AMERICAN UNIVERSITY OF BEIRUT

The Wage Effect of Immigration on European Labor Markets

by
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An Abstract of the Thesis of

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In 2010, the beginning of the Arab Spring brought about instability to the Arab world and with it new waves of immigration towards Europe. This has sparked new debates across the old continent about the effects of immigration on the labor markets of the receiving countries, with the impact of immigration becoming a key concern for European policy makers. Of particular interest is the relationship between migrant and native workers, and the wage effect of immigration

This paper attempts to answer these questions by following a structural approach using data from 26 European countries from 2009 to 2013 in order to estimate the parameters of a transcendental logarithmic production function with three factors of production-Native workers, Migrant workers,and Capital- and therefore determine the Hicks Elasticity of Complementarity and the Elasticity of Factor Price.

I find a complementary relationship between native labor and migrant labor as well as a substitute relationship between migrant labor and capital which seem to contradict textbook models. On the other hand, native labor and capital are found to be complementary.

The calculated Elasticities of Factor Price allow us to quantify the marginal effect of immigration on the wages of the factor of productions. A 1% increase in the amount of migrant workers is expected to increase the wages of native labor by 0.038%, decrease the rental rate of capital by 0.017%, and decrease the wages of migrant labor by 0.46%. The wage effect of immigration on the wages of native labor and capital is very small but the size of the migratory waves might be big enough to make an impact, on the other hand migrant workers stand to lose the most from an influx of migrants.

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Chapter 1

Introduction

In 2010, the beginning of the Arab Spring brought about instability to the Arab world and with it new waves of immigration towards Europe. Indeed, according to the Migration Policy Institute of the United Nations' Department of Economics and Social Affairs[1], migrant arrivals in Germany from 2010 to 2015 totaled 2,272,000 while they were only 741,000 from 2000 to 2010; while in France the change was equal to 588,00 in the 5 year span compared to 918,000 in the 10 year span, the UK also received 1,538,000 in the 5 year span compared to 2,300,000 in the 10 year span. This has sparked new debates about the effects of immigration on the receiving countries. While not all of the questions raised by the arrival of these migrants can be addressed by an economic analysis, indeed some issues are too politically sensitive and relate to geopolitical and cultural concerns, there is still a great deal an economic analysis can help us predict.

One of the central issues in immigration economics is the impact of immigration on the wage structure of the receiving country, is the arrival of migrants going to push down the wages of native workers? Are migrants and natives competing for the same jobs, in other words are they complements or substitutes? Since the 1980s there has been a vast array

[1]Migration Policy Institute tabulation of data from the United Nations, Department of Economic and Social Affairs, Trends in International Migrant Stock: The 2013 revision (2013)

of literature that tries to tackle these questions in the context of the United-States labor markets, with migratory waves such as the "Mariel Boatlift"[2] presenting economists like Card and Borjas among others with the opportunity to study these issues. Card found the Mariel supply shocks had effect on the Miami labor market (Card, 1991), Borjas determined that the arrival of the Marielitos had caused a significant drop in the wages low skill workers in Miami (Borjas, 2015). On the other hand, although there is extensive literature covering the characteristics of immigrants and the causes of migration in Europe[3], there is not much literature about the wage impact of migration and the relationship between migrants workers and natives workers in European labor markets.(Gang and Rivera-Batiz, 1994)

This paper specifically takes on the aforementioned questions, namely the impact of immigration on the wage structure of the European labor markets and the complementarity between immigrants and natives, since these migratory waves offer a good opportunity to gain a better understanding of the impact immigration has on European labor markets and offers further insight into the relationship between migrant and native workers in recent times. I use a structural approach, and data from 26 European countries from 2009 to 2013 retrieved from the the statistical office of the European Union (Eurostat) and from United Nations databases. I estimate the coefficients of a Translog production function with three factors of production, Native Workers, Migrant Workers, and Capital, by setting up a system of equations that regresses the output share of each factor of production on the natural logarithms of the quantity of those factors using Zellner's SUR method. I then use the coefficients to calculate the Hicks Elasticity of Complementarity and the Elasticity of Factor Price in order to determine the relationship between factors of production and the impact of immigration on the wage structure respectively. The

[2]A mass emigration of Cubans who traveled from Cuba's Mariel Harbor to the United States between 15 April and 31 October 1980

[3]see Straubhaar and Zimmermann 1993, Licht and Steiner 1992

Hicks Elasticity of Complementarity points to complementary relationship between migrant workers and native workers, while migrants and capital seem to be weak substitutes, and natives and capital are weak complements. The Elasticity of Factor price suggests that a 1% increase in migrants will lead to a small 0.038% increase in the wage of natives, however it will also lead to a 0.46% decrease in the wage of migrant workers and a 0.017% decrease in the rental rate of capital.

The structure of the paper is as follows. In the next chapter I will go over the existing literature on the subject, I will then give an overview of the data and where it was obtained before giving some statistics on the current migrant stock in Europe. This is followed by a Chapter detailing the microeconomic model used, and the derivation of the elasticities required for the analysis. I will then move on to an overview of the econometric technique employed in the paper, before moving to the chapter dedicated to the findings of this study which is followed by the conclusion and the annex containing the tables and figures.

Chapter 2

Literature Review

Although immigration economics is now a popular topic in labor economics, it was largely untouched prior to 1980s with no empirical studies looking at the effects that immigration had on labor markets. (Borjas, 2014) Indeed a survey of the literature done by Greenwood and McDowell (1986) reports that substantive empirical evidence regarding the effects of immigration is generally scarce. Little direct evidence is available on immigration's impact on the employment opportunities and wages of domestic workers. However, with immigration becoming a growing subject of interest worldwide, immigration became an important branch of labor economics with an increasing number of studies looking to assess the impact of immigration and developing new methods of approaching the question. (Borjas, 2014)

There are two major types of studies, structural and descriptive. The first and oldest type was structural studies, which assume a functional form for the production function and proceed to estimate the parameters of the function. The second type is the descriptive studies which dropped the structural part and regressed the wage of local workers on the number of immigrants in the area, thus obtaining the impact of immigration on the wages. However, descriptive studies did keep one important aspect that was established in structural studies, the assumption that a labor market could be defined in terms of a

particular geographic area. (Borjas, 2014)

As mentioned previously structural studies impose a specific form on the technology of the labor market such as a transcendental logarithmic production function or a CES production function, they then proceed to estimate the parameters of these production functions and in order to predict the wage effect(Borjas, 2014). One of the first structural studies to tackle the problem of the impact of immigration on local labor markets was Grossman in her 1982 paper "The Substitutability of Natives and Immigrants in Production", she assumed that a labor market could be defined using geographic borders. The production function chosen by Grossman in her paper was the Translog production function, the advantages of which are mentioned in the latter parts of this chapter, and the chosen inputs were the number of foreign-born workers, native workers, second generation native workers, and the capital stock in a SMSA. She estimated the parameters of the function using a system of factor share equations and calculated the Hicks elasticity of complementarity and the elasticity of factor price in order to measure the wage impact of immigration; she found a weak negative relationship between native and foreign labor, and deduced that immigration has little impact on the wage structure of the native workforce.(Grossman, 1982) The Grossman paper does have some drawbacks, the scarcity of data at the time meant that the author had to use cross-sectional data from the 1970 U.S. Census of the Population and assume no mobility. Her results might be biased by the fact migrants are more likely to settle in high-wage areas meaning that the endogeneity of supply shocks can induce a spurious positive correlation between immigration and wages. (Borjas, 2015) My paper tackles this problem in two ways, on one hand the use of panel data with country fixed effects should control for the wage differences between the countries, and on the other hand the migratory wave considered in this paper is not due to economic reasons as it is due to geopolitical reasons namely the multitude of uprisings in the Arab World and North-Africa. Moreover similar, to Card's 1990 study of the

Mariel supply shocks, this paper studies the impact of immigration in the years directly following the supply shock, meaning that "we should be measuring the short-run elasticity, an elasticity that is not yet contaminated by labor market adjustments" (Borjas, 2014). Card found no significant effect on the Miami labor market from the Mariel supply shocks, native wages as a whole did not go down and unemployment even for low-skill groups remained unchanged.(Borjas, 2015) The major benefit gained from the structural approach is the ability to effectively measure cross-elasticities between the factors of production, something that is not possible to achieve with a descriptive approach.(Borjas, 2014) Furthermore, structural estimates are less likely to suffer from omitted variable bias than their descriptive counterparts, since they estimate models that are based on microeconomic theory. However, the structural approach does have some drawbacks. First of all, the size of the predicted effect of immigration on the average wage is driven by the functional form we chose for the production function instead of the data.(Borjas, 2014) Second of all, and in the case of the Translog particularly, the number of parameters to estimate tends to be really large and can considerably reduce the degrees of freedom in the model (Krussel et al., 2000). As a result of these drawbacks, the structural approach fell out of favor in the 1990's, but there has been a renewed interest in this approach during the last decade as problems with the descriptive approach, outlined in the next part of this review, have come to light. The new studies using the structural approach are paying close attention to the problem of an enlarged parameter space and are trying to build a closer link between the theoretical models and the actual data. (Borjas,2014)

The descriptive approach, is more direct and parsimonious, it often consists of simple regressions of the wage of natives on the amount of immigrants in a certain locality while including some control variables. The main benefits from using this descriptive approach are clear, they are simple to estimate and the size of the predicted wage effect of immigration they estimate comes entirely from the data and is not influenced by the assumption

of a functional form. However, as Borjas remarks in his 2014 book "Immigration Economics" the descriptive approach has a fundamental flaw, repeating studies using the same data, the measured wage effect of immigration obtained using this method varies a lot, it "depends almost entirely on how the analyst chooses to define the labor market", structural studies avoid this pitfall since the predicted wage effect is driven by the functional form as is mentioned previously. Indeed, Borjas remarks that the cross-section spatial correlations across metropolitan areas vary considerably over time both in terms of sign and magnitude, a problem that arises from the fact that the "geographic sorting of immigrants" in regions is not random and that region fixed effects alone can't account entirely for these differences.(Borjas, 2014) Moreover, as observed by Borjas, Freeman, and Katz in 1996, the size of the wage effect of immigration also depends on how large of a geographic area the labor market is considered to be, with spatial correlations being increasingly negative as the size of the geographical area increases. One proposed solution to the endogeneity problem caused by non-random sorting of immigrants was proposed by Altonji and Card in 1991, they proposed using the lag of the immigrant's share in the labor market as an instrument, arguing that immigrants are likely to settle in similar areas as previous migrants which will lead to those areas having a larger migrant share (Altonji and Card, 1991), making the lag of this variable a suitable instrument since the lagged immigrant's share doesn't affect current wages. However, Borjas argues that there are a multitude of problems that this instrument does not correct, the most prominent ones being that the initial sorting of immigrants was influenced by pre-existing labor market conditions, the presence of "serial correlation in wage and employment opportunities within metropolitan areas", and the fact that the sorting of natives might also have an endogeneity problem. Borjas also points out the fact that labor economist have stricter requirement for the construction of instruments outside of immigration economics, and that no satisfactory reason for the validity of this instrument is given. To summarize, the estimates from spatial correlations do not seem to "be robust to specification changes",

they are unlikely to be able to accurately measure the structural parameter that measures the impact immigration has on the wage structure of the receiving labor market.(Borjas, 2014)

Given the aforementioned benefits and drawbacks of each of these approaches and the limitations of the descriptive approach, this paper will employ a structural approach using a Translog production function as it allows for the estimation of more types substitution than a CES function at the expense of a greater loss of degrees of freedom (Borjas, 2014). The loss of degrees of freedom is not a significant problem in this case as the scarcity of data limits us to just three factors of production.

The results of my paper are in line with those found by Constant in her 2014 paper "Do migrants take the jobs of native workers?" where the author looks to see if migrant workers replacing native workers instead of filling existing vacancies in OECD countries by estimating the correlation between unemployment and immigration rates and by doing a survey of the existing literature. Constant finds that "Immigration's positive effects far outweigh any negative impact" since migrants tend to complement natives by doing the jobs that natives are not willing or able to do, concluding that immigration boosts employment in the long run and eases upward mobility for natives. My results are also similar to those of Ozden and Wagner in their 2014 paper "Immigrant Versus Natives? Displacement and Job Creation", who use instrumental variable estimates to find the elasticity of labor demand and the elasticity of substitution between natives and immigrants. They find that in Malaysia an increase in immigrant labor leads to a small increase in the wages of natives, but they to remark that the effect of immigration is heterogeneous depending on the skill-level of the natives, as was also remarked by Borjas (2014). Another recent structural study by Alberto Behar in 2010 also has similar findings, indeed by estimating elasticities of substitution and factor demand between capital and four labour

types using a Translog Cost Function, the author finds that capital and all types of labor are substitute, but that many occupations are themselves complements most notably unskilled labor is complementary with managerial/professional labor and semi-skilled labor (Behar, 2010). A 1995 survey of the literature by Friedberg and Hunt also suggests that "empirical estimates in a variety of settings and using a variety of approaches have shown that the effect of immigration on the labor market outcomes of natives is small"(Friedberg and Hunt, 1995), while the 1997 National Academy of Sciences report on the economic impact of immigration also suggests that the empirical results suggest that the wage effect of immigration on the wages of natives is small (Smith and Edmonston, 1997), the results of my study are in line with these statements, since I find that a 1% increase in the supply of migrant workers is only expected to increase the wage of native by 0.038%.

Furthermore, in a 2007 paper entitled "Does immigration affect wages? A look at occupation-level evidence", Orrenius and Zavodny look at the effect of higher levels of immigration on the wages of natives. Using occupation as a proxy for skill and controlling for endogeneity by using area-specific time trend or area-year fixed effects and an instrumental variable approach, the authors determine that while higher levels of immigration have a negative impact on the wages of blue collar native workers, there is no evidence of negative wage impact on medium-and high-skilled native workers. They find that immigration can actually lead to an increase in the wage of skilled natives, arguing that this might point to a level complementarity between natives and immigrants in high-skill categories. They also suggest that "Wage effects generally become more negative as skill levels decrease"(Orrenius and Zavodny, 2007). Additionally, in their 1995 paper "Economic effects of immigrants on native and foreign-born workers: Complementarity, substitutability, and other channels of influence", Greenwood and Hunt use data from a 1980 census of Standard Metropolitan Statistical Areas to "estimate a structural model of native/foreign-born labor demand and labor supply that distinguishes the effects on

real wages of each type of labor and on employment of natives" , however their model also takes into account demand and native labor supply channels. They find that while migrant and native workers are substitutes in the production process, the wage effect of immigration on natives is "almost always negligible or slightly positive" when they take into account the other channels. Similarly to the results of my paper, they also find that the largest negative effect of immigration is incurred by the foreign-born population, stating that "foreign-born workers have the greatest negative influence on other foreign-born workers"(Greenwood and Hunt, 1995). Moreover, in the 2011 paper "The Effect of Immigration along the Distribution of Wages" by Dustmann, Frattini, and Preston, the authors estimate wage effect of immigration along the distribution of native wages in the UK. They find that while immigration tends to decrease wages under the 20^{th} percentile of the native wage distribution, it has a positive effect on the wages in the upper parts of the distribution (Dustmann et al., 2011).

Chapter 3

Data Description

The data used in this paper consists of aggregated data for 26 European countries, all of the European Union countries excluding Romania and Bulgaria due to the unavailability of data, spanning the years 2009-2013. It consists of six variables:

1. Migrants' Share of Value Added: It is defined as total compensation of foreign-born employees as a percentage of gross value added.
2. Natives' Share of Value Added: It is defined as total compensation of native employees as a percentage of gross value added.
3. Capital's Share of Value Added: It is defined as total rent paid for capital as a percentage of gross value added. It was obtained by taking one minus labors share of value added.
4. Migrant Worker Stock: The number of migrant workers, obtained from the Eurostat Labor Force Survey.
5. Native Worker Stock: The number of native workers, obtained from the Eurostat Labor Force Survey.
6. Capital Stock: The amount of capital used in production in millions, obtained from the United Nations database of National Accounts Estimates of Main Aggregates.

Compensation of employees was collected from the National accounts domain of Eurostat,the statistical office of the European Union situated in Luxembourg, while gross value added was taken from the United Nations database of National Accounts Estimates of Main Aggregates.[1] The summary statistics of the variables are presented in Table 9.1.

[1]Links to the databases are provided in the references

Chapter 4

Overview of the Migrant Stock

In order to better understand the relationship between migrant and native workers, it is important to look at the socio-economic status of the migrant stock in the host countries as it allows us to compare these migrants to the native on an aggregate scale. Moreover, as Borjas remarks in his 2014 book Immigration Economics "the presence of capital-skill complementarities ensures that the gains from immigration are larger for a high-skill than for a low-skill supply shock", so knowing the relative skill-level of the migrants will also allow us to better predict the impact of the arrival of more migrants with similar backgrounds.

To examine these socio-economics conditions, this paper uses indicators provided by Eurostat for the year 2013 for the 28 European countries as a whole, and 8 other countries with reliable and public data available.

Looking first at the education statistics of migrants and natives presented in Table 9.2, Table 9.3, Figure 9.1, Figure 9.2, and Figure 9.3; aggregating over the European Union (28 countries, aggregated by Eurostat), on average natives seem to be more educated than migrants. Indeed, 35% of migrants have not completed an upper secondary education, the equivalent of finishing high-school, compared to 27% of natives. While 47.8% of natives

have at least completed an upper secondary education up to a post secondary but not tertiary education, the equivalent of finishing high-school and possibly undertaking some sort of technical formation, compared to 36.3% of migrants. The picture is somewhat different when it comes to a tertiary education, the equivalent of having at least a bachelor's degree, where 28% of migrants have completed a tertiary education compared to 25% of natives; this is somewhat a reflection of Europe's ability to attract high-skill immigrants, such as international students looking to pursue a higher education or career in European institutions.

The picture is somewhat less homogeneous when we look at the issue at the country level. For example, comparing countries like the UK, Ireland, and Estonia to France, Belgium, and Greece a clear difference exists; while the migrant stock in the first group seems to be mostly high-skill with over 40% of migrants in those countries have at least a Bachelor's degree compared to around 30% of the native population, the migrants in second group of countries is mostly low-skill with over 40% of the migrants not having completed high-school compared to 26% to 34% of natives. However, the rate of early leavers from education and training among people aged 18 to 24 presented in Figure 9.4 provides a clearer and more homogeneous picture, across the 28 EU countries the rate is 22.4% for migrants compared to 11.1% for natives, and the statistics at country level are all similar with the rate for migrants being considerably higher than for natives except in the UK; this statistic might be explained when looking at the economic conditions of migrants, it might be that some young migrants or second-generation migrants are forgoing their education to join the workforce out of necessity.

In terms of economic conditions, the migrants are indeed worse off than the natives. The mean income of migrants is lower than that of natives in the 28 EU countries, with migrants earning an average of 16599 euros per year while natives earn an average of

18122.9 euros per year. This is also the case for all the countries presented in Figure 9.5, but the disparity is not the same across countries; for example in France the difference is considerable with migrants earning 19471 euros on average compared to the average of 25768 euros that natives make, while in the UK the difference is almost negligible with migrants earning an average of 21979.1 euros compared to 22311.1 euros for natives. The percentage of migrants at risk of poverty is also higher than that of natives, which might explain the aforementioned problem of young migrants leaving their education early. Indeed as is seen in Figure 9.6, across the 28 EU countries 26% of migrants are at risk of poverty compared to 15% of natives, the picture is similar in all of the considered countries where migrants are clearly more at risk than natives. Finally, as we can see from Figure 9.7, in the 28 EU countries the unemployment rates for migrants is 15.8% compared to 10.2% for natives, the unemployment rates for migrants are also higher in all of the considered countries. However, the situation is notably worse in Greece and Spain where unemployment rates for migrants are at 38.1% and 35.7% respectively.

To summarize, while there are some exceptions and Europe is still attracting some high-skill migrants, the overall trend is for migrants to be less educated and poorer than natives across the continent. However, the condition of migrants seems to vary widely based on which country they are in, implying that some specific country effects such as immigration and integration policies are in play.

Chapter 5

The Model

In order to determine the labor market impact of immigration in Europe, this paper will adopt the approach of Jean Baldwin Grossman in her 1982 paper "The Substitutability of Natives and Immigrants in Production". Namely, I will use a structural approach, estimating a Transcendental Logarithmic Production Function and using the obtained coefficients to calculate the Hicks Elasticity of Complementarity in order to determine whether natives and migrants are substitutes in production. From the elasticities of complementarity I will then derive the Elasticity of Factor Price to quantify the impact that an increase in the supply immigrant labor has on the wages of the other factors of production.

5.1 The TransLog Production Function

Consider a production function $Q = F(N, M, K)$ where quantity produced Q depends on three factors, the number of native employees N, the number of migrant employees M, and the capital stock K. Let this production function be the Transcendental Logarithmic Production Function introduced by Christensen, Jorgenson, and Lau (1971); the function

takes the form:

$$ln\ Q = ln\ \beta_0 + \sum_i \beta_i\ ln\ i + \frac{1}{2}\sum_i \sum_j\ \gamma_{ij}\ ln\ i\ ln\ j \tag{5.1}$$

Since demand theory requires symmetry $\gamma_{ij} = \gamma_{ji}$ (Grossman, 1982), where $i,j = N, M, K$. Assuming the producer is maximizing output; he sets $F_i = w_i$ where F_i is the marginal product of factor i and w_i is the wage of factor i. If we differentiate the TransLog function with respect to any factor i we can see that:

$$\frac{dln\ Q}{dln\ i} = \beta_i + \sum_j \gamma_{ij}\ ln\ j \tag{5.2}$$

However, using the fact that $F_i = w_i$ we can also write:

$$\frac{dln\ Q}{dln\ i} = \frac{i}{Q}\frac{dQ}{di} = \frac{i}{Q}F_i = \frac{i}{Q}w_i = S_i \tag{5.3}$$

Where S_i factor i's share of output. Therefore the coefficients of the TransLog production function can be estimated using a system of factor share equations of the form:

$$S_i = \beta_i + \gamma_{ij}\ ln\ j + \gamma_{iz}\ ln\ z + \gamma_{ii}\ ln\ i \tag{5.4}$$

Where $i,j,z = N, M, K.\ i \neq j \neq z$.

The following sections will be dedicated to showing how we obtain the Hicks Elasticity of Complementarity and the Elasticity of Factor Price using the coefficients from the estimated equations. The two elasticities are the central part of this study, as they will allow me to check for a complementary relationship between the factors of production as well as quantify the impact of an increase in migrant workers.

5.2 The Hicks Elasticity of Complementarity

The Hicks Elasticity of Complementarity (HEC) is defined as the proportional change in the relative wage for factor i given a proportional change in factor j's endowment, it is calculated using $C_{ij} = \frac{F_{ij}F}{F_iF_j}$ where F_{ij} is a second derivative and F_j and F_i are first derivatives (Grossman,1982). Hicks defines two inputs to be complements (substitutes) in the production of output if an increase in the quantity of one input increases (decreases) the marginal product of another input (Kim,1997),*i.e* $F_{ij} > 0 (< 0)$. Therefore, if C_{ij} is positive then i and j are complements and if C_{ij} is negative then i and j are substitutes.

5.2.1 Expressing the HEC in terms of the coefficients of the TransLog production function

I will show that the HEC can be expressed in terms of the coefficient, it is usually just stated as fact, so it would be useful to see how this is obtained. We know that the HEC is:

$$C_{ij} = \frac{F_{ij}F}{F_iF_j} \tag{5.5}$$

.

Taking that $F_i = w_i$, $F_j = w_j$, and $F_{ij} = \frac{dF_i}{dj} = \frac{dw_i}{dj}$,we can write that $C_{ij} = \frac{Q}{w_iw_j}\frac{dw_i}{dj}$.
However since $S_i = \frac{i}{Q}w_i$ then:

$$w_i = \frac{QS_i}{i}. \tag{5.6}$$

So we obtain:

$$\frac{dw_i}{dj} = \frac{d\frac{QS_i}{i}}{dj} = \frac{S_i}{i}\frac{dQ}{dj} + \frac{Q}{i}\frac{dS_i}{dj} \tag{5.7}$$

Furthermore, given that:

$$S_i = \beta_i + \gamma_{ij} lnj + \gamma_{iz} lnz + \gamma_{ii} lni \tag{5.8}$$

We can conclude that $\frac{dS_i}{dj} = \frac{\gamma_{ij}}{j}$.

Combining this with the fact that $\frac{dQ}{dj} = F_j = w_j$, we obtain:

$$\begin{aligned} HEC &= \frac{Q}{w_i w_j}(\frac{S_i}{i} w_j + \frac{Q}{i}\frac{\gamma_{ij}}{j}) && (5.9)\\ &= (\frac{Qij}{Q^2 S_i S_j})(\frac{S_i}{i}\frac{QS_j}{j} + \frac{Q}{ij}\gamma_{ij}) && (5.10)\\ &= \frac{\gamma_{ij}}{S_i S_j} + 1 && (5.11)\\ &= \frac{\gamma_{ij} + S_i S_j}{S_i S_j} && (5.12) \end{aligned}$$

Where Equation 5.10 follows from 5.6.

So the HEC can be expressed as the following:

$$C_{ij} = \frac{\gamma_{ij} + S_i S_j}{S_i S_j} \tag{5.13}$$

We can similarly derive an expression for the Own Hicks Elasticity of Complementarity (OHEC), setting $i = j$ in equation 5.5 we get $C_{ii} = \frac{F_{ii} F}{F_i^2}$.

We can write:

$$
\begin{aligned}
OHEC &= \frac{Q}{w_i^2}\frac{dw_i}{di} && (5.14)\\
&= \frac{Q}{w_i^2}\frac{d(\frac{QS_i}{I})}{di} && (5.15)\\
&= \frac{Q}{w_i^2}\frac{(iw_i - Q)S_i + \gamma_{ii}Q}{i^2} && (5.16)
\end{aligned}
$$

Substituting $w_i = \frac{QS_i}{i}$ we obtain:

$$
\begin{aligned}
OHEC &= \frac{Qi^2}{S_i^2Q^2}\frac{(S_iQ - Q)S_i + \gamma_{ii}Q}{i^2} && (5.17)\\
&= \frac{(S_iQ - Q)S_i + \gamma_{ii}Q}{S_i^2Q} && (5.18)\\
&= \frac{\gamma_{ii} + S_i^2 - S_i}{S_i} && (5.19)
\end{aligned}
$$

So in terms of the estimated coefficients, the OHEC can be expressed as the following: $C_{ii} = \frac{\gamma_{ii}+S_i^2-S_i}{S_i}$.

5.3 The Elasticity of Factor Price

The Elasticity of Factor Price is defined as the relative change in the wage of factor i in response to a relative change in the quantity of factor j, it is therefore very useful in measuring the wage impact of immigration since we can observe the change in the wage of any factor with respect to the change in the quantity of migrant workers. Furthermore, it is also easy to estimate using the HEC.

As shown previously we can express the HEC as $C_{ij} = \frac{Q}{w_iw_j}\frac{dw_i}{dj}$.
Multiplying the previous expression by $\frac{jw_j}{Q} = S_j$ yields:

$$
\begin{aligned}
C_{ij}S_j &= \frac{Q}{w_i w_j}\frac{dw_i}{dj}\frac{jw_j}{Q} && (5.20)\\
&= \frac{j}{w_i}\frac{dw_i}{dj} && (5.21)\\
&= \frac{dln\ w_i}{dln\ j} && (5.22)\\
&= \epsilon_{i,j} && (5.23)
\end{aligned}
$$

Therefore,The Elasticity of Factor Price can be expressed as $\epsilon_{i,j} = C_{ij}S_j$.

Chapter 6

Econometric Overview

I estimate the system of three factor share equations using the seemingly unrelated regression method (two-step Feasible Generalized Least Squares) proposed by Arnold Zellner (1962), in order to account for possible cross-equation correlation, and to be able to impose cross-equation symmetry restrictions such as $\gamma_{MN} = \gamma_{NM}$.

As stated in the Data Description and detailed in the Overview of the Migrant Stock parts, the data used is a panel of 26 European countries spanning 5 years (2009-2013) and the conditions of migrants vary widely based on the country, so country specific effect dummies are added to the regressions in order to control for country effects that may bias the results.

The estimated system of equations is the following:

$$S_{M,it} = \beta_M + \gamma_{MN}\ ln\ N_{it} + \gamma_{MM}\ ln\ M_{it} + \gamma_{MK}\ ln\ K_{it} + u_{M,it} \tag{6.1}$$

$$S_{N,it} = \beta_N + \gamma_{NN}\ ln\ N_{it} + \gamma_{MN}\ ln\ M_{it} + \gamma_{NK}\ ln\ K_{it} + u_{N,it} \tag{6.2}$$

$$S_{K,it} = \beta_K + \gamma_{NK}\ ln\ N_{it} + \gamma_{MK}\ ln\ M_{it} + \gamma_{KK}\ ln\ K_{it} + u_{K,it} \tag{6.3}$$

The SUR model consists of N regression equations, where each regression satisfies the assumption of a regular Ordinary Least Squares model:

$$y_i = X_i\beta_i + u_i \; where \; i = 1, 2, 3, ..., N \tag{6.4}$$

Where y_i and u_i are T-vectors such as $y_i = (y_{i1}, y_{i2}, ..., y_{iT})$, X_i is a $T \times K_i$ matrix and β_i is a K_i vector. Let u_{it} be the the tth element of vector u_i. We assume that $(u_{1t}, u_{2t}, ..., u_{Nt})$ is an independent and identically distributed random vector, where $E(u_{it}) = 0$ and $Cov(u_{it}, u_{jt}) = \sigma_{ij}$. (Amemiya, 1985) Taking $y = (y_1^{'}, y_2^{'}, ..., y_N^{'})'$, $\beta = (\beta_1^{'}, \beta_2^{'}, ..., \beta_N^{'})'$, $u = (u_1^{'}, u_2^{'}, ..., u_N^{'})'$, and $\underline{X} = diag(X_1, X_2, ..., X_N)$ we get:

$$y = \underline{X}\beta + u \tag{6.5}$$

The SUR model is a special case of the GLS model, where the variance-covariance matrix of u is:

$$Euu^{'} = \Omega = \Sigma \otimes I_T \; where \; \otimes \; is \; the \; Kronecker \; Product \; and \; \Sigma = \{\sigma_{ij}\} \tag{6.6}$$

To be able to run FGLS, we need a consistent estimate for Σ. This can be obtained by finding consistent estimates for its ith,jth element, which we can find by taking:

$$\widehat{\sigma_{ij}} = T^{-1}\widehat{u_i}^{'}\widehat{u_j} \; where \; \widehat{u_i} = y_i - X_i\widehat{\beta_i} \; are \; the \; OLS \; residuals \; of \; equation \; i \tag{6.7}$$

(Amemiya, 1985)
The FGLS estimator of β is equal to:

$$\widehat{\beta}_{FGLS} = (\underline{X}^{'}\widehat{\Omega}^{-1}\underline{X})^{-1}\underline{X}^{'}\widehat{\Omega}^{-1}y \tag{6.8}$$

In this specific case where the independent variables are the same in all the equations, in other words $X_1 = X_2 = ... = X_N = X$, we can show that $\widehat{\beta}_{FGLS}$ will coincide with $\widehat{\beta}_{OLS}$ using the following properties:

$$1- \quad \underline{X} = diag(X, X, X, ..., X) = I \otimes X. \tag{6.9}$$

$$2- \quad (A \otimes B)(C \otimes D) = AC \otimes BD \; if \; AC \; and \; BD \; are \; defined. \tag{6.10}$$

Consider $\widehat{\beta}_{FGLS}$:

$$\begin{aligned}
\widehat{\beta}_{FGLS} &= [\underline{X}'(\widehat{\Sigma}^{-1} \otimes I)\underline{X}]^{-1}\underline{X}'(\widehat{\Sigma}^{-1} \otimes I)y && (6.11)\\
&= ((I \otimes X')(\widehat{\Sigma}^{-1} \otimes I)(I \otimes X))^{-1}(I \otimes X')(\widehat{\Sigma}^{-1} \otimes I)y && (6.12)\\
&= (\widehat{\Sigma}^{-1} \otimes X'X)^{-1}(\widehat{\Sigma}^{-1} \otimes X')y && (6.13)\\
&= [I \otimes (X'X)^{-1}X']y && (6.14)\\
&= (\underline{X}'\underline{X})^{-1}\underline{X}'y && (6.15)\\
&= \widehat{\beta}_{OLS} && (6.16)
\end{aligned}$$

The only difference between the two estimators being the Variance, since the Variance of the FGLS estimator is still obtained using $Var(\widehat{\beta}_{FGLS}) = [\underline{X}'(\widehat{\Sigma}^{-1} \otimes I)\underline{X}]^{-1}$

Chapter 7

Results

7.1 Examining the Relationship Between the Factors of Production

The estimation results are presented in Table 9.4.

First, it is possible to check for constant returns to scale by testing the hypothesis:

$$H_0 : \sum \beta_i = 1 \; where \; i = N, M, K$$

The P-value obtained for test is 0.7829, therefore we cannot reject that the production function exhibits constant returns to scale.

We can use the formulas developed in the previous parts to obtain the Hicks Elasticity of Complementarity by plugging in γ_{ij} and the mean shares of factor i and j into equation 5.13 (or γ_{ii} and the mean share of factor i in equation 5.19 for the OHEC), the elasticities are presented in Table 9.5.

The values on the diagonal of the table represent the Own Hicks Elasticity of Complementarity; unsurprisingly they are all negative, meaning that each factor is a substitute for itself. However, with an OHEC of -21.78, Migrant Labor seems to be the easiest factor to replace, and we can expect the impact of an increase in immigration to be very detrimental to the wages of migrants currently employed in the European area.

The most interesting finding is the complementary relationship between native and migrant labor, with an HEC of 1.8 that implies that an increase in migrant labor will lead to more productive native labor. In that sense when wages are flexible, we can expect an increase in the wage of native workers following an influx of migrant workers to Europe. However, migrants and capital seem to be weak substitutes for each other as is indicated by the HEC of -0.816. On the other hand, natives and capital seem to be weak complements with a HEC of .611. This is reasonable because native labor is relatively high-skill, and capital tends to be complementary with high-skill labor since a key feature is that growth in the capital stock increases the marginal product of skilled labor (Krussel et al., 2000).

I will argue that these findings are consistent with the differences in the socioeconomic and educational characteristics between migrants and natives found in the data, as the findings of Alberto Behar also suggest that unskilled labor is complementary with managerial/professional labor and semi-skill labor, while it is a substitute with capital and skilled artisanal labor(Behar, 2010). Namely, migrant workers in Europe are on average less educated and poorer than natives, with about 35.8% of migrants aged 15 to 64 in 2013 having not completed a secondary education compared to 26.9% of the native population aged 15 to 64.

The percentage of natives having completed an upper secondary and post-secondary

non-tertiary education in 2013 is also higher across the twenty-eight EU countries. When it comes to tertiary education the aggregate picture is not as clear, with 28% of migrants having completed a tertiary education compared to 25% of natives in the twenty-eight EU countries; as stated before a lot of discrepancies are apparent between countries in this category of education, with some countries having a higher percentage of completion among natives and other having a higher percentage among migrants. These statistics imply that while on average migrant workers tend to be low-skill labor, Europe is still attracting a good amount of educated migrants. This can explain the complementary relationship between native and foreign labor in the sense that migrant workers are not competing with natives for employment opportunities as much as they are competing with migrants that are already present in the labor market, in other words migrant workers tend to work in low-skill/low-pay jobs such as manual labor while natives gravitate towards jobs with higher skill caps, which can explain foreign labors substitutability with capital.

However, I also expect migrant labor to be substitutable with low-skill native labor, and the use of more detailed data containing the skill-levels of each group in further studies would be a good opportunity to study that. Indeed, a similar case is the re-examination of the Mariel Supply Shock by Borjas in his 2015 paper "The Wage Impact of the Marielitos: A Reappraisal", where the author found that previous results showing that this shock had no impact on the Miami labor market were erroneous since they did not look at the low-skill group that was the most likely to be affected by the arrival of low-skill labor. The author found that the arrival of the Marielitos had caused a significant drop in the wages of high-school dropouts in Miami.

7.2 Quantifying the Impact of an Increase in Foreign Labor

In order to better understand the impact that a migratory wave might have on the European labor market, we need to be able to approximate the impact immigration will have on the wage structure. One way to estimate that is to use the aforementioned Elasticity of Factor Price (Grossman,1982), indeed it allows us to see the change in the wage of a certain group i given a change in the quantity of workers in group j.

I will examine the change in the wage of all three of the considered factors of production given a change in the quantity of migrant workers assuming all wages are flexible, the resulting elasticities are presented in Table 9.6.

Looking first at $\epsilon_{n,m}$, the percentage change in the wage of natives given a one percent increase in the quantity of migrant workers, it takes the value of .03830993, meaning that a 1% increase in the supply of immigrants lead to a 0.038% increase in the wages of native workers. While this increase is not very large, we must consider two things; first it goes against the traditional view that immigration tends to decrease the wage rate by increasing the supply of Labor (Borjas,2014), and second we must consider the large number of immigrants arriving in Europe, for example Germany's net migration was only 31,640 from 2002 to 2007 but it increased to 1,249,998 for the period 2007-2012 according to the World Bank World Development Indicators(2016).

With respect to the rental rate of Capital, the Elasticity of Factor Price $\epsilon_{k,m}$ is equal to -.0173505, meaning that a 1% increase in the supply of immigrants lead to a 0.017% decrease in the rental rate of capital. While again this number is not very large, it does go against the theoretical suggestion that since immigration increases the number of workers

it makes capital more valuable thus increasing its rental rate. This result, coupled with the sign of C_{km}, seem to suggest that immigrants are substituting capital thus making native "High Skill" workers more valuable.

Finally, the own Elasticity of Factor Price for migrant workers is -.46304015, meaning that a 1% increase in the supply of immigrants lead to a 0.46% decrease in the wage of immigrant workers. Unsurprisingly, this results points to the fact that migrant workers are substitutable with other migrant workers, an increase in their number would render migrant workers less scarce and lead to decrease in their wage rate (Borjas,2014).

If we compare these results to the ones Grossman obtained in her 1982 paper "The Substitutability of Natives and Immigrants in Production", we can see how migration has changed over the years. Indeed, the Elasticities of Factor Price that Grossman finds for natives, capital, and migrants' wages with respect to a change in the quantity of migrant workers are the following: $-0.10, 0.42, -0.23$ respectively.
As we can see in this case migrants and natives are indeed substitutes, a 1% increase in the quantity of migrant workers will lead to a 0.10% decrease in the wages of natives, and migrants are complements with capital, a 1% increase in the quantity of migrant workers will lead to a 0.42% increase in the rental rate of capital. Other papers also looking into the substitutability of immigrant and natives during the same time period as Grossman, such as Anderson (1977),Grant (1979), and Welch (1970) found a similar relationship.
Moreover, the profile of the migrant stock in the US in 1970 is very different from the current one in Europe, indeed Grossman reports from the 1970 U.S. Census of the Population that 44% of Foreign Born individuals had a White Collar job compared to 45% for natives with native parents and 53.9% for second-generation natives. This stock of migrant clearly belonged to a higher "skill bracket" than the current stock of migrants in Europe, in that they are directly competing with native labor for jobs compared to the

current stock who tend to complement the native stock.

Chapter 8

Conclusion

Using aggregated data for 26 European countries from 2009 to 2013, this paper set out to study the relationship between migrant workers and other factors of production in Europe, as well as try to predict the impact the arrival of more migrants will have on the wage structure.The estimates obtained from a Translog production function were used to determine the Hicks Elasticity of Complementarity and the Elasticity of Factor Price for the three factors of production, Native Workers, Migrant Workers, and Capital. The obtained elasticities indicate a complementary relationship between native labor and migrant labor, and the predicted wage effect of the arrival of more migrants is a small increase in the wages of native workers, a small decrease in the rental rate of capital, and a decrease in the wage of migrants. This main finding goes against textbook model prediction that an influx of migrants leads to decrease the wage rate by increasing the supply of Labor; the migrants in the European market don't seem to be competing for the same positions as natives, this might be explained by the fact that on aggregate the current migrant stock seems to be less skilled and poorer than the natives.

The skill-level difference between immigrants and natives can also explain each of their relationships with capital, with natives and capital being complements while migrants and capital are substitutes. The capital-skill complementarity hypothesis holds in this frame-

work, the demand for "high-skill" natives increases as capital per worker increases while the demand for "low-skill" migrant workers decreases as capital per worker increases.

The findings of this paper also show that the current migrant stock in Europe will be the factor that is the most affected by the arrival of further migrants. Indeed, with an Own Hicks Elasticity of Complementarity equal to -21.78 migrant workers are easily substitutable among each other and the arrival of more migrants will increase the supply of available foreign workers and make them less valuable relative to the other factors of production. This is further evidenced by the Elasticity of Factor Price showing that a 1% increase in migrant workers leads to a 0.46% decrease in their wage.

Finally, I expect further studies with the use of microdata to provide more information on the subject. Dividing native and migrant workers into skill-groups will allow for a more comprehensive understanding of the impact immigration will have on the wage structure of the receiving country, particularly I expect "low-skill" native workers to be as vulnerable to the arrival of more foreign labor as the present migrant stock is. The ability to quantify such an impact will be of a particular interest to policy makers given the recession some European countries are facing and ever-increasing supply of migrants.

Chapter 9

Appendix

9.1 Tables

Table 9.1: Summary Statistics

Variable	Mean	Standard Deviation	Observations	Min	Max
Migrant Share	.0212562	.0249813	126	7.00e-06	.114118
Native Share	.4817187	.0949852	126	.124373	.638108
Capital Share	.4970251	.0971429	126	.359736	.875269
Migrant Stock	574125.4	922200.2	126	3800	3549000
Native Stock	7251152	9419463	126	111000	3.54e+07
Capital Used	85925.72	124827.4	126	870.1006	502000

Table 9.2: Levels of Education of Migrants

	Levels of Education of Migrants		
	Up to Lower Secondary	Up to Post-Secondary	Tertiary Education
EU 28 countries	36%	36%	28%
Belgium	41%	30%	29%
Estonia	7%	52%	41%
Ireland	22%	31%	47%
Greece	45%	41%	14%
Spain	46%	31%	23%
France	42%	31%	27%
Italy	47%	42%	11%
United Kingdom	19%	35%	46%

Source: Eurostat.

Table 9.3: Levels of Education of Natives

Levels of Education of Natives			
	Up to Lower Secondary	Up to Post-Secondary	Tertiary Education
EU 28 countries	27%	48%	25%
Belgium	28%	40%	32%
Estonia	17%	52%	31%
Ireland	29%	37%	34%
Greece	34%	41%	25%
Spain	46%	22%	32%
France	26%	45%	29%
Italy	43%	42%	15%
United Kingdom	22%	44%	34%

Source: Eurostat

Table 9.4: Regression Results

	(1) Migrant Share Equation 1		(2) Native Share Equation 2		(3) Capital Share Equation 3	
Ln Native	0.00822*	(2.21)	0.0863***	(5.08)	-0.0931***	(-5.12)
Ln Migrant	0.0110***	(6.67)	0.00822*	(2.21)	-0.0192***	(-4.50)
Ln Capital	-0.0192***	(-4.50)	-0.0931***	(-5.12)	0.112***	(5.42)
Country FE						
_cons	0.0264	(1.25)	0.106	(1.10)	0.903***	(10.46)
N	126		126		126	
R^2	0.991		0.990		0.988	

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 9.5: The Hicks Elasticity of Complementarity

Hicks Elasticity of Complementarity			
	Natives	Migrants	Capital
Natives	-.70380477*** (0.000)	1.8022943* (0.027)	.61113793*** (0.000)
Migrants	.	-21.783769*** (0.000)	-.81625606*** (0.000)
Capital	.	.	-.27790438*** (0.000)

P-values of γ_{ij} coefficients in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 9.6: The Elasticity of Factor Price

The Change in wage of	Natives	Migrants	Capital
With Respect to the Quantity of			
Migrants	.03830993	-.46304015	-.0173505

9.2 Figures

The Data displayed in all the figures has been retrieved from Eurostat.

Figure 9.1: Percentage of Population Having Completed up to a Lower Secondary Education

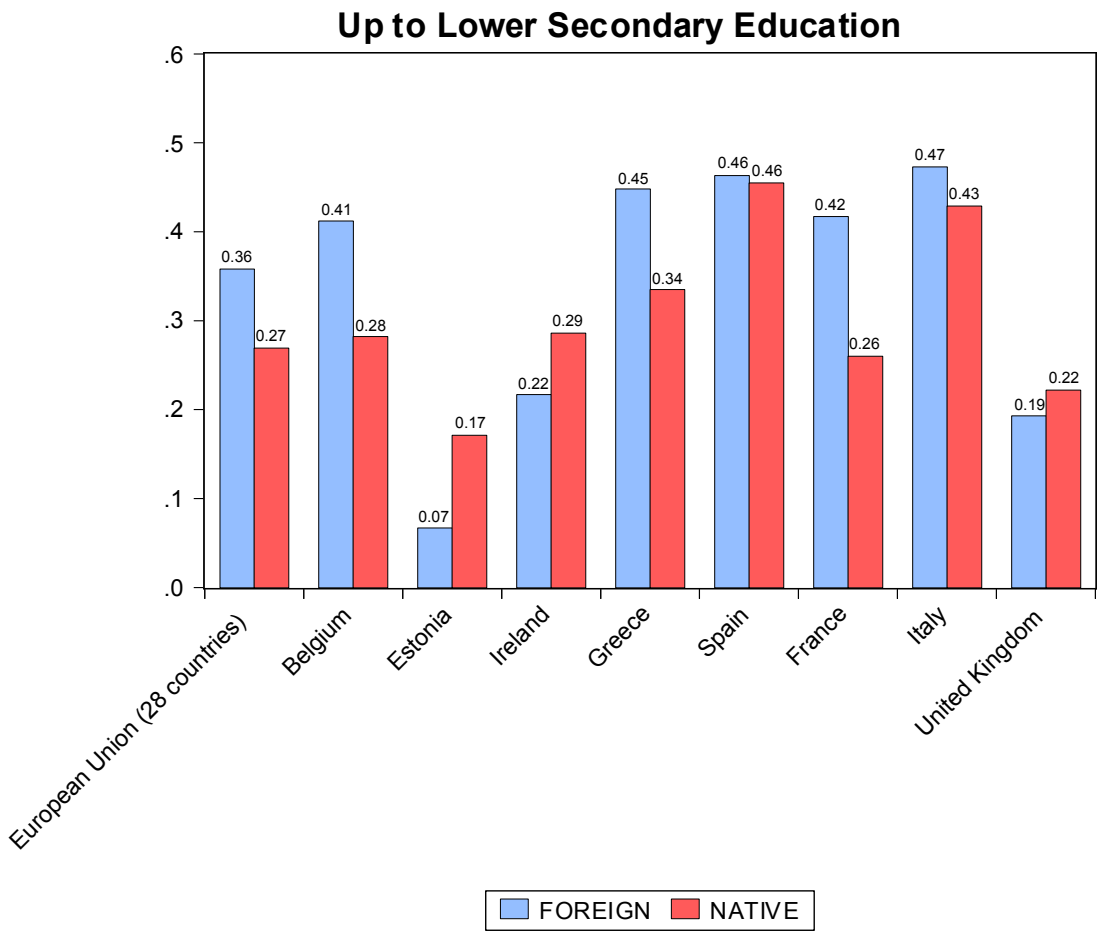


Figure 9.2: Percentage of Population Having Completed an Upper Secondary Education up to a Post Secondary Non Tertiary Education

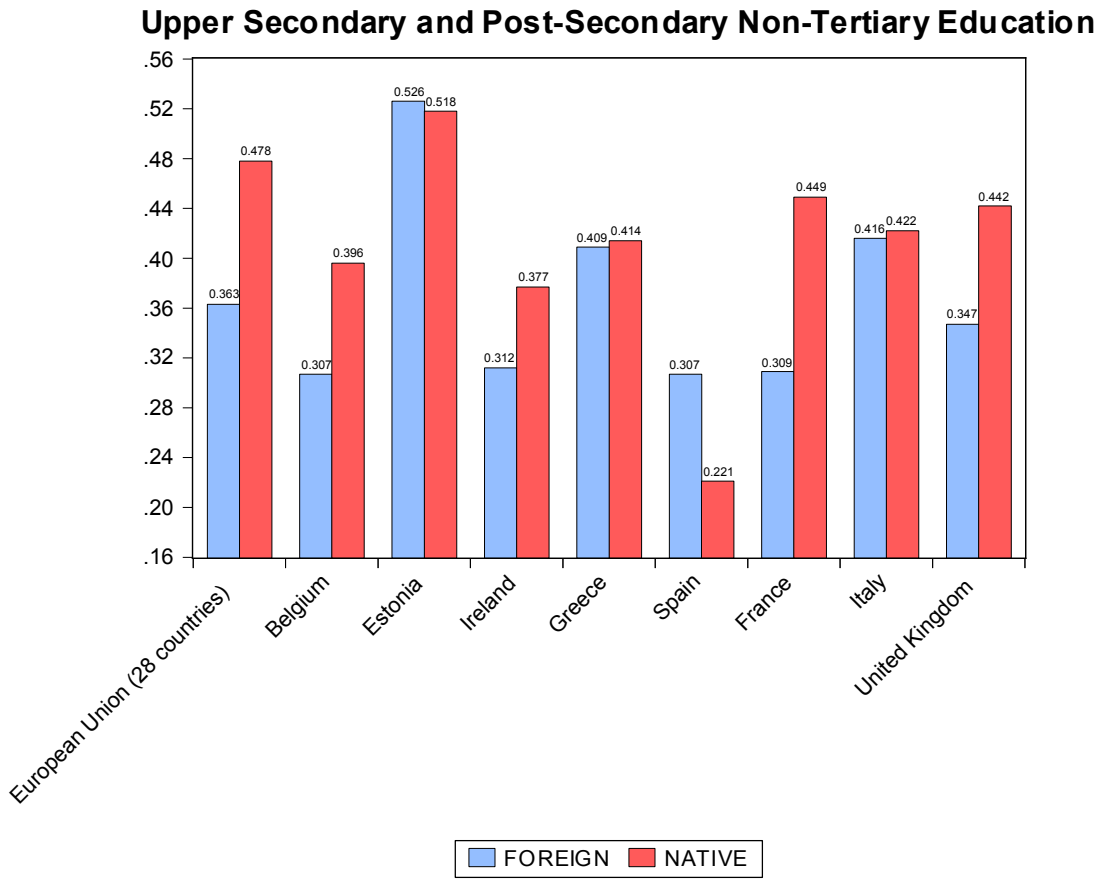


Figure 9.3: Percentage of Population Having completed a Tertiary Education

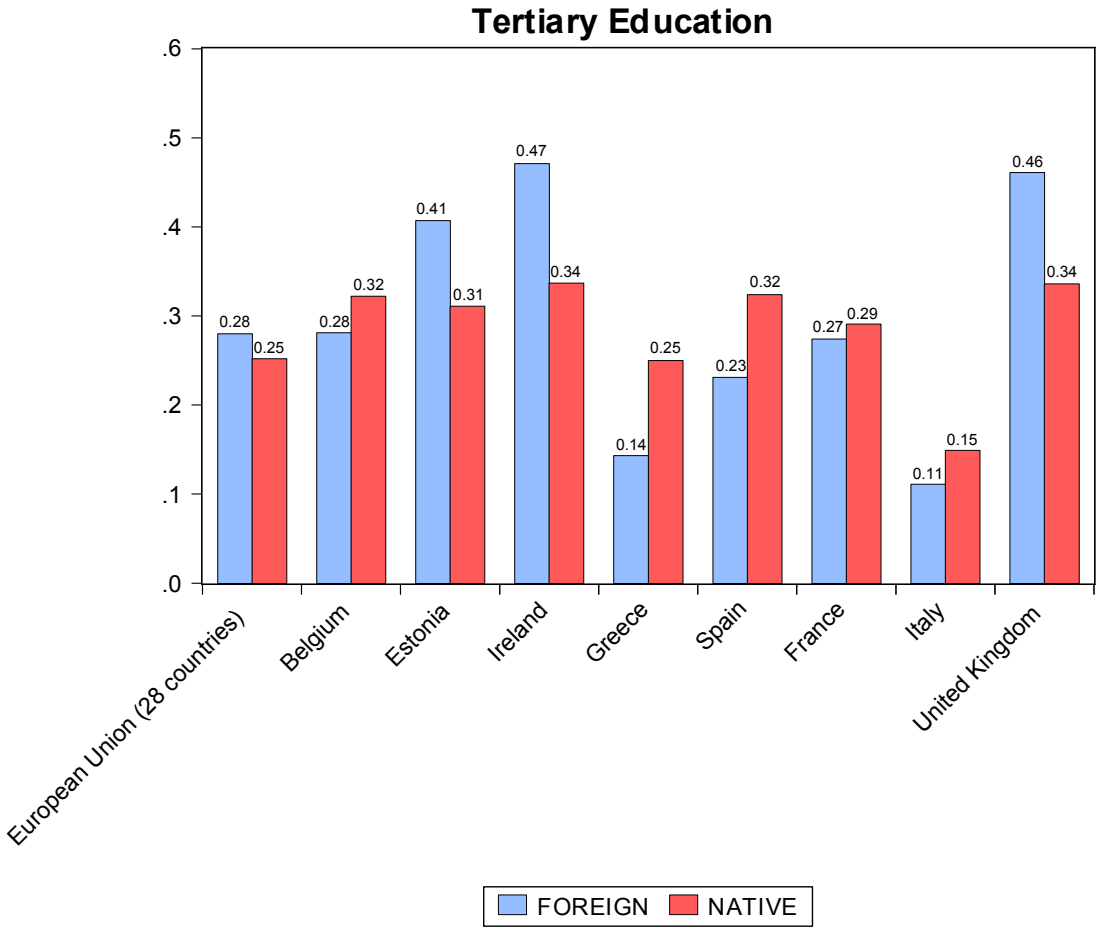


Figure 9.4: The Rate of Early Leavers from Education and Training among People Aged 18 to 24

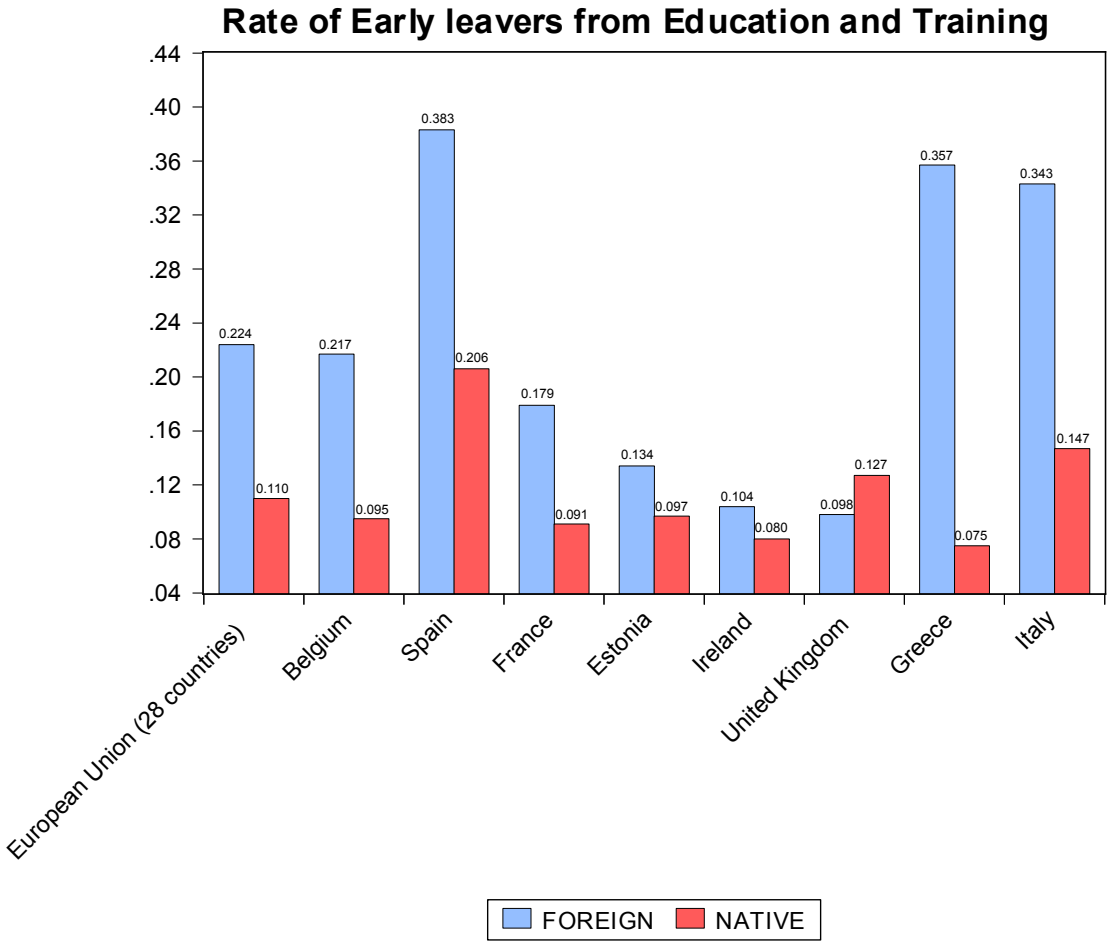


Figure 9.5: Mean Yearly Income

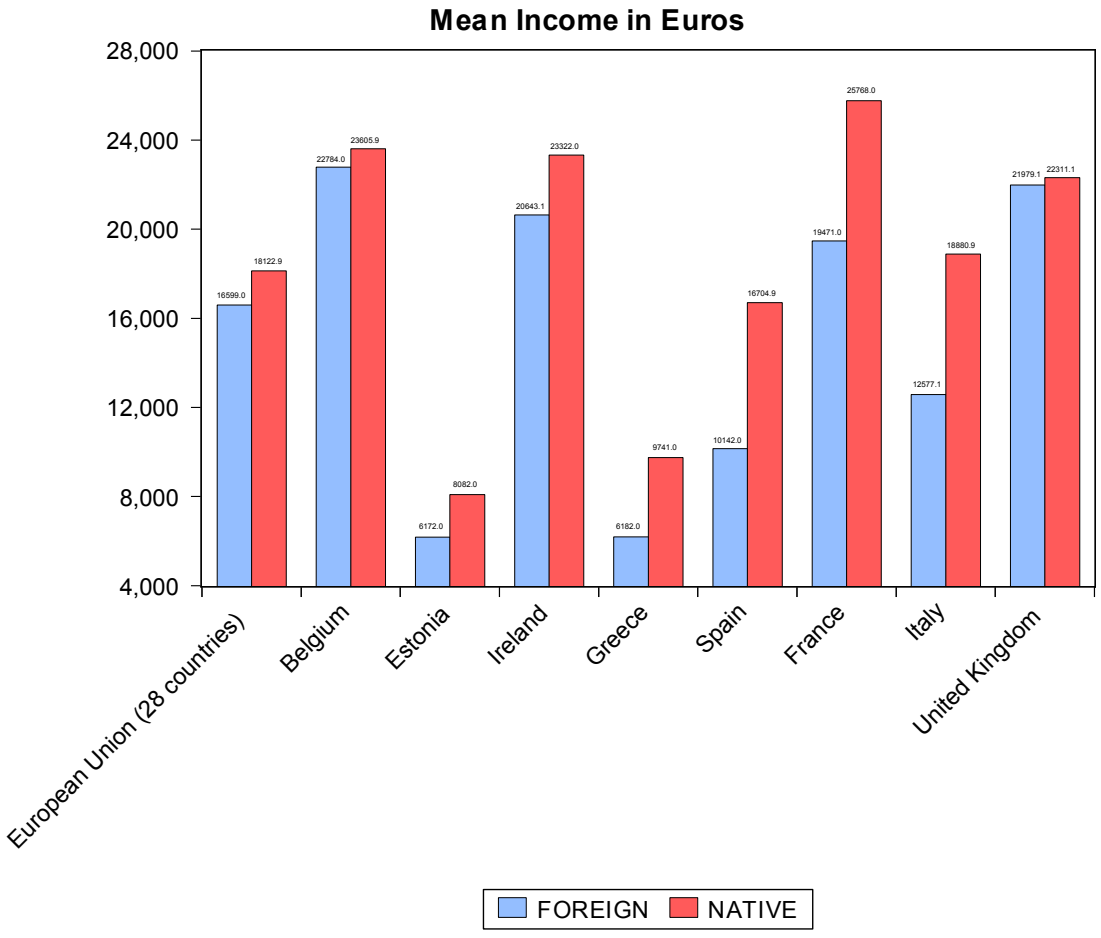


Figure 9.6: Percentage of Population at Risk of Poverty

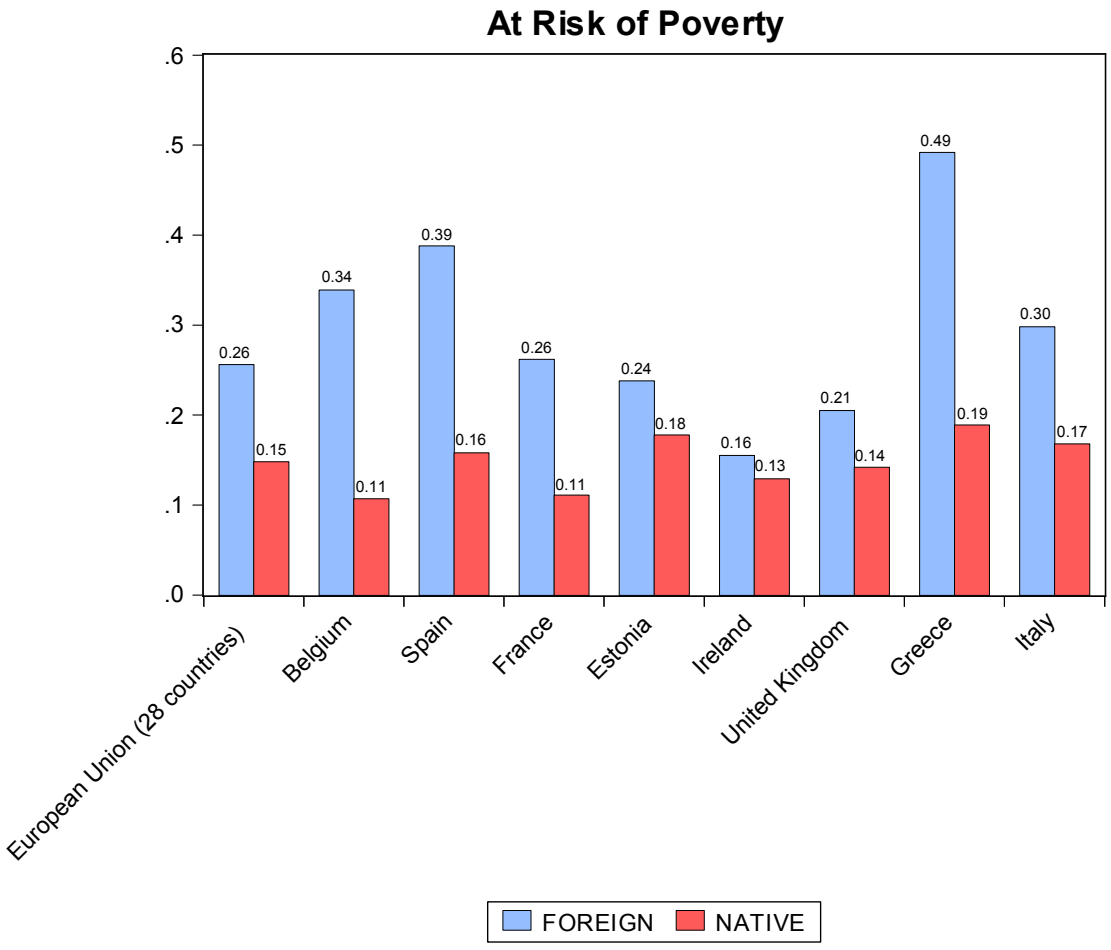
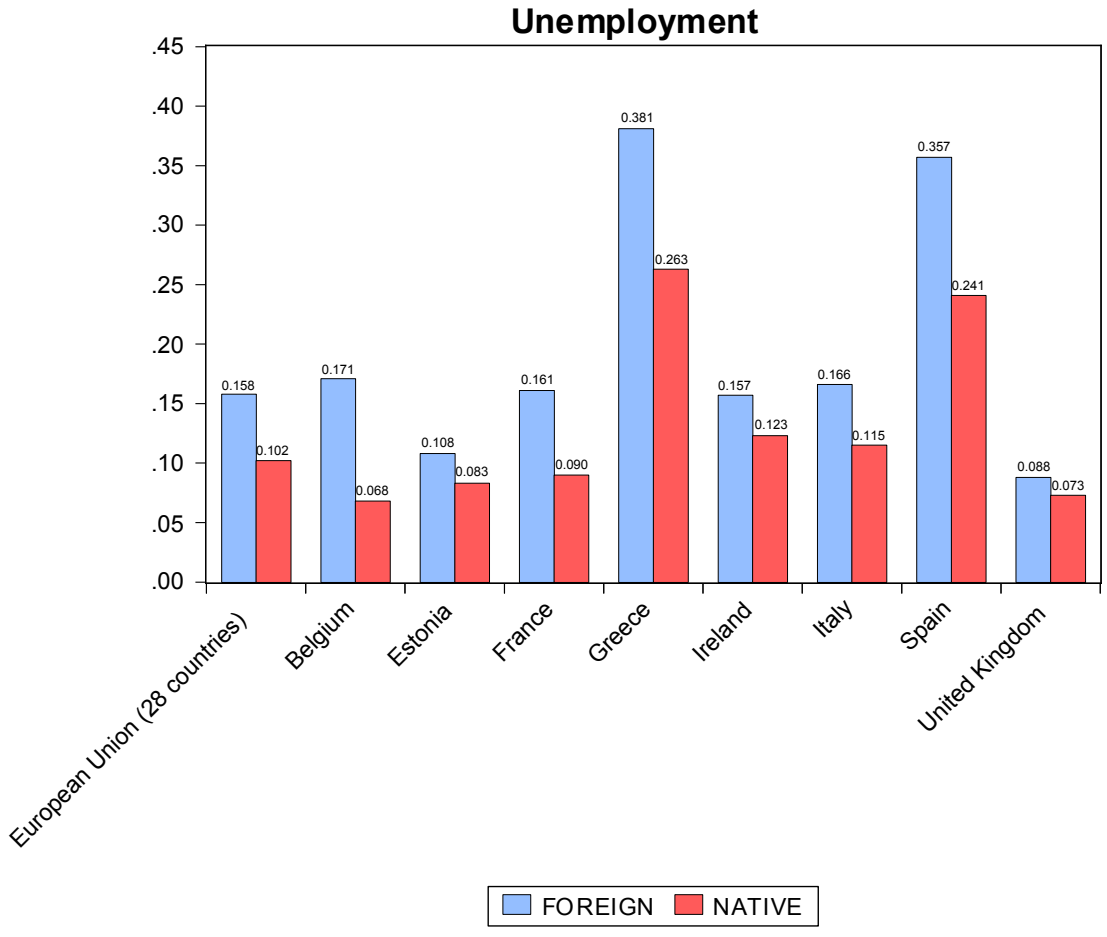


Figure 9.7: Unemployment Rate



Chapter 10

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