N^i = \left(s_{N1}^i, s_{N2}^i, ..., s_{NJ}^i\right), \text{ where } \quad s_{Nj}^i \equiv \frac{\#\text{ native workers in occupation } j \text{ and country } i}{\#\text{ native workers in country } i}$$

$$S_I^i = \left(s_{I1}^i, s_{I2}^i, ..., s_{IJ}^i\right), \text{ where } \quad s_{Ij}^i \equiv \frac{\#\text{ EU15-immigrant workers in occupation } j \text{ and country } i}{\#\text{ EU15-immigrant workers in country } i},$$

respectively, where J is the number of subgroups considered, $J = 26$ for the ISCO 2-digit.

Then, for each occupation j , we extract the shares by country for both native and immigrant workers: $(s_{Nj}^1, ..., s_{Nj}^I)$ and $(s_{Ij}^1, ..., s_{Ij}^I)$. Next, we compute the correlation between the

occupational distribution of native workers and that of EU15 foreign-born workers, regressing S_N^i on S_I^i and a set of year dummies. We interpret this empirical measure as suggestive of how EU15 foreign-born workers allocate themselves across countries based on the given occupational distribution of natives. Table 2 illustrates, as an example, how this shares look like for subgroup 12 (Corporate Managers).[14]

Table 2: Share of Natives and Immigrants by country of residence, Corporate Managers (2010)

Country	Share Natives	Share Foreign EU-15
Austria	3.56	6.02
Belgium	7.40	14.12
Denmark	2.81	4.40
Spain	2.52	3.64
Finland	6.51	4.70
France	5.88	5.95
Greece	1.69	2.00
Ireland	9.08	14.60
Italy	2.09	2.75
Luxembourg	1.51	3.36
Netherlands	5.38	4.72
Portugal	2.07	3.98
Sweden	4.57	3.74
United Kingdom	12.07	11.53

Notes: Column 2 includes the ratio between the number of native-born workers in occupation 12 and the total number of native-born workers. Column 3 includes the ratio between the number of foreign-born workers in occupation 12 and the total number of foreign-born workers.

We obtain a correlation of 0.66, significant at the 1% level. As a comparison, this number is only 0.40 for immigrants from outside the EU15. The result of this analysis suggests that if a country has a relatively large fraction of native population working in a high-educated occupation –recall that each occupation has an education level we can associate to–, managers in the example shown in Table 2, this country will also have a relatively large share of EU15 foreign labor of the same occupation.

To answer the question that we posed at the beginning of the subsection, people working

[14]To gain intuition consider corporate managers, a *high-educated* occupation where countries with the highest fraction of immigrants from the EU15 employed as managers are also those with the highest fraction of natives working as managers. In this case a simple correlation the distributions of natives and immigrant in that occupation alone is high and positive (0.96) pointing towards more EU15 foreigners migrating to countries where there are more natives in that specific occupation. We extend and formalize the analysis regressing 26 occupations and including time controls.

in high-educated occupations do migrate to countries where there are more native workers with those same characteristics. This is an example of what we previously referred to as north-north migration patterns.

Concentration Patterns

"Do countries keep a balanced distribution of workers across occupations or are some groups of workers more concentrated in one country?" To answer this question, we present a measure of concentration of workers.

First, we define the occupational distribution of the total working population in country i as:

$$S^i = \left(s_1^i, s_2^i, ..., s_J^i\right), \text{ where } \quad s_j^i \equiv \frac{\#\text{ all workers in occupation } j \text{ and country } i}{\#\text{ all workers in country } i},$$

i.e. the share of workers of each occupation in country i, regardless of their origin, out of all workers of that country.

We then group occupations in two: High-Educated (HE) and Low-Educated (LE), according to the educational component of the ISCO-88 classification, as explained in the data description. And, express S^i as $S_{HE}^i \bigcup S_{LE}^i$, where S_{HE}^i contains the shares of high-educated occupations corresponding to the 11 subgroups of groups 1-3, and S_{LE}^i those of low-educated occupations corresponding to the 15 subgroups of groups 4-9.

We then calculate average correlations for each education group as follows: First, for each pair of countries in our main sample, i and h, we compute $Corr(S_{HE}^i, S_{HE}^h)$ and $Corr(S_{LE}^i, S_{LE}^h)$, for each year of the sample. Then, for each country i and year we compute the average (across education levels) of each pairwise correlation with the other countries in the sample. Finally, we calculate the average across years.

We want to emphasize the difference with respect to the previous analysis. In this case, the population of analysis is total EU15 working population of a country in each occupation, regardless of their country of birth. Second, these correlations are computed over the occupational distribution, by education group.

We interpret a positive correlation as evidence that the country keeps a balanced structure in that education group and a negative correlation as evidence of concentration. A negative correlation suggests that a country has a lower share of its working population in occupations where other countries have a high share. Or, in other words, that in occupations of that group level (in our case it will be high-educated) a high share of workers (out of all workers of those occupations) are employed in certain countries, while in the other countries that share is low, this is: they are concentrated in the first group of countries.

Table 3 presents the average correlations. We find two main results: First, for low-educated occupations, average correlations are positive and high in general, suggesting countries keep a more balanced structure. Second, high-educated occupations display concentration patterns (using the aforementioned analysis). In this occupation group, the results are more heterogeneous, yet correlations are generally lower and even negative for some cases.[15]

Table 3: Concentration Patterns (1996-2010)

Country	Average Correlation High Educated	Average Correlation Low Educated
Austria	.31	.75
Belgium	.34	.65
Denmark	.49	.76
Spain	.58	.69
Finland	.58	.68
Greece	.15	.39
Ireland	-.15	.79
Italy	.25	.66
Luxembourg	.57	.53
Netherlands	.58	.76
Portugal	.45	.44
Sweden	.57	.67
United Kingdom	-.43	.74

Notes: Average correlations across years and occupations of each HE and LE group.

We will use these two main findings of occupational migration and concentration as inputs in our model. We will have three sectors: one that will exhibit constant returns to scale and employs only low-educated labor, and two that will exhibit increasing returns to scale and employ only high-educated workers.

[15] For information and a country comparison of shares of HE and LE workers in each country see Table 1.

4 The Model

Framework

We consider a static model of education and migration choice. An economy consists of firms and households. There are two countries: 1 and 2. Both countries have identical production technologies and initial size. We normalize initial population size to 1 in each country.

There are three sectors in each country that produce each a different consumption good: one displays constant returns to scale (CRS), and the other ones increasing returns to scale (IRS) at the industry level, i.e. IRS are external to the firm. They produce using Low-Educated and High-Educated labor specific to each industry, respectively.

Households are heterogeneous in ability and mobility. They make consumption, education and migration decisions and they supply labor inelastically. Their education decision determines the education level and sector of their labor supply, and their migration choice determines the country of residence. We introduce differentiated highly educated labor across industries or sectors, that can pay different wages, and individual sector-specific ability, to motivate high-educated occupational choice. In this way, we think of HE labor specific to a sector as a HE occupation and in the model people acquire education to work in one of the different sectors which are to capture the production of workers in different occupations.

We begin with a closed economy with no migration choice. Next, we analyze a two-country open economy model, where we allow for free mobility of goods, labor and degrees (skills).[16]

4.1 Closed Economy

Production and Firms

There are three goods in the economy: X, Y, and Z. Industries X and Y are composed each of a continuum of symmetric firms in the interval $[0, 1]$ using as their only input HE labor specific to that industry, that we think of as occupations. Output of a firm $q \in [0, 1]$ operating

[16] To capture free transferability of academic credits and the mutual recognition of degrees across the EHAE.

in industry X, and that of a firm $r \in [1, 0]$ operating in industry Y is:

$$x_q = A(H_X) \cdot h_{Xq}, \quad \text{where} \quad H_X = \int_0^1 h_{Xq}\, dq, \tag{1}$$

$$y_r = A(H_Y) \cdot h_{Yr}, \quad \text{where} \quad H_Y = \int_0^1 h_{Yr}\, dr, \tag{2}$$

respectively. Where h_{Xq} is the amount of HE labor used by firm q of sector X, h_{Yr}, is the amount of HE labor used by firm r of sector Y, and A is a productivity term with $A' > 0$, $A'' < 0$, that we will further discuss below.

Production goods X and Y exhibit IRS at the country-industry level, but these are external to individual firms. Following Chipman (1970), these external, or parametric, economies of scale are introduced in the production functions through a productivity term (A) that depends on aggregate employment in each industry, but that is treated as a constant, or a parameter, by each firm. According to the former, the more HE workers in each industry –or of each HE occupation in the economy–, the higher the output of each producer. For the latter, each individual firm is atomless and does not internalize its effect on aggregate demand of HE labor in their sector and country (and therefore behaves competitively).

Good Z is produced with LE labor as the only input with the following CRS technology: $Z = B \cdot L_Z$, where $B \geq 1$ and L_Z denotes the amount of LE labor used.

For simplicity and since within a sector firms are identical, we characterize the equilibrium using representative firms in each sector that, given prices, choose outputs and inputs to solve:

$$\max_{\{X, h_X\}} \quad \pi_X = P_X \cdot X - w_X \cdot h_X \tag{3}$$
$$\text{s.t.} \quad X \leq A(H_X) \cdot h_X$$

$$\max_{\{Y, h_Y\}} \quad \pi_Y = P_Y \cdot Y - w_Y \cdot h_Y \tag{4}$$
$$\text{s.t.} \quad Y \leq A(H_Y) \cdot h_Y$$

$$\max_{\{Z, L_Z\}} \quad \pi_Z = P_Z \cdot Z - w_Z \cdot L_Z \tag{5}$$
$$\text{s.t.} \quad Z \leq B \cdot L_Z.$$

Since producers of goods X and Y are individually competitive and good Z technology

exhibits CRS, in equilibrium they make zero profits (denoted by π_X, π_Y, π_Z, respectively).[17]

Households

Households are heterogeneous in sector-specific ability and make consumption and education decisions. For the latter, recall that we consider differentiated HE labor and sector-specific ability to motivate HE occupational choice and think of HE labor specific to an industry as a HE occupation. Households are born low educated and can decide to remain uneducated and earn w_Z working in the CRS sector. Alternatively, they can choose to become highly educated to work in an IRS industry, X or Y, by incurring an individual-specific cost in terms of the disutility of exerting effort,[18] and then earn w_X or w_Y. Regardless of their choice, since they do not derive utility from leisure, they supply labor inelastically. Thus the education/occupation choice consists of deciding among being HE for sector X, HE for sector Y, or LE for sector Z, i.e. $e_j \in \{HE_X, HE_Y, LE_Z\}$.

At the beginning of the period, each household $j \in [0, 1]$ makes a draw that determines her sector-specific education costs $(\theta_{Xj}, \theta_{Yj})$, each being negatively related to her ability in that sector. HE sector-specific ability can be motivated by considering that regardless of being highly educated, workers can be employed in occupations that require different abilities or skills, for instance in occupations with different task content for which they might be more or less able to perform routine or cognitive tasks. For the most able individual of a given HE sector $s \in \{X, Y\}$, education will have zero cost of effort, while for the least able one these cost will be the highest possible $\bar{\theta_s}$. These education costs are uniformly distributed in $\left[0, \bar{\theta_X}\right] \times \left[0, \bar{\theta_Y}\right]$, and they are independent across sectors $(\theta_X \perp\!\!\!\perp \theta_Y)$.

Given ability draw and prices $\left(\theta_{Xj}, \theta_{Yj}, P_X, P_Y, P_Z, w_X, w_Y, w_Z\right)$, each household j chooses an education level and a consumption bundle $\left\{e_j \in \{HE_X, HE_Y, LE_Z\}, c_{Xj}, c_{Yj}, c_{Zj}\right\}$

[17] As pointed out by Chipman (1970) the competitive equilibrium of this framework, where there are differences among degrees of homogeneity across industries –two being IRS and one CRS–, is not Pareto Optimal, and in equilibrium H_X and H_Y are under provided. See appendix.

[18] In general, education costs can be interpreted as effort, negatively related to ability.

to solve:

$$\max_{\{e_j, c_{Xj}, c_{Yj}, c_{Zj}\}} \quad \left(c_{Xj}\right)^{\gamma_X} \left(c_{Yj}\right)^{\gamma_Y} \left(c_{Zj}\right)^{\gamma_Z} - \theta_{ej} \tag{6}$$

$$\begin{aligned}
\text{s.t.} \quad & P_X c_{Xj} + P_Y c_{Yj} + P_Z c_{Zj} \leq W_j + \pi_X + \pi_Y + \pi_Z \\
& W_j = w_{e_j} \\
& c_{Xj} \geq 0, \quad c_{Yj} \geq 0, \quad c_{Zj} \geq 0, \\
\text{where} \quad & \theta_{ej} = \theta_{Xj} \text{ if } e_j = HE_X, \quad \theta_{ej} = \theta_{Yj} \text{ if } e_j = HE_Y, \quad \theta_{ej} = 0 \quad \text{if } e_j = LE_Z, \\
\text{and} \quad & w_{ej} = w_X \text{ if } e_j = HE_X, \quad w_{ej} = w_Y \text{ if } e_j = HE_Y, \quad w_{ej} = w_Z \text{ if } e_j = LE_Z,
\end{aligned}$$

and where households preferences over goods are represented by a Cobb-Douglas utility function u, with $\gamma_k \in [0,1]$ reflecting the valuation of good $k = \{X, Y, Z\}$, and $\sum_k \gamma_k = 1$.

Definition 4.1. ***Autarky Equilibrium:*** *Given the ability distribution $U[0, \bar{\theta_X}] \times U[0, \bar{\theta_Y}]$, a competitive equilibrium for this economy is: (i) education and consumption choices of households: $\left\{\left(e_j, c_{Xj}, c_{Yj}, c_{Zj}\right)\right\}_{j \in [0,1]}$, (ii) production plans of firms: (X, Y, Z, h_X, h_Y, L_Z), (iii) and prices: $(P_X, P_Y, P_Z, w_X, w_Y, w_Z)$, such that:*

1. *Given prices, and ability draw $(\theta_{Xj}, \theta_{Yj})$, $(c_{Xj}, c_{Yj}, c_{Zj}, e_j)$ solves j's problem (6), $\forall j$.*
2. *Given prices, the production plan of representative firm in sector X (X, h_X) solves (3).*
3. *Given prices, the production plan of representative firm in sector Y (Y, h_Y) solves (4).*
4. *Given prices, the production plan of representative firm in sector Z (Z, L_Z) solves (5).*
5. *Labor markets clear:*

$$\begin{aligned}
& h_X = H_X = \int_{\mathcal{HX}} j\, dj, && \textit{where} \quad \mathcal{HX} \equiv \left\{j \in [0,1] \mid e_j = HE_X\right\} \\
& h_Y = H_Y = \int_{\mathcal{HY}} j\, dj, && \textit{where} \quad \mathcal{HY} \equiv \left\{j \in [0,1] \mid e_j = HE_Y\right\} \\
& 1 = H_X + H_Y + L_Z, \quad L_Z = \int_{\mathcal{LZ}} j\, dj, && \textit{where} \quad \mathcal{LZ} \equiv \left\{j \in [0,1] \mid e_j = LE_Z\right\}
\end{aligned}$$

6. *Goods markets clear:*

$$X = \int_{\mathcal{HX}} c_{Xj} dj + \int_{\mathcal{HY}} c_{Xj} dj + \int_{\mathcal{LZ}} c_{Xj} dj$$
$$Y = \int_{\mathcal{HX}} c_{Yj} dj + \int_{\mathcal{HY}} c_{Yj} dj + \int_{\mathcal{LZ}} c_{Yj} dj$$
$$Z = \int_{\mathcal{HX}} c_{Zj} dj + \int_{\mathcal{HY}} c_{Zj} dj + \int_{\mathcal{LZ}} c_{Zj} dj$$

7. *Profits are zero:* $\pi_X = \pi_Y = 0 = \pi_Z = 0$.

Characterization of the Equilibrium and HE Labor Supply

Firms' inverse demands for labor are given by:

$$w_Z = B \cdot P_Z, \qquad w_X = A(H_X) \cdot P_X, \qquad w_Y = A(H_Y) \cdot P_Y, \tag{7}$$

where the first equation holds with equality because of CRS, and the last two do so because firms in the IRS sectors take the productivity term (A) as a constant and therefore behave competitively (making zero profits in equilibrium). Notice that because of these IRS at the industry level $(A' > 0)$, given prices of final goods, wages are strictly increasing in the total amount of HE labor, and this will be the main mechanism of the model that drives the concentration result in the open economy.

Households consumption demand functions are:

$$c_{Xj} = \frac{\gamma_X}{P_X} \cdot W_j, \qquad c_{Yj} = \frac{\gamma_Y}{P_Y} \cdot W_j, \qquad c_{Zj} = \frac{\gamma_Z}{P_Z} \cdot W_j. \tag{8}$$

Given prices, households spend a fraction of their income in each good and therefore, given the ability draw $(\theta_{Xj}, \theta_{Yj})$, they maximize the utility they would derive choosing each sector specific education level. Let $u(w_k)$ denote the indirect utility associated with wage w_k.[19] The

[19] $u(w_k) \equiv u\left(c_{Xj}(w_k), c_{Yj}(w_k), c_{Zj}(w_k)\right) = \left(\frac{\gamma_X}{P_x} w_k\right)^{\gamma_X} \left(\frac{\gamma_Y}{P_Y} w_k\right)^{\gamma_Y} \left(\frac{\gamma_Z}{P_Z} w_k\right)^{\gamma_Z}$

education decision[20] boils down to:

$$e_j = \begin{cases} HE_X & \text{if } u(w_X) - \theta_{Xj} \geq u(w_Z) \ \ \& \ \ u(w_X) - \theta_{Xj} \geq u(w_Y) - \theta_{Yj} \\ HE_Y & \text{if } u(w_Y) - \theta_{Yj} \geq u(w_Z) \ \ \& \ \ u(w_Y) - \theta_{Yj} \geq u(w_X) - \theta_{Xj} \\ LE_Z & \text{otherwise.} \end{cases} \tag{9}$$

Let $\theta_X^* \equiv u(w_X) - u(w_Z)$ and $\theta_Y^* \equiv u(w_Y) - u(w_Z)$. Every household j with $\theta_{Xj} \leq \theta_X^*$ and $\theta_{Xj} \leq \theta_{Yj} + (\theta_X^* - \theta_Y^*)$, $e_j = HE_X$, and every household j with $\theta_{Yj} \leq \theta_Y^*$ and $\theta_{Yj} \leq \theta_{Xj} + (\theta_Y^* - \theta_X^*)$, $e_j = HE_Y$. The education decision is therefore determined by cutoff rules, where the thresholds θ_X^* and θ_Y^* will characterize the sets of educated workers.

Workers will choose to acquire sector-specific education if the indirect utility associated with the wage, net of education cost in that sector is higher than in the other one, and if it is higher than the indirect utility associated with the wage of working in the LE sector.

For intuition, we define the spread between the utility derived from the wage of a worker in a HE sector and a low educated one as the *education premium* in utils. Notice that the thresholds θ_X^* and θ_Y^*, are precisely these education premia. We also define the utility associated with the wage of working in a HE sector minus the education cost in that sector as the *skill premium* in utils.

The first inequality in (9) indicates that the draw of education cost must be lower than or equal to the education premium, while the second inequality gives a relationship between relative ability across sectors and potential earnings in those, for HE_X workers:

$$\theta_{Xj} - \theta_{Yj} \leq u(w_X) - u(w_Y)$$

that we can relate to skill premia.

To complete the characterization and solve for the equilibrium, we substitute consumption demands in the indirect utility functions of (9), to get expressions for the thresholds:

$$\theta_X^* = \frac{\Gamma \cdot (w_X - w_Z)}{{P_X}^{\gamma_X} {P_Y}^{\gamma_Y} {P_Z}^{\gamma_Z}}, \qquad \theta_Y^* = \frac{\Gamma \cdot (w_Y - w_Z)}{{P_X}^{\gamma_X} {P_Y}^{\gamma_Y} {P_Z}^{\gamma_Z}}, \tag{10}$$

where $\Gamma \equiv {\gamma_X}^{\gamma_X} {\gamma_Y}^{\gamma_Y} {\gamma_Z}^{\gamma_Z}$, and $\mathbb{P} \equiv {P_X}^{\gamma_X} {P_Y}^{\gamma_Y} {P_Z}^{\gamma_Z}$ is a price index of this economy.

[20] We can think of this as an individual policies of educational / sectoral choice.

Aggregate supply of workers is:

$$H_X = Pr\left(\theta_{Xj} \leq \theta_X^* \text{ and } \theta_{Yj} \geq \theta_{Xj} - (\theta_X^* - \theta_Y^*)\right) \tag{11}$$

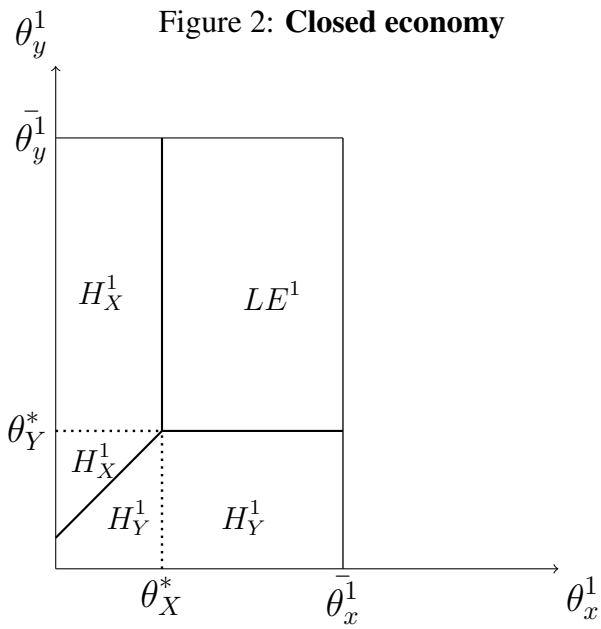
$$H_Y = Pr\left(\theta_{Yj} \leq \theta_Y^* \text{ and } \theta_{Xj} \geq \theta_{Yj} - (\theta_Y^* - \theta_X^*)\right) \tag{12}$$

$$L_Y = Pr\left(\theta_{Xj} \geq \theta_X^* \text{ and } \theta_{Yj} \geq \theta_Y^*\right). \tag{13}$$

Combining (9) with firms' demands for workers (optimal wages), and using the distributions of θ_X and θ_Y we get expressions for (10)-(13)[21] in terms of H_X, H_Y, P_X, P_Y, P_Z, and we combine with market clearing conditions of goods to solve for the equilibrium. Importantly, these system of equations depends on the parameters $\bar{\theta_X}$, $\bar{\theta_Y}$, i.e. the maximum costs of becoming highly educated in each sector. Note that equilibrium solutions depend on the parameter specification, henceforth we characterize equilibria locally in the indicated parametric space (this also applies to the open economy of the following section).

In Figure 2 we provide a graphical depiction of the equilibrium, where $\bar{\theta}_1 = 0.2$ and $\bar{\theta}_2 = 0.3$. Shares of HE labor of each occupation are: $H_X^1 = 0.30$, $H_Y^1 = 0.27$.

Figure 2: **Closed economy**



Notes: The figure shows the equilibrium in the labor market under the following specification: $\bar{\theta}_1 = 0.2$, $\bar{\theta}_2 = 0.3$, $A(H_k) = H_k^{\alpha}$, $\alpha = 0.5$, $\gamma_x = \gamma_y = \gamma_z = 0.33$, $B = 1$, $P_Z \equiv 1$.

[21] For these expressions, see equations 24 - 26 in the appendix.

Table 4, illustrates the equilibrium under different ability supports. The lower the maximum cost of acquiring education, the bigger the share of HE people working in that IRS sector. We emphasize this result, since in the integrated economy countries will differ in the distribution of abilities. Specifically, one country will be better at educating HE workers of one sector –with a lower maximum cost of becoming HE in that sector– and the other one will be better in the other sector. A second result is that to have differences in the distribution of natives in HE occupations one must consider different ability across sectors in the same economy. This is important to have a suitable framework that relates to our empirical finding, i.e: countries with relatively large fraction of natives working in HE occupations tend to attract foreign labor of the same occupation. We will now analyze an integrated economy.

Table 4: Closed Economy, ability supports

$\bar{\theta_X}, \bar{\theta_Y}$	0.2, 0.2	0.8, 0.8	0.2, 0.8	0.2, 0.3
H_X	0.294	0.203	0.311	0.298
H_Y	0.294	0.203	0.208	0.273
L_Z	0.413	0.592	0.481	0.429
θ_X^*	0.072	0.184	0.076	0.074
θ_Y^*	0.072	0.184	0.181	0.096
P_X	2.593	6.460	2.777	2.645
P_Y	2.593	6.460	5.062	3.010
$\frac{w_X}{\mathbb{P}}$	0.744	0.840	0.641	0.723
$\frac{w_Y}{\mathbb{P}}$	0.744	0.840	0.957	0.788
$\frac{w_Z}{\mathbb{P}}$	0.530	0.288	0.414	0.501

Notes: we use the specification $A(H_k) = H_k^{\alpha}$, $\alpha = 0.5$, $\gamma_x = \gamma_y = \gamma_z = 0.33$, $B = 1$, $P_Z \equiv 1$.

4.2 Integrated Economy

We now consider an integrated economy consisting of two countries indexed by i. Countries are identical in production technologies, preferences, and population sizes, but differ in the

distribution of abilities. The world population is normalized to 2 (1 for each country). All goods are tradable and both countries are big.

Households are heterogeneous in mobility and ability. In each country, there is an exogenous fraction $\lambda \in (0,1)$ that is perfectly mobile, and a fraction $(1-\lambda)$ that is perfectly immobile. The assumption of having an exogenous and constant fraction of mobile and immobile households aims to simplify migration costs which we do not model explicitly. Both HE and LE workers of each industry, are perfect substitutes across countries, that is, natives and immigrants are assumed to be equally productive. The ability distribution is now country specific: $U\left[0,\bar{\theta}_X^i\right] \times U\left[0,\bar{\theta}_Y^i\right]$, where $\theta_X^i \perp\!\!\!\perp \theta_Y^i$, $i \in \{1,2\}$, and it is the same across mobile and immobile groups. People get educated in their country of origin and can freely transfer their degree across countries.

Firms' problems in each country remain unchanged. Since goods are perfectly tradable, prices will equalize across countries. This, together with the fact that the CRS sectors are identical, imply that wages of the low educated sector are also equalized across countries ($w_Z^1 = w_Z^2$).

In the open economy, there are immobile and mobile households. Immobile ones face the same problem (6) as in the closed economy. Mobile households, however, now have the additional choice of migrating to the other country and working abroad in the sector they got educated for (at home). A worker j in country i chooses, if immobile, her sector-specific education, and, if mobile, in addition her migration status:

(i) Education: $e_j^i \in \{HE_X, HE_Y, LE_Z\}$, that determines the sector where she will work.

(ii) Migration status: $m_j^i \in \{N, M\}$, where N stands for *Native* and M for *Migrant*. This decision, given (i), determines her country of residence and, therefore, her wage.

Notice that education, working, and migration decisions are simultaneous, we can think of this setup as one in which households have perfect foresight of earnings in both countries.

Given mobility, ability draw, and prices $\left(\lambda, \theta_{Xj}^i, \theta_{Yj}^i, P_X, P_Y, P_Z, w_X^i, w_Y^i, w_Z^i\right)$, each mobile household j from country $i \in \{1,2\}$ chooses an education level, a migration status and

a consumption bundle: $\left\{e_j^i \in \{HE_X, HE_Y, LE_Z\}, m_j^i \in \{N, M\}, c_{Xj}^i, c_{Yj}^i, c_{Zj}^i\right\}$ to solve:

$$\max_{\left\{e_j^i, m_j^i, c_{Xj}^i, c_{Yj}^i, c_{Zj}^i\right\}} \left(c_{Xj}^i\right)^{\gamma_X} \left(c_{Yj}^i\right)^{\gamma_Y} \left(c_{Zj}^i\right)^{\gamma_Z} - \theta_{e_j}^i \tag{14}$$

$$\begin{aligned}
s.t. \quad & P_X c_{Xj}^i + P_Y c_{Yj}^i + P_Z c_{Zj}^i \leq W_j^i + \pi_X^i + \pi_Y^i + \pi_Z^i \\
& W_j = w_{e_j}^i \qquad \text{if } m_j^i = N \\
& W_j = w_{e_j}^{-i} \qquad \text{if } m_j^i = M \\
& c_{Xj}^i \geq 0, \quad c_{Yj}^i \geq 0, \quad c_{Zj}^i \geq 0, \\
\text{where} \quad & \theta_{ej}^i = \theta_{Xj}^i \text{ if } e_j^i = HE_X, \quad \theta_{ej}^i = \theta_{Yj}^i \text{ if } e_j^i = HE_Y, \quad \theta_{ej}^i = 0 \quad \text{if } e_j^i = LE_Z, \\
\text{and} \quad & w_{ej} = w_X \text{ if } e_j^i = HE_X, \quad w_{ej} = w_Y \text{ if } e_j^i = HE_Y, \quad w_{ej} = w_Z \text{ if } e_j^i = LE_Z.
\end{aligned}$$

Without loss of generality, we assume that, in case of indifference, a worker remains in her country of origin. This implies that low-educated individuals will always stay in their home country, i.e. $m_j^i = N$ if $e_j^i = LE_Z$.

Let $\mathcal{HX}_N^i$ and $\mathcal{HY}_N^i$ denote the sets of HE workers born in country i that will work in sectors X and Y, respectively, and choose to stay home, and $\mathcal{HX}_M^i$ and $\mathcal{HY}_M^i$ be the sets of HE workers that will work in those sectors abroad, i.e.:

$$\mathcal{HX}_N^i = \left\{j \in [0,1] \mid e_j^i = HE_X \text{ and } m_j^i = N\right\} \quad \mathcal{HX}_M^i = \left\{j \in [0,1] \mid e_j^i = HE_X \text{ and } m_j^i = M\right\}$$
$$\mathcal{HY}_N^i = \left\{j \in [0,1] \mid e_j^i = HE_Y \text{ and } m_j^i = N\right\} \quad \mathcal{HY}_M^i = \left\{j \in [0,1] \mid e_j^i = HE_Y \text{ and } m_j^i = M\right\}.$$

Definition 4.2. ***Integrated Equilibrium:*** *Given mobility λ and ability distributions $U\left[0, \bar{\theta}_X^i\right] \times U\left[0, \bar{\theta}_Y^i\right]$, $i \in \{1,2\}$, a competitive equilibrium for the two-country economy is:*

- *education, migration, consumption choices of households:* $\left\{e_j^i, m_j^i, c_{Xj}^i, c_{Yj}^i, c_{Zj}^i\right\}_{j\in[0,1], i\in\{1,2\}}$,
- *production plans of firms:* $\left\{X^i, h_X^i, Y^i, h_Y^i, Z^i, L_Z^i\right\}_{i\in\{1,2\}}$, *and*
- *prices:* $\left\{w_X^i, w_Y^i, w_Z^i\right\}_{i\in\{1,2\}}$, P_X^w, P_Y^w, P_Z^w, *such that:*

1. *Given prices, mobility, and ability draw* $(\theta_{Xj}^i, \theta_{Yj}^i)$, $\left\{e_j^i, m_j^i, c_{Xj}^i, c_{Yj}^i, c_{Zj}^i\right\}_{i\in\{1,2\}}$ *solve j's problem (14)* $\forall$ *mobile* $j \in [0, \lambda)$.

2. *Given prices, mobility, and ability draw* $(\theta^i_{Xj}, \theta^i_{Yj})$, $\left\{e^i_j, c^i_{Xj}, c^i_{Yj}, c^i_{Zj}\right\}_{i\in\{1,2\}}$ *solve* j*'s problem (6)* $\forall$ *immobile* $j \in [\lambda, 1]$.

3. *Given prices,* $\left\{X^i, h^i_X\right\}_{i\in\{1,2\}}$ *solve (3).*

4. *Given prices,* $\left\{Y^i, h^i_Y\right\}_{i\in\{1,2\}}$ *solve (4).*

5. *Given prices,* $\left\{Z^i, L^i_Z\right\}_{i\in\{1,2\}}$ *solve (5).*

6. *Labor markets clear (in each* $i = 1, 2$*):*

$$h^i_X = H^i_X = \int_{\mathcal{HX}^i} j dj \qquad H^i_X = H^i_{XN} + H^{-i}_{XM}$$

$$h^i_Y = H^i_Y = \int_{\mathcal{HY}^i} j dj \qquad H^i_Y = H^i_{YN} + H^{-i}_{YM}$$

$$L^i_{ZN} = \int_{\mathcal{LZ}^i} j\, dj, \qquad \textit{where} \quad \mathcal{LZ}^i \equiv \left\{j \in [0,1] \mid e^i_j = LE_Z\right\}$$

$$1 = H^i_{XN} + H^i_{XM} + H^i_{YN} + H^i_{YM} + L^i_{ZN}, \quad L^i_Z = L^i_{ZN} + L^{-i}_{ZM}, \quad \textit{wlog} \quad L^{-i}_{ZM} = 0$$

and where $\mathcal{HX}^i = \mathcal{HX}^i_N \bigcup \mathcal{HX}^i_M$, $\mathcal{HY}^i = \mathcal{HY}^i_N \bigcup \mathcal{HY}^i_M$, *and* $\mathcal{LZ}^i = \mathcal{LZ}^i_N \bigcup \mathcal{LZ}^i_M$.

7. *Goods markets clear:*

$$X^1 + X^2 = \sum_{i=1}^{2} \left[\int_{\mathcal{HX}^i} c^i_{Xj} dj + \int_{\mathcal{HY}^i} c^i_{Xj} dj + \int_{\mathcal{LZ}^i} c^i_{Xj} dj\right]$$

$$Y^1 + Y^2 = \sum_{i=1}^{2} \left[\int_{\mathcal{HX}^i} c^i_{Yj} dj + \int_{\mathcal{HY}^i} c^i_{Yj} dj + \int_{\mathcal{LZ}^i} c^i_{Yj} dj\right]$$

$$Z^1 + Z^2 = \sum_{i=1}^{2} \left[\int_{\mathcal{HX}^i} c^i_{Zj} dj + \int_{\mathcal{HY}^i} c^i_{Zj} dj + \int_{\mathcal{LZ}^i} c^i_{Zj} dj\right].$$

8. *Profits are zero:* $\left\{\pi^i_X = \pi^i_Y = 0 = \pi^i_Z = 0\right\}_{i\in\{1,2\}}$.

Equilibrium Characterization, HE Labor Supply, and Migration

Households consumption demand functions are as in the closed economy:

$$c^i_{Xj} = \frac{\gamma_X}{P_X} \cdot W^i_j, \qquad c^i_{Yj} = \frac{\gamma_Y}{P_Y} \cdot W^i_j, \qquad c^i_{Zj} = \frac{\gamma_Z}{P_Z} \cdot W^i_j. \tag{15}$$

Therefore, since, as in that setup, they spend a fraction of their income in each good, given prices and ability draws they maximize the utility that they would derive choosing each – sector specific– education level and migration status (if mobile).

In the integrated economy, the latter choices, i.e. sector specific-education level and migration status, are jointly determined. For immobile workers, the education decision follows the same rule as in the closed economy (see equation 9): to become HE in a given sector if the utility associated with that wage net of education costs is higher than in the other HE and LE sectors, all in country i.

For mobile workers, the education decision must now incorporate the possibility of higher earnings abroad. A mobile worker j in country i will choose to become HE in a sector if the indirect utility of her wage net of education cost in that sector is higher than that of the other sector, working in either country, and if it is higher than the indirect utility associated with remaining LE in i, i.e:

$$e^i_j = \begin{cases} HE_X \text{ if } \max\left\{u(w^i_X), u(w^{-i}_X)\right\} - \theta^i_{Xj} \geq u(w_Z) \,\&\, \max\left\{u(w^i_X), u(w^{-i}_X)\right\} - \theta^i_{Xj} \geq \max\left\{u(w^i_Y), u(w^{-i}_Y)\right\} - \theta^i_{Yj} \\ HE_Y \text{ if } \max\left\{u(w^i_Y), u(w^{-i}_Y)\right\} - \theta^i_{Yj} \geq u(w_Z) \,\&\, \max\left\{u(w^i_Y), u(w^{-i}_Y)\right\} - \theta^i_{Yj} \geq \max\left\{u(w^i_X), u(w^{-i}_X)\right\} - \theta^i_{Xj} \\ LE_Z \text{ otherwise.} \end{cases} \tag{16}$$

Regarding migration status, a HE worker of sector $s \in \{X, Y\}$ will simply go wherever she gets a higher wage, in utils. This is, $\forall j$ with $e^i_j = HE_s$:

$$\begin{aligned} m^i_j &= N \quad \text{if } u(w^i_s) \geq u(w^{-i}_s), \\ m^i_j &= M \quad \text{otherwise.} \end{aligned} \tag{17}$$

As in the closed economy, education decisions and individual supply of HE labor are

determined by cutoff rules, but now immobile (ι) and mobile (μ) agents have potentially different thresholds:

$$\theta^{i*}_{X\iota} \equiv u\left(w^i_X\right) - u\left(w_Z\right) \qquad \theta^{i*}_{Y\iota} \equiv u\left(w^i_Y\right) - u\left(w_Z\right)$$

$$\theta^{i*}_{X\mu} \equiv \max\left\{u(w^i_X), u(w^{-i}_X)\right\} - u\left(w_Z\right) \qquad \theta^{i*}_{Y\mu} \equiv \max\left\{u(w^i_Y), u(w^{-i}_Y)\right\} - u\left(w_Z\right)$$

For mobile agents, since (i) wages in the LE sector equalize across countries because of trade of LE goods and since (ii) $\max\left\{u(w^i_s), u(w^{-i}_s)\right\}$ is the same for both countries, there is only one education cost threshold for these workers of a given sector s. In equilibrium what determines the aforementioned second factor (ii), is the largest amount of HE labor in each sector across countries, and this is so because trade of goods equalize prices across countries. We can see this in the expression:

$$u(w^i_s) = \frac{\Gamma \cdot w^i_s}{\mathbb{P}} = \frac{\Gamma \cdot P_s \cdot A(H^i_s)}{{P_X}^{\gamma_X} {P_Y}^{\gamma_Y} {P_Z}^{\gamma_Z}} \tag{18}$$

Therefore, migration (trade of factors of production) and trade of goods also equalize marginal costs of education across countries.[22]

Further manipulation of the first inequality of HE_X workers in (16) shows that it can be decomposed in a migration premium and the education premium at home as follows:

$$\theta^i_{Xj} \leq \max\left\{u(w^i_X), u(w^{-i}_X)\right\} - u\left(w_Z\right) = \underbrace{\max\left\{u(w^i_X), u(w^{-i}_X)\right\} - u(w^i_X)}_{\text{Migration Premium}} + \underbrace{u(w^i_X) - u(w_Z)}_{\text{Domestic Education Premium}}$$

If the *migration premium* is positive, mobile HE workers benefit from both premia. They earn higher (real) wages because they are highly educated and on top of that they can have even higher (real) wages abroad if they migrate.[23] Likewise, using the second inequality we can decompose the skill premium of mobile workers in a domestic element and another one arising from possibility of migrating.

[22] Here we use the term marginal cost of education to refer to the cost of the marginal person, this is the person that is indifferent between becoming HE in sector s or not which is related to the thresholds.

[23] Notice that $u(w^i_s) = \frac{\Gamma \cdot w_s}{\mathbb{P}}$, i.e. indirect utilities wages are proportional to real wages.

The migration decision can also be expressed as $m_j^i = M$, if:

(i) $\max\left\{u(w_s^i), u(w_s^{-i})\right\} = u(w_s^{-i})$, (ii) $\theta_{sj}^i \leq u(w_s^{-i}) - u(w_Z)$, and

(iii) $\theta_{sj}^i - u(w_s^{-i}) \leq \theta_{-sj}^i - \max\left\{u(w_{-s}^i), u(w_{-s}^{-i})\right\}$,

where every mobile individual j in i with a low enough education cost in sector s –lower than its education premium, and low in relation to the other sector so that its net cost (in terms of utility i.e. education utility-cost minus the utility associated with the wage) are lower than in the other sector– will choose to be HE and to migrate.[24]

The introduction of a migration choice generates two equilibrium objects in the HE sectors: (i) Aggregate supply of native HE labor H_{NX}^i, H_{NY}^i and (ii) Aggregate supply HE emigrants H_{MX}^i, H_{MY}^i. Using the share of immobile workers $1-\lambda$, the aggregate supply of immobile HE native workers in each sector is:

$$H_{NX,\iota}^i = (1-\lambda)\cdot Pr\left(\theta_{Xj} \leq \theta_{X\iota}^{i*} \text{ and } \theta_{Yj} \geq \theta_{Xj} - (\theta_{X\iota}^{i*} - \theta_{Y\iota}^{*})\right) \tag{19}$$

$$H_{NY,\iota}^i = (1-\lambda)\cdot Pr\left(\theta_{Yj} \leq \theta_{Y\iota}^{i*} \text{ and } \theta_{Xj} \geq \theta_{Yj} - (\theta_{Y\iota}^{i*} - \theta_{X\iota}^{i*})\right). \tag{20}$$

Likewise, using the share of mobile workers λ, aggregate supply of mobile HE natives and emigrants in each sector is:

$$\begin{aligned}
&H_{NX,\mu}^i = \lambda\cdot Pr\left(\theta_{Xj} \leq \theta_{X\mu}^{i*} \text{ and } \theta_{Yj}^i \geq \theta_{Xj}^i - \left(\theta_{X\mu}^{i*} - \theta_{Y\mu}^{i*}\right)\right), \quad H_{MX}^i = 0 \quad \text{if } w_X^i \geq w_X^{-i} \\
&H_{NY,\mu}^i = \lambda\cdot Pr\left(\theta_{Yj} \leq \theta_{Y\mu}^{i*} \text{ and } \theta_{Xj}^i \geq \theta_{Yj}^i - \left(\theta_{Y\mu}^{i*} - \theta_{X\mu}^{i*}\right)\right), \quad H_{MY}^i = 0 \quad \text{if } w_Y^i \geq w_Y^{-i} \\
&H_{NX,\mu}^i = 0, \;\; H_{MX}^i = \lambda\cdot Pr\left(\theta_{Xj} \leq \theta_{X\mu}^{i*} \text{ and } \theta_{Xj}^i \geq \theta_{Yj}^i - \left(\theta_{X\mu}^{i*} - \theta_{Y\mu}^{i*}\right)\right) \quad \text{if } w_X^{-i} \geq w_X^i \\
&H_{NY,\mu}^i = 0, \;\; H_{MY}^i = \lambda\cdot Pr\left(\theta_{Yj} \leq \theta_{Y\mu}^{i*} \text{ and } \theta_{Yj}^i \geq \theta_{Xj}^i - \left(\theta_{Y\mu}^{i*} - \theta_{X\mu}^{i*}\right)\right) \quad \text{if } w_Y^{-i} \geq w_Y^i,
\end{aligned} \tag{21}$$

where:

$$\theta_{X\iota}^{i*} = \frac{\Gamma\cdot\left(w_X^i - w_Z\right)}{{P_X}^{\gamma_X}{P_Y}^{\gamma_Y}{P_Z}^{\gamma_Z}}, \qquad \theta_{Y\iota}^{i*} = \frac{\Gamma\cdot\left(w_Y^i - w_Z\right)}{{P_X}^{\gamma_X}{P_Y}^{\gamma_Y}{P_Z}^{\gamma_Z}}, \tag{22}$$

$$\theta_{X\mu}^{i*} = \frac{\Gamma\cdot\left(w_X^{i*} - w_Z\right)}{{P_X}^{\gamma_X}{P_Y}^{\gamma_Y}{P_Z}^{\gamma_Z}}, \qquad \theta_{Y\mu}^{i*} = \frac{\Gamma\cdot\left(w_Y^{i*} - w_Z\right)}{{P_X}^{\gamma_X}{P_Y}^{\gamma_Y}{P_Z}^{\gamma_Z}}, \tag{23}$$

[24]This result points to the direction of migrants to be positively self selected from the top abilities distribution in the sending country, as treated in the literature that focuses on the determinants of relative earnings of immigrants pioneered Borjas (1987) and subsequent works that followed that line of research like Chiquiar and Hanson (2005), however the analysis and data considered in this paper is insufficient to verify this hypothesis.

$$
\begin{aligned}
H_X^i &= H_{NX}^i - H_{MX}^i + H_{MX}^{-i} & H_X^i &= H_{NY}^i - H_{MY}^i + H_{MY}^{-i} \\
H_{NX}^i &= H_{NX,\mu}^i + H_{NX,\iota}^i & H_{NY}^i &= H_{NY,\mu}^i + H_{NY,\iota}^i \\
w_X^i &= P_X A(H_X^i) & w_Y^i &= P_Y A(H_Y^i) \qquad w_Z^i = P_Z B,
\end{aligned}
$$

$w_Y^{i*} = \max\left\{w_Y^i, w_Y^{i-}\right\}$, $w_X^{i*} = \max\left\{w_X^i, w_X^{i-}\right\}$, and P_X, P_Y, P_Y are such that markets clear.

This completes the characterization of equilibria for the general case. Next, we will illustrate and discuss the results under the assumption of countries differing in the distribution of abilities in a symmetrical way.

5 Results and Discussion

We are interested on the comparison of countries with different distribution of native HE population. In particular we will model two countries, each with a relatively high fraction of native HE workers in a HE occupation to show it will attract HE immigrants of the same occupation, in line with our empirical findings. In our model we generate a heterogeneity on HE native shares by considering different abilities distribution, which in turns translates into different education costs. We will specifically consider that both countries differ in the maximum education cost of a given sector in a symmetrical way.

Assumption 5.1. *The maximum education cost of sector X in country 1 is lower than in country 2, i.e.* $\bar{\theta}_X^1 < \bar{\theta}_X^2$*, the other way around in sector* Y *i.e.* $\bar{\theta}_Y^2 < \bar{\theta}_Y^1$*, and this is symmetric* $\bar{\theta}_X^1 = \bar{\theta}_Y^2$*,* $\bar{\theta}_Y^1 = \bar{\theta}_X^2$*.*

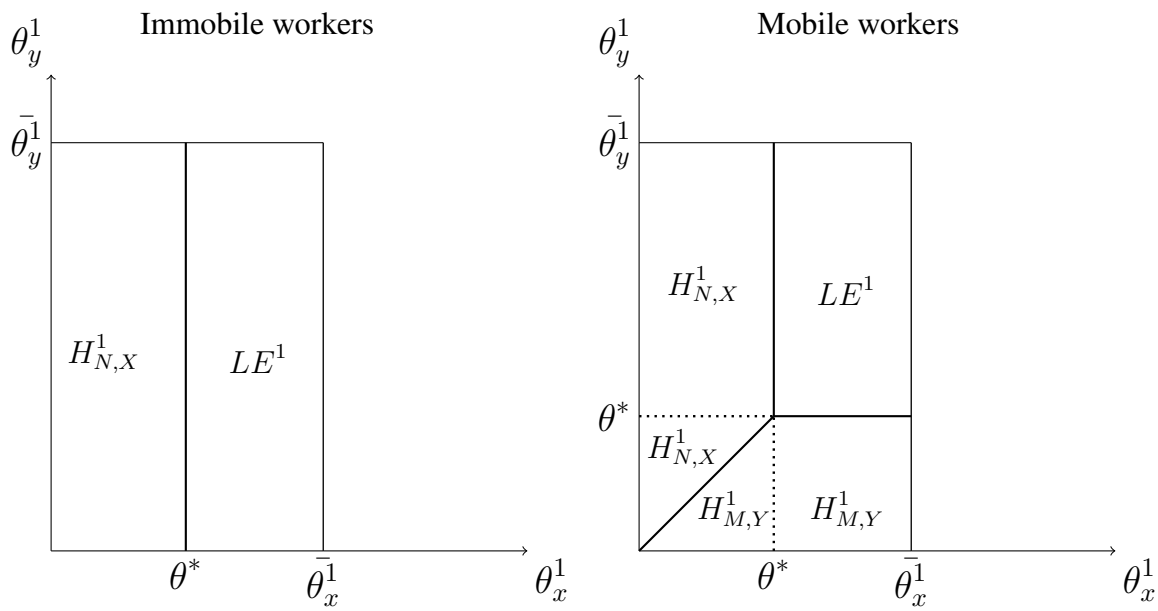
As we showed in the closed economy, lower education costs in a HE sector increase the share of HE workers of that sector in that country, thus in autarky this share is higher in country 1 than in country 2. Since sectors that use HE labor as input exhibit external economies of scale, for this environment with labor mobility, and for the rest of the analysis we focus in the case where foreign HE workers of industry X work in country 1 and those

of industry Y in country 2,[25] i.e. where in an integrated economy HE labor clusters in the countries where natives have a higher ability.

However we acknowledge that in our model, as in other models with external economies of scale, there is a multiplicity of equilibria. For our analysis, this means that, even if in autarky countries 1 and 2 would have a higher labor the HE intensive sectors X and Y, respectively, it is possible that in an integrated economy this HE labor clusters in the opposite countries. Despite the fact that this case is possible, it is not desirable because it induces a lower level of world (total) GDP and welfare (see Table 10 in the appendix).

We now restrict our attention to the full-specialization equilibrium, we conjecture and impose that $u(w_X^{1w}) > u(w_X^{2w})$ and $u(w_Y^{2w}) > u(w_Y^{1w})$.[26] As a result, every mobile household with high education in sector X from country 2 will migrate to country 1, all mobile households from country 1 will stay, while all mobile households with HE in Y of country 1 will migrate to 2, natives will stay. We illustrate this in Figure 3.

Figure 3: **Integrated economy: Country 1**



Notes: The figure shows the equilibrium in the labor market under the following specification $A(H_k)=H_k^{\alpha}$, $\alpha=0.5$, $\gamma_x=\gamma_y=\gamma_z=0.33$, $B=1$, $P_Z\equiv 1$, $\bar{\theta_X}^1=\bar{\theta_Y}^2=0.2$, $\bar{\theta_X}^2=\bar{\theta_Y}^1=0.3$, $\lambda=0.5$

[25] These labor flows would at the same time increase real wages of X in country 1 and of Y in country 2 in the integrated economy reinforcing migration (see equation 18).

[26] After this conjecture we verify with the numerical results, following a guess and verify approach.

Tables 5 and 6 contain numerical results for the equilibrium, both in the integrated economy and in autarky, under different ability supports.[27]

Table 5: Numerical Exercise ($\bar{\theta}_X^1 = 0.2$, $\bar{\theta}_Y^2 = 0.8$), Labor Allocations

	Integrated		**Autarky**	
	Country 1	Country 2	Country 1	Country 2
HE	56.9%	56.9%	51.9%	51.9%
H_X (total)	56.9%		31.1%	20.8%
$H_{NX,\iota}$ (immobile)	26.9%			
$H_{NX,\mu}$ (mobile)	25.1%			
$H_{MX,\mu}$ (immigrants)	4.9%			
H_Y (total)		56.9%	20.8%	31.1%
$H_{NY,\iota}$ (immobile)		26.9%		
$H_{NY,\mu}$ (mobile)		25.1%		
$H_{MY,\mu}$ (immigrants)		5.9%		
LE	43.1%	43.1%	48.1%	48.1%

Notes: we use the specification $A(H_k)=H_k^{\alpha}$, $\alpha=0.5$, $\gamma_x=\gamma_y=\gamma_z=0.33$, $B=1$, $P_Z\equiv 1$, $\lambda=0.5$

This numerical exercise illustrates the main result of our model: that if a country has a relatively large fraction of native population working in a high educated (IRS) sector, this country will also have foreign labor of the same kind. Higher real net-wages in the host country are the determining factor behind this migration pattern. And, real wages are higher because of the IRS feature in that sector, i.e. they are strictly increasing in the amount of HE workers of that sector working in the country (both foreigners and natives).

This result is consistent with north-north migration patterns observed in HE occupations our sample of analysis. The model we propose allows for the possibility of workers migrating to a place where there are more workers with their same characteristics, as opposed to the standard south-north approach where migration flows are due to scarcity: workers migrating to places where there are less workers of their kind.

[27] We consider a mobile fraction λ of 0.5, and the rest of the parameters are the same as in Figure 1 of the closed economy. Numerical results are more stark when the distribution of abilities across sectors is more dissimilar, for this reason we discuss henceforth the case of $\bar{\theta}_X^1 = 0.2$ and $\bar{\theta}_Y^2 = 0.8$. For the figure we provide a more similar distributions for visual purposes.

Table 6: Numerical exercises $\bar{\theta}_X^1 = 0.2$, $\bar{\theta}_Y^2 = 0.8$ and $\bar{\theta}_X^1 = 0.2$, $\bar{\theta}_Y^2 = 0.3$

$\bar{\theta}_X^i, \bar{\theta}_Y^i$	(0.2, 0.8)		(0.8, 0.2)		(0.2, 0.3)		(0.3, 0.2)	
	Integrated		**Autarky**		**Integrated**		**Autarky**	
	OP_1	OP_2	CE_1	CE_2	OP_1	OP_2	CE_1	CE_2
H_X^i	0.569	0	0.311	0.208	0.578	0	0.298	0.273
H_Y^i	0	0.569	0.208	0.311	0	0.578	0.273	0.298
L_Z	0.431		0.481	0.481	0.422		0.429	0.429
θ_X^*	0.108		0.076	0.181	0.099		0.074	0.096
θ_Y^*	0.108		0.181	0.076	0.099		0.096	0.074
P_X	2.006		2.777	5.062	1.918		2.645	3.010
P_Y	2.006		5.062	2.777	1.918		3.010	2.645
$\frac{w_X}{\mathbb{P}}$	0.952	0	0.641	0.957	0.945	0	0.723	0.788
$\frac{w_Y}{\mathbb{P}}$	0	0.952	0.957	0.641	0	0.945	0.788	0.723
$\frac{w_Z}{\mathbb{P}}$	0.629	0.629	0.414	0.414	0.648	0.648	0.501	0.501

Notes: we use the specification $A(H_k)=H_k^{\alpha}$, $\alpha=0.5$, $\gamma_x=\gamma_y=\gamma_z=0.33$, $B=1$, $P_Z\equiv 1$, $\lambda=0.5$

Additionally, we find that in a human capital free mobility area with free mobility of labor and transferability of education, the interaction between migration and education decisions increase the total HE labor stock –in autarky 52% of the population (in each country) is HE, in contrast to 57% in the integrated economy–. Other workers become HE to take advantage of migration premium and spillovers from the IRS sector. This translates into agents willing to incur higher education costs, thresholds in the country with the comparative advantage are higher than in autarky (see Table 6) and this is so since HE real wages increase with the inflow of HE immigrants due to the production externality hence more people become HE.

6 Conclusions

In this paper, we have first provided suggestive evidence that, EU15 countries with a relatively large fraction of native population working in a high-educated occupation, also have a relatively large fraction of foreign EU15 labor of the same occupation. This result is in line with what we have refered to as north-north migration patterns, where workers migrate to countries similar to their source country and where their labor characteristics are relatively abundant. We have also documented that high-educated occupations display concentration patterns in the sense that workers in those occupations tend to cluster in specific countries.

As we have emphasized, the intra EU15 migration phenomenon cannot be studied under the traditional south-north approach. The reason is that this framework assumes that migration is driven by differences between source and host countries in terms of both income and characteristics of their labor force, like the relative abundance of low-educated workers, that are not observed in the EU15. To fill this gap, in this paper we propose a model that allows for labor flows between similar countries, specifically we focus on high-skilled labor flows across high-income countries. Our model successfully generates the EU15 migration patterns we have documented and it is consistent with high-educated occupations clustering in specific countries.

These occupational-migration and concentration patterns of the data are generated in the model through the following agglomeration mechanism: real wages for HE occupations are strictly increasing in the amount of highly educated workers, both foreign and natives, employed. This is achieved via external economies of scale in sectors that are intensive in HE labor. Hence, at the individual level, for the most able individuals it is worthwhile to become highly educated and move to the country where there are more highly educated native workers of their occupation.

To properly analyze selective policies, it is imperative to propose better mechanisms of analysis of migration flows, not only to fill in the aforementioned north-north gap in the literature, but also to shed light on important dimensions that determine labor flows of different

skill levels. In that sense, the empirical findings and the theoretical framework of this paper suggest that it might be important to consider the occupational structure of the natives and immigrants distribution as a possible dimension in the design of selective policies of migration aimed at attracting high-educated labor in the European Union.

Our model can be extended along several dimensions. It is first in our agenda to model migration costs. Another interesting direction is to include more structure in the CRS sector. In particular we could include a sector in the model with CRS or even decreasing returns to scale, and that is attached to the size or structure of the population in each country. This could be interesting since there are differences within the low-educated group in the data. Service Elementary occupations workers behave very differently from, for example, Machine Operators.[28] This could happen because the former group faces a considerably inelastic demand and is directly attached to the population size. In contrast, the latter group could be more exposed to country-specific sectoral shocks. For instance, we could think of the 2000's construction boom in Spain as an exogenous increase in Spain's construction labor productivity, B^i, that can drive a positive correlation between the share of native and immigrants.

Additionally we could allow for migration in the CRS sector, in order to generate more heterogeneity of migration flows. In a multi-country setup, this extensions together with considering different productivity levels across countries could extend the framework to allow for differences in income levels across countries. When analyzing different labor flows we could also incorporate heterogeneous migration costs across countries and allow for ability losses upon migration depending on the institutional framework of each country (for example considering differences in validation of recognition of studies).

[28] Groups 91 and 81 at the 2-digit ISCO-88 level, respectively.

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Appendix

To provide a glimpse of changes in the European job and migration structure, columns 1 to 4 of Table 7 show employment shares of occupations, by migration status. Columns 5 to 8 show their percentage point changes between 1996 and 2010. We consider 3 migration categories: native-born (Native), born in a EU-15 country different to the one of current residency (FB-EU15), and born outside the EU-15 but working in one of our selected countries (FB-Rest). We pool employment for each group and occupation across our 15 European countries.

Table 7: Summary Statistics Occupations

	ISCO code	Employment Share (2010)				$N_{2010} - N_{1996}$			
		Pop	Native	FB-EU15	FB-Rest	Pop	Native	FB-EU15	FB-Rest
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
High-Paying Occupations		38.16	39.74	41.64	23.50	17.58	21.82	46.47	-22.05
Corporate managers	12	4.80	4.98	6.74	2.73	8.79	12.79	36.73	-35.88
Physical, mathematical, and engineering professionals	21	4.14	4.29	4.84	2.61	51.04	59.24	52.93	-20.21
Life science and health professionals	22	2.41	2.46	2.58	1.97	9.08	12.54	52.60	-35.46
Other professionals	24	5.08	5.27	6.94	2.99	40.97	47.52	107.77	-18.27
Managers of small enterprises	13	4.70	4.73	5.71	4.20	-16.10	-16.42	16.19	-17.15
Physical and engineering associate professionals	31	4.41	4.65	4.37	2.38	15.70	20.74	13.68	-22.00
Other associate professionals	34	9.47	10.03	7.93	5.11	28.55	33.09	65.91	-1.17
Life science and health associate professionals	32	3.14	3.34	2.51	1.51	16.30	22.94	43.25	-42.30
Medium-Paying Occupations		33.81	34.20	31.19	31.20	-20.64	-20.05	-27.93	-21.24
Stationary and plant related operators	81	1.14	1.18	1.01	0.80	-19.64	-15.20	-51.45	-51.20
Metal, machinery and related trades workers	72	4.56	4.70	3.44	3.64	-26.08	-24.29	-47.88	-28.01
Drivers and mobile plant operators	83	4.59	4.60	3.20	4.88	-8.66	-9.03	-38.50	-0.18
Office clerks	41	9.71	10.30	7.64	5.19	-21.83	-18.79	-11.15	-42.21
Precision, handicraft, craft printing printing and related trade workers	73	0.38	0.38	0.44	0.36	-55.50	-56.22	-22.14	-48.90
Extraction and building trades workers	71	6.23	5.77	9.50	9.35	-10.77	-15.47	-25.21	17.12
Customer service clerks	42	2.42	2.50	2.25	1.82	-2.49	-1.14	58.57	-6.55
Machine operators and assemblers	82	2.99	2.99	2.47	3.12	-30.62	-29.01	-46.88	-46.14
Other craft and related trades workers	74	1.79	1.78	1.24	2.03	-39.12	-40.69	-14.95	-21.89
Low-Paying Occupations		28.03	26.06	27.17	45.30	12.37	5.92	-3.97	49.79
Laborers in mining, construction, manufacturing and transport	93	2.82	2.52	1.75	5.68	-12.84	-20.89	-35.69	39.61
Personal and protective service workers	51	11.45	11.09	10.50	14.81	18.11	14.10	15.60	56.72
Models, salespersons, and demonstrators	52	5.49	5.62	4.19	4.72	6.53	6.16	27.25	30.83
Sales and services elementary occupations	91	8.27	6.83	10.73	20.09	20.56	6.65	-18.70	53.16

Notes: Occupations are ordered by their mean wage across 10 European countries across all years, following wage information in Goos, Manning and Salomons (2014). Columns 1 to 4 contain employment shares by migrant status, pooled across countries. Columns 5 to 8 contain growth rates of employment shares from 1996-2010. Pop. stands for total workers, regardless of country of origin.

Table 8: ISCO-88 Major Groups and Skill Level

	Major Group	ISCO Education Level
1	Legislators and Managers	4
2	Professionals	4
3	Technicians and Associate professionals	3
4	Clerks	2
5	Service and Sales	2
6	Skilled Agricultural and Fishery	2
7	Craft and Related	2
8	Plant and Machine Operators	2
9	Elementary Occupations	1

Source: International Labour Organization, ILO (1990).

Table 9: ISCO-88 2-digit Subgroups and Educational Classification

ISCO 2 digit	Occupation	Classification
11	Legislators and Senior Officials	HE
12	Corporate Managers	HE
13	General Managers	HE
21	Physical Mathematical & Engineering Science Professionals	HE
22	Life Science and Health Professionals	HE
23	Teaching Professionals	HE
24	Other Professionals	HE
31	Physical and Engineering Science Associate Professionals	HE
32	Life Science and Health Associate Professionals	HE
33	Teaching Associate Professionals	HE
34	Other Associate Professionals	HE
41	Office Clerks	LE
42	Customer Services Clerks	LE
51	Personal and Protective Service Workers	LE
52	Models, Salespersons and Demonstrators	LE
61	Market-Oriented Skilled Agricultural and Fishery Workers	LE
71	Extraction and Building Trade Workers	LE
72	Metal, Machinery and Related Trades Workers	LE
73	Precision Handicraft, Printing & Related Trades Workers	LE
74	Other Craft and Related Trades Workers	LE
81	Stationary-Plant and Related Operators	LE
82	Machine Operators and Assemblers	LE
83	Drivers and Mobile-Plant Operators	LE
91	Sales and Services Elementary Occupations	LE
92	Agricultural, Fishery and Related Labourers	LE
93	Labourers in Mining, Construction, Manufacturing and Transport	LE

Source: ISCO and occupations names according ILO (1990), and educational classification according our criteria.

Planner's Problem (closed economy)

A Benevolent Planner giving equal weight to all agents solves the following problem:

$$\max \int_{\mathcal{HX}} u\left(c_{Xj}, c_{Yj}, c_{Zj}\right) dj + \int_{\mathcal{HY}} u\left(c_{Xj}, c_{Yj}, c_{Zj}\right) dj + \int_{\mathcal{LZ}} u\left(c_{Xj}, c_{Yj}, c_{Zj}\right) dj - \int_{\mathcal{HX}} \theta_{Xj} dj - \int_{\mathcal{HY}} \theta_{Yj} dj$$

$$\begin{aligned}
\text{s.t.} \quad X &= \int_{\mathcal{HX}} c_{Xj} dj + \int_{\mathcal{HY}} c_{Xj} dj + \int_{\mathcal{LZ}} c_{Xj} dj \\
Y &= \int_{\mathcal{HX}} c_{Yj} dj + \int_{\mathcal{HY}} c_{Yj} dj + \int_{\mathcal{LZ}} c_{Yj} dj \\
Z &= \int_{\mathcal{HX}} c_{Zj} dj + \int_{\mathcal{HY}} c_{Zj} dj + \int_{\mathcal{LZ}} c_{Zj} dj \\
X &= {H_X}^{(\alpha+1)}, \quad Y = H_Y^{(\alpha+1)}, \quad Z = B \cdot L_Z, \quad 1 = H_X + H_Y + L_Z \\
H_X &= \int_{\mathcal{HX}} j dj = Pr\left(\theta_{Xj} \leq \theta_X^* \text{ and } \theta_{Yj} \geq \theta_{Xj} - (\theta_X^* - \theta_Y^*)\right) \\
H_Y &= \int_{\mathcal{HY}} j dj = Pr\left(\theta_{Yj} \leq \theta_Y^* \text{ and } \theta_{Xj} \geq \theta_{Yj} - (\theta_Y^* - \theta_X^*)\right) \\
L_Z &= \int_{\mathcal{LZ}} j dj = Pr\left(\theta_{Xj} \geq \theta_X^* \text{ and } \theta_{Yj} \geq \theta_Y^*\right).
\end{aligned}$$

Where $E_\theta \equiv \int_{\mathcal{HX}} \theta_{Xj} dj + \int_{\mathcal{HY}} \theta_{Yj} dj$ is a function of θ_X^* and θ_Y^* which at the same time are functions of H_X, H_Y, L_Z (using the last three equations, see 24 -26 below). The problem of the planner can therefore be reduced to choosing labor allocations to:

$$\max_{\left\{H_X, H_Y, L_Z, \theta_X^*, \theta_Y^*\right\}} \quad u\left(X(H_X), Y(H_Y), Z(L_Z)\right) - E_\theta\left(\theta_X^*(H_X, H_Y, L_Z), \theta_Y^*\left(H_X, H_Y, L_Z\right)\right)$$

Where: $X = {H_X}^{(\alpha+1)}, \quad Y = H_Y^{(\alpha+1)}, \quad Z = B \cdot L_Z, \quad 1 = H_X + H_Y + L_Z$, and

$$H_X = \frac{1}{\bar{\theta_X}\bar{\theta_Y}} \left[\left(\bar{\theta_Y}\theta_X^* - \frac{{\theta_Y^*}^2}{2}\right) \frac{\max\left\{\theta_X^* - \theta_Y^*, 0\right\}}{\theta_X^* - \theta_Y^*} + \left(\bar{\theta_Y}\theta_X^* - \theta_X^*\theta_Y^* + \frac{{\theta_X^*}^2}{2}\right) \frac{\max\left\{\theta_Y^* - \theta_X^*, 0\right\}}{\theta_Y^* - \theta_X^*}\right], \quad (24)$$

$$H_Y = \frac{1}{\bar{\theta_X}\bar{\theta_Y}} \left[\left(\bar{\theta_X}\theta_Y^* - \frac{{\theta_X^*}^2}{2}\right) \frac{\max\left\{\theta_Y^* - \theta_X^*, 0\right\}}{\theta_Y^* - \theta_X^*} + \left(\bar{\theta_X}\theta_Y^* - \theta_X^*\theta_Y^* + \frac{{\theta_Y^*}^2}{2}\right) \frac{\max\left\{\theta_X^* - \theta_Y^*, 0\right\}}{\theta_X^* - \theta_Y^*}\right], \quad (25)$$

$$L_Z = \frac{1}{\bar{\theta_X}\bar{\theta_Y}} \left(\bar{\theta_X}\bar{\theta_Y} - \bar{\theta_Y}\theta_X^* - \bar{\theta_X}\theta_Y^* + \theta_Y^*\theta_X^*\right), \quad (26)$$

$$E(\theta) = \frac{1}{\bar{\theta_X}\bar{\theta_Y}} \left[\frac{\bar{\theta_Y}{\theta_X^*}^2}{2} + \frac{\bar{\theta_X}{\theta_Y^*}^2}{2} + \left(\frac{\theta_2^{*3}}{3} - \theta_X^*{\theta_Y^*}^2\right) \frac{\max\left\{\theta_X^* - \theta_Y^*, 0\right\}}{\theta_X^* - \theta_Y^*} + \left(\frac{\theta_Y^3}{3} - \theta_Y^*{\theta_X^*}^2\right) \frac{\max\left\{\theta_X^* - \theta_Y^*, 0\right\}}{\theta_X^* - \theta_Y^*}\right] \quad (27)$$

16\ For instance with Tx=0.2, Ty=0.3, the allocation: $H_X = 0.35$, $H_Y = 0.35$, $LZ = 0.25$, $\theta_X^* = 0.0955$, $\theta_Y^* = 0.1278$ in the planners problem yields a welfare of 0.1989 that compares to a welfare of the closed economy competitive equilibrium of 0.1927.

Table 10: Numerical Exercise ($\bar{\theta}_X^1 = 0.2$, $\bar{\theta}_Y^2 = 0.8$), *Cases*

	Case 1		**Case 2**	
	Country 1	Country 2	Country 1	Country 2
Labor allocations				
H_X^i (total)	56.9%			51.2%
$H_{NX,\iota}^i$ (immobile)	26.9%			9.82%
$H_{NX,\mu}^i$ (mobile)	25.1%			5.96%
$H_{MX,\mu}^i$ (immigrants)	4.9%			35.42%
H_Y^i (total)		56.9%	51.2%	
$H_{NY,\iota}^i$ (immobile)		26.9%	9.82%	
$H_{NY,\mu}^i$ (mobile)		25.1%	5.96%	
$H_{MY,\mu}^i$ (immigrants)		5.9%	35.42%	
L_Z	43.1%	43.1%	48.8%	48.8%
Thresholds				
θ_X^*	0.108	0.108	0.157	0.157
θ_Y^*	0.108	0.108	0.157	0.157
Prices				
P_X	2.006	2.006	2.663	2.663
P_Y	2.006	2.006	2.663	2.663
$\frac{w_X^i}{\mathbb{P}}$	0.952	0	0	0.992
$\frac{w_Y^i}{\mathbb{P}}$	0	0.952	0.992	0
$\frac{w_Z}{\mathbb{P}}$	0.629	0.629	0.5205	0.5205
Welfare				
W^i	0.255	0.253	0.219	0.222
W^1+W^2	0.508		0.441	
Production				
X^i	0.430	0	0	0.366
Y^i	0	0.430	0.366	0
Z^i	0.431	0.431	0.488	0.488
GDP^w	1.720		1.709	

Notes: Case 1 is the case where labor clusters in the country with higher ability and Case 2 the opposite, GDP^w is world GDP, and W^i is welfare in each country as defined in equation (28).

$$W^i = \int_{\mathcal{HX}_N^i \cup \mathcal{HX}_M^{-i}} u\left(c_{Xj}, c_{Yj}, c_{Zj}\right) dj + \int_{\mathcal{HY}_N^i \cup \mathcal{HY}_M^{-i}} u\left(c_{Xj}, c_{Yj}, c_{Zj}\right) dj + \int_{\mathcal{LZ}^i} u\left(c_{Xj}, c_{Yj}, c_{Zj}\right) dj$$
$$- \int_{\mathcal{HX}_N^i} \theta_{Xj}^i dj - \int_{\mathcal{HX}_M^{-i}} \theta_{Xj}^{-i} dj - \int_{\mathcal{HY}_N^i} \theta_{Yj}^i dj - \int_{\mathcal{HY}_M^{-i}} \theta_{Yj}^{-i} dj \tag{28}$$