The Immigration Surplus and the Substitutability of Immigrant and Native Labor: Evidence from Spain

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Abstract: How immigration affects the labor market of the host country is a topic of major concern for many immigrant-receiving nations. Spain is no exception following the rapid increase in immigrant flows experienced over the past decades. We assess the impact of immigration on Spanish natives' incomes by estimating the net immigration surplus under the assumption of perfect and imperfect substitutability of immigrant and native labor of similar educational attainment. To address the imperfect substitutability of immigrant and native labor, we use information on the occupational distribution of immigrants and natives of similar educational attainment to learn about the equivalency of skilled immigrants to skilled and unskilled natives. The results show that the magnitude of the immigration surplus significantly rises with the degree of imperfect substitutability between immigrant and native labor.

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1. Introduction

How immigration affects the labor market of the host country is a topic of major concern for many immigrant-receiving nations. Spain is no exception following the rapid increase in immigrant flows experienced over the past two decades. In 1991, only 1.2 percent of the Spanish adult population (about 300,000 individuals) was foreign-born. Within a decade, this percentage quadrupled to 4.0 percent (1,370,000 individuals) and, by 2008, it had roughly reached 11 percent (5,200,000 individuals). In fact, since the year 2000, Spain has displayed one of the largest rates of immigration in the world –three to four times as large as the average immigration rate in the U.S. Hence, it is not surprising that the majority of Spanish citizens usually declare immigration as one of their main social concerns together with unemployment, housing and terrorism according to the Spanish Sociological Research Centre (CIS).

But, perhaps, what is of greater concern to natives is how immigrants affect their incomes. Do immigrants raise the incomes of Spanish natives? In this study, we follow the framework proposed by Borjas (1999) to calculate the net immigration surplus that accrues to Spanish natives under the assumption of heterogeneous labor. However, in addition to assuming perfect substitutability between immigrants and natives of similar educational attainment, we compute the net immigration surplus under the assumption that immigrants and natives of alike educational attainment are imperfect substitutes. With the exception of a few studies that calculate wage elasticities in response to an immigrant shock (*e.g.* Ottaviano and Peri 2010, Peri 2006 and Manacorda *et al.* 2006), most analyses assume perfect substitutability between immigrants and natives within age-education cells. Yet, as noted by Amuedo-Dorantes and de la Rica (2011) for Spain, immigrants display a distinct task specialization and occupational distribution than natives in each of those cells. For instance, using data from the 1999-2008 *Encuesta de Población Activa* (EPA) or labor force surveys,

approximately 80 percent of immigrants with a secondary education and 75 percent of immigrants with a primary or lower education are concentrated in three occupations (*i.e.* low skill jobs that only require an elementary education, service and sale related occupations, and craft and related trade jobs) relative to 55 percent and 61 percent of similarly educated natives. Therefore, even within an educational attainment cell, immigrants display a distinct task specialization and occupational distribution than natives.

We allow for the imperfect substitutability between immigrant and native labor of alike educational attainment by using a strategy complementary to the one used by Altonji and Card (1991), Card (2001), Borjas (1995, 2003), and Ottaviano and Peri (2005, 2010) when computing wage elasticities in response to an immigration shock. Specifically, we rely on information on the occupational distribution of college and non-college educated immigrants and natives to develop a mapping of immigrant-to-native skills. The mapping, which informs on the substitutability between immigrants and natives at the occupational level, reveals the equivalence between college-educated immigrants and college-educated (and, by default, non-college educated) natives. In that regard, instead of solely relying on their educational attainment, we use information on their job placement to assess the degree to which they are substitutes in the labor market. The results show that the magnitude of the immigration surplus significantly rises with the size of the immigrant population and with the revealed imperfect substitutability between immigrant and native labor.

In the next section, we describe the theoretical framework and the strategy followed to address the imperfect substitutability between immigrants and natives. Section 3 discusses the data used in our simulations and Section 4 our findings. Section 5 concludes the analysis with a summary of our findings.

2. Theoretical Framework

2.1. Immigration Surplus: Heterogeneous Labor and Perfectly Elastic Capital

We use the framework proposed by Borjas (1995, 1999) to measure the net immigration surplus in an economy with two types of workers: skilled (*i.e.* college-educated) and unskilled (*i.e.* non-college educated). The production technology is summarized by the following linear homogenous aggregate production function:

$$Q = f(K, L_S, L_U) = f[K, bN + \beta M, (1-b)N + (1-\beta)M] \qquad (1)$$

where K stands for capital, N and M represent the number of native and immigrant workers, and b and β are the shares of skilled workers among natives and immigrants, respectively.

We make several assumptions about the production function. To start with, we assume that the production function is continuous and twice-differentiable, with $f_i > 0$ and $f_{ii} < 0$ $(i = K, L_S, L_U)$. Prices of the factors of production (r for capital and w_i for labor, i = S, U) are given by the corresponding marginal productivity conditions. Additionally, we assume that all capital is owned by natives and, in this first subsection, we allow capital to be infinitely elastically supplied at a constant rate r. This assumption is changed in the following subsection and the supply of capital is assumed to be perfectly inelastic. Finally, we assume that the production function exhibits constant returns to scale; therefore, the entire output is distributed among workers.[1] Under these conditions, the immigration surplus is positive as long as the skill composition of immigrants differs from that of native workers, *i.e.*, inasmuch as immigrants' skill shares (β) differs from those of natives (b). Otherwise, wages would be unaffected by immigration and the immigration surplus would equal zero.

At equilibrium, the price of each of the factors of production has to equal the value of its marginal product and, consequently, the increase in income accruing to natives following the entry of M immigrants is given by:

[1] Capital owners do not obtain any gain as there is no change in the rental rate of capital, r.

$$\Delta Q_{N,dr=0} = \left(bN\frac{\partial w_S}{\partial M} + (1-b)N\frac{\partial w_U}{\partial M}\right)M \qquad (2)$$

where w_S and w_U stand for the wages of skilled and unskilled workers, respectively. Borjas (1999, p. 1705) explains how equation (2) can be rewritten as follows:

$$\frac{\Delta Q_N}{Q}|_{dr=0} = \frac{-\alpha_S^2}{2c_{KK}}[c_{SS}c_{KK} - c_{SK}^2]\frac{(\beta-b)^2}{p_S^2 p_U^2}(1-m)^2 m^2 \qquad (3)$$

where α_S is the share of national income accruing to skilled workers, the c_{ij} are the elasticities of complementarity for any two inputs, p_S and p_U represent the shares of the work force that are skilled and unskilled, and m is the fraction of the work force that is immigrant ($m = M/L$). Immigrants create a surplus as long as their skills differ from those of natives. Otherwise, owing to the constant returns to scale production function assumption, the prices of the various factors of production would remain unchanged (as their relative supplies would remain unaltered) and natives would not gain anything from immigration.

2.2. Immigration Surplus: Heterogeneous Labor and Perfectly Inelastic Capital

How does the immigration surplus change if the supply of capital is assumed to be perfectly inelastic? At equilibrium, we continue to have that the price of each of the factors of production has to equal the value of its marginal product. Hence, the immigration surplus is now equal to:

$$\Delta Q_{N|dK=0} = \left(K\frac{\partial r}{\partial M} + bN\frac{\partial w_S}{\partial M} + (1-b)N\frac{\partial w_U}{\partial M}\right)M \qquad (4)$$

Borjas (1999, p. 1706) explains how equation (4) can be rewritten as follows:

$$\frac{\Delta Q_N}{Q}|_{dK=0} = -\frac{\alpha_S^2 c_{SS}\beta^2 m^2}{2p_S^2} - \frac{-\alpha_U^2 c_{UU}(1-\beta)^2 m^2}{2p_U^2} - \frac{\alpha_S\alpha_U c_{SU}\beta(1-\beta)m^2}{p_S p_U} \qquad (5)$$

As shown in Borjas (1999, p. 1706-07) natives now gain from immigration even if the skill distribution of immigrants and natives is alike and, overall, the immigration surplus is larger than when the capital supply is assumed to be perfectly elastic.

2.3. Imperfect Substitutability of Immigrants and Natives within Skill Groups

In equation (3), where skill is defined in terms of educational attainment (*i.e.* college vs. no college), it is assumed that immigrants and natives with the same educational attainment are perfect substitutes. As noted by Ottaviano and Peri (2010) for the United States and by Amuedo-Dorantes and De la Rica (2011) for Spain, this is a strong and incorrect assumption since immigrants of the same educational attainment as natives are more likely to occupy low-skilled occupations than their native counterparts. This finding is consistent with those from Peri and Sparber (2009), who point out that low-skill immigration in the United States induces low-skilled natives to switching toward occupations that are more communication intensive as opposed to manual intensive. Likewise, focusing on Spain, Farré *et al*. (2011) document that immigrants in the bottom half of the educational distribution are disproportionally employed in low-earnings occupations relative to similarly educated natives.

To provide some descriptive evidence on the different occupational distributions at a 3-digit level of natives and immigrants of alike educational attainment, we compute Welch's (1999) index of congruence for natives and immigrants with and without a college education using data from the 2008 Spanish labor force survey.[2] The Welch's index for natives and immigrants with a college education equals 0.19 and that of their non-college educated counterparts equals 0.32. The congruence index thus falls with educational attainment as immigrants tends to, as a whole, be disproportionally employed in manual non-qualified occupations and, overall, provides empirical evidence of the dissimilar occupational distribution of immigrant and native workers of alike educational attainment.

[2] The index, defined as: $G_{NM} = \frac{\sum_c (q_{Nc} - \overline{q_c})(q_{Mc} - \overline{q_c})/\overline{q_c}}{\sqrt{\left(\sum_c (q_{Nc} - \overline{q_c})^2/\overline{q_c}\right)\left(\sum_c (q_{Mc} - \overline{q_c})^2/\overline{q_c}\right)}}$, where q_{ic} gives the share of group i (i = N, M) employed in occupation c and $\overline{q_c}$ gives the share of the entire workforce employed in that occupation. The index ranges between (-1, 1). It equals 1 when the two groups being compared have identical occupational distributions and -1 when the two concentrate in entirely different occupations.

Therefore, in addition to considering their educational attainment, we rely on information regarding their occupations to proxy for their actual labor market skills. In particular, instead of assuming perfect substitutability between immigrants and natives within an educational attainment category, we assume that immigrants and natives of alike educational attainment are perfect substitutes if they are both employed in the same narrowly defined occupation. Note that two similarly skilled individuals employed in the same narrowly defined occupation would be expected to have similar earnings if they are, indeed, good substitutes. This supposition is not as strong of an assumption in a country like Spain where approximately 65 percent of the salary (the *base wage*) is the same for two individuals employed within the same narrowly defined occupational category as it is negotiated through collective bargaining. Furthermore, a large share of the remaining 35 percent of the salary corresponds to *wage complements* for various working conditions, such as work safety, work schedule (night shifts) and job tenure. Given that working conditions are very similar within narrowly defined occupational category, wage differentials in wage complements within the same narrowly defined occupational category should be small.

To check whether wage differentials are small, we use data from a subsample of the 2008 Spanish labor force survey for which information on the wage decile to which each native and immigrant worker belongs to is made available.[3] We first compute the average wage decile of college-educated and non-college educated immigrants and natives in each 3-digit level occupation. We then compare the average wage deciles of similarly educated immigrants and natives within each narrowly defined occupation category and calculate what we refer to as the wage-decile gap. These wage-decile gaps between college-educated immigrants and natives and between non-college educated immigrants and natives in each 3-

[3] This dataset has just been released to us by the Spanish Institute of Statistics and only information on the wage decile is made available. We tried using other sources of data on wages for both immigrants and natives, such as the 2008 EUSILC. Unfortunately, the survey only contains information on 140 immigrants (0.4 percent of the sample), rendering a comparison of immigrant and average wages within occupation unfeasible.

digit level occupation are plotted in Figures 1 and 2, respectively. To serve as a comparison, the graphs also display the average wage-decile gap between natives and immigrants of similar educational attainment with red lines. A couple of findings are worth noting. First, the vast majority of dots fall below the red lines. Therefore, the assumption of perfect substitutability between immigrants and natives of similar educational attainment within narrowly defined occupations appears to be more sensible than the more traditional assumption of perfect substitutability between immigrants and natives of alike educational attainment. Second, the majority of dots, particularly among unskilled workers to which most immigrants belong to, are centered close to zero. This finding suggests that wage differentials between similarly educated immigrants and natives within the same narrowly defined occupational category are minor. As such, the assumption of perfect substitutability among similarly educated immigrant and natives within a narrowly defined occupation seems reasonable.

Note, however, that using occupations as a proxy for skill implies having as many skills as occupational categories, making the computation of the net immigration surplus intractable and quite cumbersome. Hence, we develop an alternative and much simpler approach to implement, which consists of correcting the observed β (*i.e.* the share of skilled immigrants) to reflect what the predicted immigrant skills would be according to their occupational distribution. Specifically, we specify two educational groups, *s* (*skilled* or college-educated) and *u* (*unskilled* or non-college educated). The occupational distribution of immigrants and natives in the *s* category across the j=1…J occupational categories is denoted by I_{sj} and N_{sj}, respectively. Likewise, we denote the occupational distribution of natives in the *u* category by N_{uj}. Our intent is to learn about the equivalency of college-educated immigrants to similarly educated natives ($i.e.w_s$) in terms of their occupational distribution. We only care about the equivalency of college-educated immigrants since they are the only

ones who can be employed in a skilled occupation or downgraded to an unskilled occupation. Non-college educated immigrants cannot be downgraded any further (there are only two levels of skills: unskilled and skilled). They are fully employed in unskilled occupations. The equivalency of college-educated immigrants to college-educated natives can be estimated by the following equation:

$$I_{sj} = w_s N_{sj} + w_u N_{uj} \qquad (6)$$

where: w_s and w_u range between 0 and 1 and add up to 1.

Equation (6) can be estimated by OLS. The scalar w_s represents the estimated equivalency between a college-educated immigrant and a college-educated native occupation-wise.[4] If immigrants and natives of alike educational attainment were perfect substitutes, we would expect them to occupy similar occupations and the estimated coefficient w_s to be equal to 1. However, the value of w_s is 0.15. We use this equivalency weight to correct the share of skilled immigrants (β) so as to reflect what the true share of skilled immigrants –henceforth referred to as the *corrected* β or β_c– as follows:

$$\beta_c = w_s \beta \qquad (7)$$

Table 1 displays the OLS regression results from estimating equation (6) for 2008, whereas Table 2 shows the observed and corrected betas for college-educated immigrants (β and β_c) in that year.[5] On average, twenty-two percent of immigrants were considered skilled based on their educational attainment. Yet, the equivalency between college-educated immigrants and natives occupation-wise was 0.15. Hence, the corrected beta is given by: β_c = 0.15*0.22 = 0.03, thus implying that the share of immigrants who can be considered skilled based on their education and labor market placement is lower than the share of immigrants with a college education.

[4] Likewise, the scalar w_u represents the estimated equivalency between skilled immigrants and unskilled natives.

[5] Results for earlier years (2005, 2006 and 2007) are quite similar and are available from the authors upon request.

3. Data

To illustrate the importance of accounting for the imperfect substitutability between immigrants and natives of similar educational attainment, we simulate the immigration surplus in equation (3) and (5) under the assumptions of perfect as well as imperfect substitutability between immigrants and natives. With that purpose, we use various data sources. First, we gather data from the 2008 Spanish labour force survey (EPA) to compute the share of skilled and unskilled workers in the workforce (p_S and p_U), the shares of skilled native and immigrant workers (b and β), the corrected beta for skilled immigrant workers (β_c) and the share of immigrant workers in the workforce (m). The EPA provides us with the most representative and recent data on immigrant and native workers.[6] This allows us to account for the large immigrant shock over the time period under consideration despite the potential misrepresentation of unauthorized immigrants,[7] who are less likely to reside in the registered households.

The share of national income accruing to skilled workers (α_s) is computed using additional data sources since the EPA does not contain any information on earnings. Specifically, annual GDP data (in 2008 euros) are gathered from the national accounts available from the *Instituto Nacional de Estadística* (INE). Wage data for skilled workers are obtained from the EUSILC,[8] whereas information on the size of the skilled workforce comes from the EPA. Figures for α_s and the aforementioned parameters for the years under consideration are displayed in Table 2.

Finally, crucial for the simulation of the immigration surplus are the elasticities of complementarity for any two inputs (c_{ij}), which depend on the responsiveness of factor

[6] Immigrants are defined as foreign-born individuals.

[7] Comparing the figures from the municipal population registers (*i.e.* Padrón – in which undocumented immigrants have an incentive to register to gain access to free educational and health related services) and the number of residence permits, González-Enríquez (2009) estimates that the percentage of irregularity was approximately 12 percent (or 349,000 individuals) in January 2008.

[8] The EPA does not contain information on wages. We use average annual wages (in 2008 euros) for skilled workers in Spain from the European Survey of Living conditions.

prices to changes in labor supply. We consider a range of elasticities. First, we compute the elasticities of complementarity that arise when the factor price elasticities are: $(\varepsilon_{ss}, \varepsilon_{uu}) = (-0.76, -0.96)$. These values are derived using Spanish data from the EU-Klems for the years 1980 through 2005 following the methodology described in Hidalgo *et al*. (2008) and summarized in the appendix. Additionally, for comparability purposes, we compute the elasticities of complementarity that arise when the vector $(\varepsilon_{ss}, \varepsilon_{uu})$ takes on the following three ranges used by Borjas (1999): (-0.3, -0.5), (-0.6, -0.9) and (-0.8, -1.5). In our computations, we set the cross elasticity ε_{su} equal to 0.05. Furthermore, following Euwals and Roodenburg (2003),[9] we make use of the fact that the row-wise sum and column-wise weighted average have to equal zero to compute all other elasticities.[10] Table 3 reports the elasticities of complementarity obtained using the various factor price elasticity ranges.[11]

4. Immigration Surplus Simulations and Findings

Table 4 shows the estimated immigration surplus under the assumptions of perfect and imperfect substitutability between immigrant and native labor of alike educational attainment using the four different ranges of values for the $(\varepsilon_{ss}, \varepsilon_{uu})$. According to the theoretical derivation of the immigration surplus, we should find that the immigration surplus under the assumption of a perfectly inelastic capital supply is larger than under the assumption of a perfectly elastic capital supply. Likewise, the immigration surplus should increase with the responsiveness of factor prices to increases in labour supply. Finally, we would expect the immigration surplus to rise when we more carefully account for the

[9] We are grateful to these authors for sharing the Excel-spreadsheet they use in their study to calculate the effects of immigration.

[10] Specifically, price elasticities and elasticities of complementarity fulfill the following three identities:

Identity 1: $\varepsilon_{iK}+\varepsilon_{iS}+\varepsilon_{iU}=0$ ($i=k,s,u$)

Identity 2: $\alpha_K\varepsilon_{Ki}+\alpha_S\varepsilon_{Si}+\alpha_U\varepsilon_{Ui}=0$ ($i=k,s,u$)

Identity 3: $\alpha_K c_{Ki}+\alpha_S c_{Si}+\alpha_U c_{Ui}=0$ ($i=k,s,u$) and $c_{ij}=c_{ji}$ ($i,j=k,s,u$)

[11] A definition of each elasticity of complementarity is provided at the bottom of Table 3 as well.

imperfect substitutability of immigrant and natives. This should be particularly true under the assumption of a perfectly elastic capital supply as, in that case, the immigration surplus accrued to natives is directly related to the difference in skills between immigrants and natives (*i.e.* ($\beta - b$) in equation (3)). In contrast, the imperfect substitutability between immigrants and natives should not make as much of a difference on the immigration surplus computed under the assumption of a perfectly inelastic capital supply, as the latter exclusively depends on β (see equation (5)).

As expected, the figures in Table 4 reveal a significantly larger immigration surplus under the assumption of a perfectly inelastic capital supply than under the alternative assumption of a perfectly elastic capital supply. Second, the immigration surplus rises with the responsiveness of factor prices to immigration, regardless of whether capital is assumed to be perfectly elastic or inelastic. But of special interest to us is the extent to which immigration raises income inasmuch immigrant skills differ from native skills. The increase is particularly noticeable under the assumption of a perfectly elastic capital supply –probably a more sensible assumption in the long-run. Indeed, according to Panel A in Table 4, the immigration surplus when we take into account the imperfect substitutability between natives and immigrants is between five (4.87) and six (5.6) times larger than the one computed assuming the perfect substitutability between both types of labor. For instance, using the elasticities of complementarity computed from Spanish data (first column of Table 4), the immigration surplus under the assumption of a perfectly elastic capital supply rises from 0.042 percent of GDP to 0.230 percent of GDP in 2008 as we take into account the imperfect substitutability between immigrants and natives. Therefore, while the immigration surplus estimates under the assumption of a perfectly elastic capital supply and perfect substitutability of immigrant and native labor ranges between 0.021 and 0.05 percent of

GDP,[12] it reaches up to 0.28 percent of GDP when we take into account the imperfect substitutability between immigrant and native labor.

5. Summary and Conclusions

Spain has experienced growing immigration inflows during the past decade. As such, it is only logical to question how these new immigrants are impacting the economic well-being of Spanish natives. In this paper, we address this question using the framework proposed by Borjas (1999) to calculate the net immigration surplus under the assumption of heterogeneous labor and perfectly elastic capital. Our main contribution is to compute and compare the immigration surplus for Spain under the assumptions of perfect and imperfect substitutability between immigrant and native workers of similar educational attainment. This is important because, as noted by Amuedo-Dorantes and De la Rica (2011), foreign-born workers do not appear to be perfect substitutes of similarly educated native workers. Instead, immigrants are more highly concentrated in manual non-qualified occupations relative to similarly educated natives.

We find that the immigrant surplus significantly rises when we take into account the imperfect substitutability between immigrant and native labor. The increase is particularly larger under the assumption of a perfectly elastic capital supply –a more appealing supposition for the long-run. Indeed, in that particular case, the new immigration surplus is approximately five and a half times larger than the immigration surplus estimate computed under the traditional assumption of perfect substitutability of immigrant and native of similar skill.

[12] Borjas' (1995) estimates for the U.S. ranged between 0.01 and 0.02 percent of GDP when capital was assumed to be elastic. Differences in the IS estimates for Spain and the United States are expected given the distinct parameter values involved in the computation of the IS for the two countries, including the comparatively larger immigration shock experienced by the Spanish economy during a relatively short period of time.

What is one of the policy implications stemming from these findings? Perhaps the most obvious one refers to the fact that the magnitude of the immigration surplus depends on the degree of substitutability between immigrant and native labor. Therefore, if attempting to maximize the contribution of immigrants to national income, immigration policy should probably favour immigrant inflows with skills complementary to those of natives.

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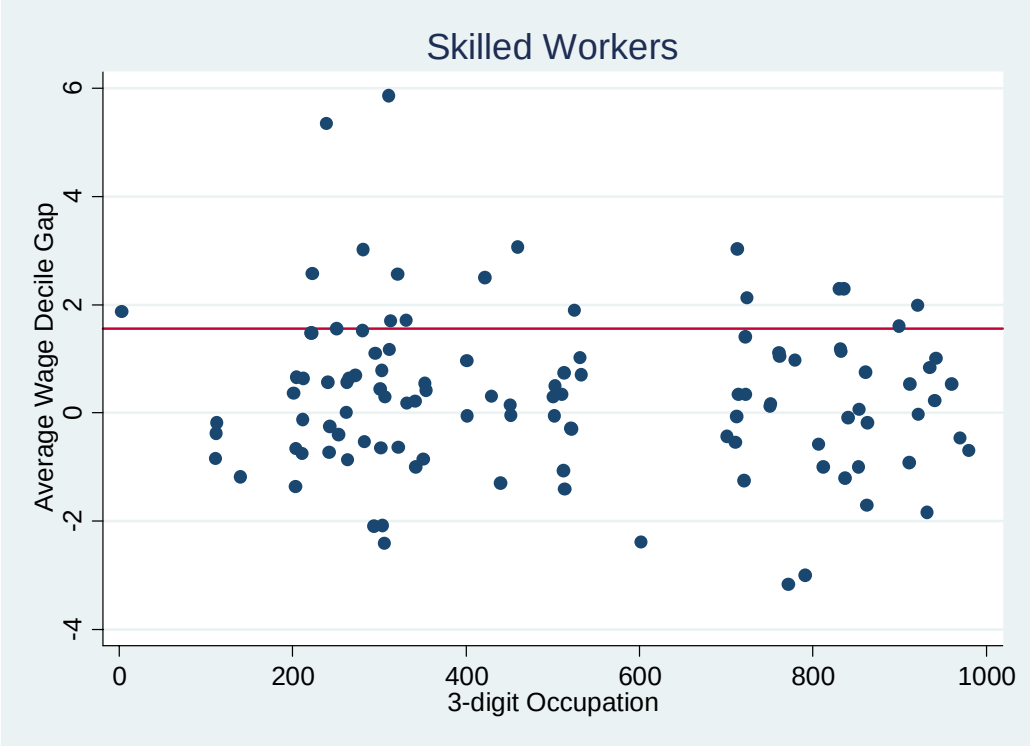
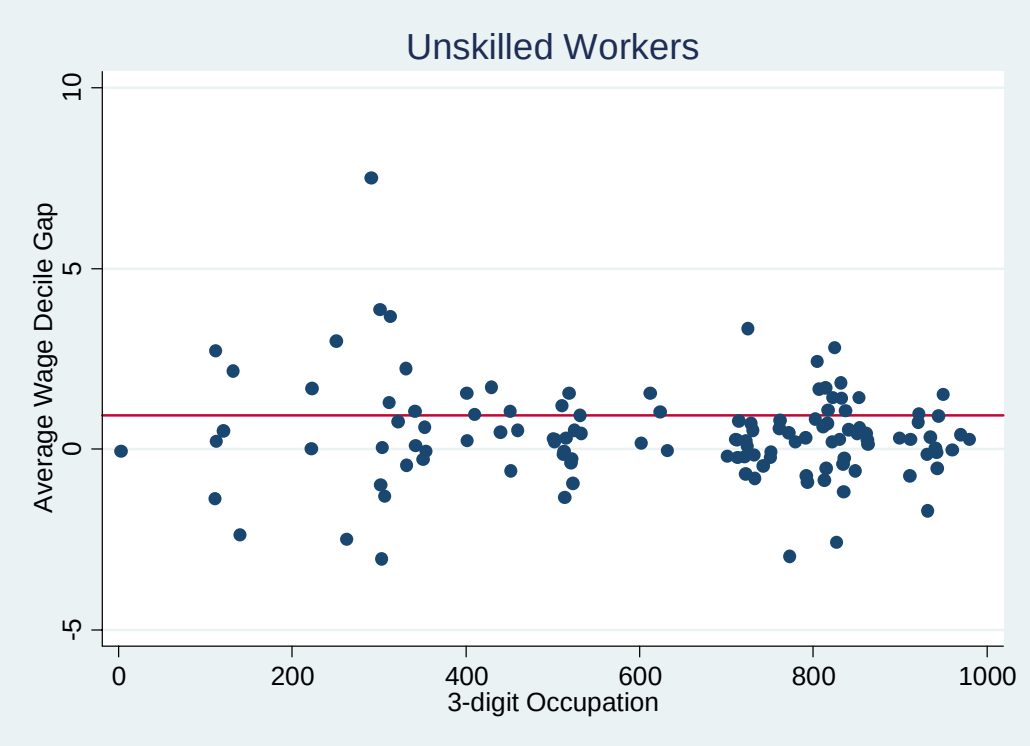
Figures 1 and 2:

Average Wage-Decile Gaps between Immigrants and Natives

Within Narrowly Defined Occupations by Educational Attainment





Note: The red lines indicate average wage-decile gaps across occupations using data from the 2008 EPA.

Table 1: Estimates of w_s and w_u

Variables	Coefficient	Robust S.E.	Normalized Estimates
N_{sj}	0.132**	0.067	w_s = 0.154
N_{uj}	0.726***	0.137	w_u = 0.846
Observations	205		
F-statistic	29.45		
Prob > F	0.000		

Notes: Spanish Labor Force Survey (EPA). We regress the occupational distribution of skilled immigrants across the 3-digit ISCO levels on the occupational distribution of skilled and unskilled natives across the same occupational break-down. ** indicates significance at the 5 percent level and *** indicates significance at the 1 percent level.

Table 2: Parameter Values for the IS Computation (2008)

Parameters	β	w_s	β_c	p_s	p_u	b	m	α_s	α_u
Values	0.219	0.154	0.034	0.348	0.653	0.355	0.149	0.287	0.413

Notes: p_s: Share of workers (20-59 years) with college education from the EPA.

p_u: Share of workers (20-59 years) with less than college education from the EPA.

b: Share of native workers (20-59 years) with college education from the EPA.

m: Share of workers (20-59 years) with a foreign nationality from the EPA.

α_s: Share of national income accruing to skilled workers (20-59 years) = (w_s*L_s/GDP). Average annual wages for skilled workers are obtained from the new release of EPA, where average wages (in intervals) are gathered. Information on L_s is gathered from the EPA, and GDP data are obtained from the Spanish Institute of Statistics website (INE).

Table 3: Factor Price Elasticities and Elasticities of Complementarity (2008)

Elasticity Ranges	**(ε_{ss}. ε_{uu})=(-0.76, -0.96)**	**(ε_{ss}. ε_{uu})=(-0.3,-0.5)**	**(ε_{ss}. ε_{uu})=(-0.6,-0.9)**	**(ε_{ss}. ε_{uu})=(-0.8, -1.5)**
c_{ss}	-2.64	-1.04	-2.09	-2.79
c_{uu}	-2.32	-1.21	-2.18	-3.63
c_{kk}	-6.50	-2.93	-5.72	-9.11
c_{su}	0.12	0.12	0.12	0.12
c_{sk}	2.36	0.83	1.83	2.50
c_{uk}	3.08	1.55	2.88	4.88

Notes: Assuming that α_k=0.3 and ε_{su}=ε_{us}=0.05, the elasticities of complementarity are computed following these three identities:

Identity 1: $\varepsilon_{iK}+\varepsilon_{iS}+\varepsilon_{iU}=0$ ($i=k,s,u$)

Identity 2: $\alpha_K\varepsilon_{Ki}+\alpha_S\varepsilon_{Si}+\alpha_U\varepsilon_{Ui}=0$ ($i=k,s,u$)

Identity 3: $\alpha_K c_{Ki}+\alpha_S c_{Si}+\alpha_U c_{Ui}=0$ ($i=k,s,u$) and $c_{ij}=c_{ji}$ ($i,j=k,s,u$)

Hence: $c_{ss}=\varepsilon_{ss}/\alpha_s$, $c_{uu}=\varepsilon_{uu}/\alpha_u$, $c_{kk}=[-(\alpha_s c_{sk}+\alpha_u c_{uk})/\alpha_k]$, $c_{su}=\varepsilon_{us}/\alpha_u$, $c_{sk}=[-(\alpha_s c_{ss}+\alpha_u c_{su})/\alpha_k]$ and $c_{uk}=[-(\alpha_s c_{us}+\alpha_u c_{uu})/\alpha_k]$.

Table 4: Immigration Surplus (IS) Simulations

PANEL A: Totally Elastic Capital (dr=0)												
Elasticity Ranges	**Specification 1 (ε_{ss}=-0.76;ε_{uu}=-0.96)**			**Specification 2 (ε_{ss}=-0.3;ε_{uu}=-0.5)**			**Specification 3 (ε_{ss}=-0.6;ε_{uu}=-0.9)**			**Specification 4 (ε_{ss}=-0.8;ε_{uu}=-1.5)**		
Substitutability	**Imperfect**	**Perfect**	**Ratio**	**Imperfect**	**Perfect**	**Ratio**	**Imperfect**	**Perfect**	**Ratio**	**Imperfect**	**Perfect**	**Ratio**
IS (%)	0.230	0.042	5.60	0.091	0.021	4.87	0.201	0.035	5.60	0.280	0.050	5.60
PANEL B: Totally Inelastic Capital (dK=0)												
Elasticity Ranges	**Specification 1 (ε_{ss}=-0.76;ε_{uu}=-0.96)**			**Specification 2 (ε_{ss}=-0.3;ε_{uu}=-0.5)**			**Specification 3 (ε_{ss}=-0.6;ε_{uu}=-0.9)**			**Specification 4 (ε_{ss}=-0.8;ε_{uu}=-1.5)**		
Substitutability	**Imperfect**	**Perfect**	**Ratio**	**Imperfect**	**Perfect**	**Ratio**	**Imperfect**	**Perfect**	**Ratio**	**Imperfect**	**Perfect**	**Ratio**
IS (%)	0.967	0.706	1.37	0.502	0.344	1.45	0.908	0.648	1.40	1.510	1.071	1.41

Notes: The ratio equals: (IS under the assumption of imperfect substitutability between immigrants and natives/IS under the assumption that immigrants and natives are perfect substitutes).

Appendix
Elasticity of Substitution for College and Non-College Workers in Spain

As noted in the text, we use the elasticities of substitution between college and non-college educated workers in Spain derived by Hidalgo *et al*. (2009).[13] In their analysis, the authors gather Spanish data from the EU KLEMS database, which contains data series for 29 productive sectors for the period 1980 through 2008.[14] They allow workers to have three different skill levels: College, high-school and drop-outs and estimate elasticities of substitution for each of them. Their results show that the elasticities of substitution for high-school and drop-outs are not statistically different, so any of them can be used to represent ε_{uu}. Hence, the elasticity of substitution for non-college educated workers (ε_{uu}) is set equal to the elasticity of substitution for high-school workers –by far the vast majority of non-college educated native and immigrant workers in Spain.

Hidalgo *et al*. (2009) follow these steps in computing the elasticities of substitution:

1. They use the Shephard's lemma to write the cost share of each type of labor (college-educated or non-college educated workers) in terms of the partial derivative of the cost function with respect to the price of each type of labor.
2. Imposing the condition of homogeneity of degree one to the cost function and taking differences of the linear representation of each factor's cost share, the authors express the change in the cost share of each labor input as function of its wage (in differences).
3. They estimate the Allen-Uzawa partial elasticity of substitution to obtain ε_{ss} and ε_{uu}.

The elasticities derived by the authors for the period 1980-2008 using Spanish data are: (ε_{ss}, ε_{uu} = -0.76, -0.96).

[13] Specific details about the derivation of these elasticities, including the equations used in the estimation, can be found in Hidalgo *et al*. (2009), pages 8-10, at: http://ideas.repec.org/p/cea/doctra/e2008_13.html
[14] For more Information on EU KLEMS dataset, please visit: http://www.euklems.net