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Labour market adjustment in the Spanish regions: a first examination to the immigration shock, 1995-2002

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Abstract. We investigate the effects of an immigration shock, which is still on course, in the productive structure of Spanish regions in a Heckscher-Ohlin framework. Immigration alters relative factor endowment composition across Spanish regions. The persistence of rigidities in the regional labour markets conditions the absorption of this labour supply shock and gives the clues to understand and anticipate future changes in regional labour markets. Moreover, we test the extent of production techniques homogeneity across regions and industries. We provide evidence that immigration had no perverse effects on regional labour markets over the period 1995-2002. Firstly, a large proportion of the observed changes came from a generalised skill biased technological change that decreases primary educated employment. Secondly, there is evidence that supports the existence of a Rybczynksi effect in the factor mix-output mix relationship. Finally, our findings also support the existence of factor price equalisation across Spanish regions.

JEL: F16, F22, J61

Keywords: Immigration, Technological change, Rybczynksi effect, Factor Price Equalisation.

Introduction

Since the mid nineties, the Spanish economy has been characterised by a continuous growth in immigration flows from African, Latin American and Eastern European countries. In the last decade the share of immigrants in the total population has steadily increased in Spain. According to the "Padrón Municipal" it rose from about 1% in 1995 to approximately 4% in 2002 and to 8% in 2006. This wave of immigrants represents a labour-supply shock that have contributed to change the labour-skill composition. Immigration has coincided with a strong period of job creation in the Spanish economy, particularly in sectors such as agriculture, construction, hotels and restaurants and domestic and cleaning services

The Central Bank of Spain states that the Spanish unemployment rate is decreasing without increasing inflation due in part to the role of immigration in the adjustments in the labour market.[1] Despite Spanish labour market still suffers from inefficiencies such as the high dispersion in regional and occupational unemployment rates, the moderation of wages growth rates in 2005 has to be related to a composition effect founded on the lower wages in new employments, reflecting a higher flexibility in the new-entrances segment of labour market where the role of immigrants has been relevant.[2] Anyway, once differences in education, experience and age are controlled, wage differentials between nationals and immigrant workers are less than 10%.[3] In this sense, a recent study of the effect of immigration on Spanish employment and wages pointed to the incorporation of the flow of immigrants in recent years seems to be a weak if not irrelevant effect on average native wages.[4] However, given the above mentioned interregional differences in labour markets and either in immigration flows, and so far we have no evidence about the impact of immigration on Spanish regional

[1] Bank of Spain. Economic Bulletin (monthly). September 2006.
[2] The Spanish Unions criticise the fact that these new jobs are to a great extent temporary and seasonal jobs with below-average wages.
[3] Bank of Spain. Annual Report, 2005.
[4] "La Caixa" Monthly Report, 295. 2006.

wages, it is harder to a priori extend this conclusion to all the Spanish regions to the same extent. [5]

According to the "Anuario de Extranjería", the number of immigrants grew fast between 1995 and 2002, from 1.27% of the total population to 3.24%. However, immigrants in Spain are not evenly distributed across the territory. Most of them are concentrated in four regions (Catalonia, Madrid, Andalusia and Region of Valencia), and that including Canary and Balearic Islands, they accumulate more than 80% of the legal immigrant population. This concentration persists over time, suggesting that immigrants tend to go to regions with relatively large populations of previous immigrants (see Table A1 in the Appendix for the figures). This suggests that the effect of immigration on labour markets could be different among Spanish regions and that could let to differences in the adjustment mechanisms to these supply shock.

Another relevant characteristic of the foreign immigrant population in Spain is that it poses a different composition of education levels and occupation categories compared to natives. Those differences in the qualification-mix of immigrants and natives may have cause a change in skill composition in the labour force across Spanish regions. The information in the Spanish Labour Force Survey allows us to examine the changes in skill composition of immigrants and of the overall labour force for 1995 and 2002 (See Table A2 in the Appendix for figures). The share of immigrants with a medium and high-educational level is higher than that of the rest of labour force. In total, the pool of immigrants is slightly more educated than the rest of labour force pointing to the fact the education can determine the emigration decision looking for better job and life conditions. In fact, skill upgrading in the immigrants group occurred only in the medium-education level in which the share of immigrants increased 12 percent from 1995 to 2002. Nevertheless, many immigrants are not employed in occupations according to their education level. The increase in medium educated immigrants over the period, it is not reflected by the shares of immigrants working in medium-qualification requirements occupied, that slightly decrease from 12.4 to 11.6% while the

[5] Recent empirical evidence for other countries finds that even immigrant induced changes in regional skill composition seemed to have little effects on relative wages; see Card (2005) for US and Dustman et al. (2005) for UK

immigrants working in low-qualification requirements increase 17 percent. On the contrary, from 1995 to 2002, immigrants have contributed to an ongoing trend of reduction in the less educated labour-force. The low-education share in the total labour force decreased from 69.3% to 51.3%, and in the immigrants group decreased from 46.9% to 44.9%. While the share of high-educated workers in the immigrants group fell by 9.3% while that of native workers grew by 6.7%. Therefore, recent immigration has contributed to the over education phenomenon in low-qualification occupations[6] but contra rest the excess of high-educated native workers in the labour market.[7]

Because all of these reasons, and given that regional economies are immerse in this process which still has not finished, the case of Spanish regions is an interesting case of study to better understand the changes that this new phenomenon is introducing in regional labour markets and its implications for regional competitiveness and development.

Regional labour markets have different mechanisms to adjust to demand and supply shocks. Changes in relative factor remuneration or interregional labour mobility are two well-known mechanisms. But small open economies like the regions within a country have other adjustment mechanisms. Firstly, trade helps a region to adjust factor-supply shock by shifting their production towards traded goods that employ intensively the factors with expanding supplies and the region might have no wage changes. This is the logic of the Rybczynski Theorem (1955), a core result of Heckscher-Ohlin (HO) trade theory[8]. Secondly, it is unlikely that output supplies have fully absorbed the changes observed in factor supplies, especially when new technologies are evolving so rapidly since the eighties. The close complementarity between these new technologies and skilled workers, given that only the latter are fully able to implement those technologies, is causing a skilled bias technological change (SBTC) among the developed countries (Berman et al, 1998; Machin and Van Reenen, 1998; Berman and

[6] This would be the case if immigrants and native workers are perfectly substitutes of native workers by level of education. Nevertheless, the titulations and degrees of immigrants from non-UE countries that are mainly arriving to Spanish regions are not easily homologate with the local ones.
[7] Alba and Blázquez (2002) show that over-education explains the rise in wage dispersion in the segment of high skilled workers in Spain.
[8] Harrigan (1995, 1997) and Bernstein and Weinstein (1998) examine whether national outputs vary systematically with national factor endowments, as predicted by the HO model.

Machin, 2000; Acemoglu, 2002; Spitz-Oener, 2006). Thirdly, the flow of ideas across regions helps to equalise their production technology and to experience common changes in production techniques in response to these global technological change. Finally, if regional flows of factors, technology and goods are sufficient for there to be factor price equalisation (FPE) across regions, then regions will experience common factor remuneration responses to national-wide factor-demand shocks and to regional-specific factor-supply shocks.

In this paper we examine whether Spanish regions have absorbed immigrant inflows (or shocks to endowments more generally) by altering the mix of goods they produce, thus relieving pressure for wages to change. We treat regions as Heckscher-Ohlin small open economies and examine the changes over time in regional factor endowments, output mix, and factor usage. If immigration has had minimal impact on the wages of Spanish workers, local output-mix changes are one potential explanation for the insensitivity of wages to immigration, but we are aware of no study before ours which analyzes this mechanism in detail for Spain.

For our empirical analysis we construct a new data set combining regional real value added by industry, regional labour employment by industry, and regional nominal wages. Labour endowments are divided into either three education categories or three occupational categories. The data cover 17 Spanish regions (CCAA, Eurostat NUTS II) and 25 sectors, spanning all civilian industries, in 1995 and 2002.

Our first approach is to analyze changes from 1995 to 2002 in regional endowment mixes and regional output mixes, in line with Hanson and Slaughter (2002) for some US states. We want to see whether regional output growth was relatively high (low) in sectors that were intensive in the use of factors whose relative supplies were expanding (declining). This attempt to find "direct" evidence for this endowment-mix output-mix hypothesis is complicated by the fact that during our sample period there likely were many shocks to preferences and technology, independent of immigration-related endowment shocks. The *ex ante* likelihood that factor endowments and output mixes have changed for reasons other than immigration makes it impossible to test the simple textbook version of the Rybczynski Theorem, where the only exogenous shock is a small endowment change. We extend the analysis in Hanson and Slaughter (2002), considering both the labour composition of Spanish regions by education categories and by qualification requirements of occupation. This is a novelty in the study to analyse up to which point the phenomenon of over-education in the occupation can distort the results.

Our second approach to testing the output-mix hypothesis is to test for factor-price equalization (FPE) across Spanish regions. A sufficient condition for the endowment-mix output-mix hypothesis, in which relative regional wages are insensitive to regional relative factor-supply changes, is that *relative* FPE holds across Spanish regions – i.e., that factor prices for productivity-equivalent units are equalized across regions. Relative FPE would be consistent, for instance, with Hicks neutral technology differences among regions (Trefler, 1993). A sufficient condition for relative FPE between two regions is that for each factor in each industry the two regions have the same unit factor requirements, up to some scalar which is constant across industries. From a general production function framework, we test for FPE by comparing industry unit factor requirements across regions as in Hanson and Slaughter (2002). Unlike them, we use data on wages by region-industry-type of labour, providing a more rigorous test for FPE.

There are four additional sections to this paper. Section 2 describes the data. Section 3 examines regional endowment-mix changes and their link to national-wide technological changes and regional-specific output-mix changes. Section 4 introduces the methodology for testing FPE and presents regression evidence on relative FPE among Spanish regions. Section 5 concludes.

Data description.

To construct data on the regional labour force for both native and foreign workers we use data from the Spanish Labour Force Survey (Economically Active Population Survey, EPA). Industry total employment and real value added output by region come from Spanish Regional Accounts (SRA). The number of industries that provide a correct match between the EPA and SRA is 25. We obtain nominal wage information from *Encuesta de Estructura Salarial* (EES). The period analysed is 1995-2002. The Data Appendix describes data sources and variable construction.

We examine three education categories of labour: workers with no education or primary school (low); workers with high school (medium); workers with university degree or equivalent (high). We also examine three occupational categories: manual workers (low); non-manual workers in clerical, administrative and technical activities (medium); non-manual workers in professional and managerial activities (high). Within education categories, we aggregate over foreign and native workers, which is appropriate given that changes in output mix depend on changes in *total* factor endowments.[9]

Table 1 presents data on labour endowments for Spain and its 17 regions in 1995 and 2002. Each row of Table 1 reports the share of the total regional (and national) labour force accounted for by each of the three education types and three occupation categories. The second part of Table 1 reports the changes in these shares over the period. Table 1 shows that, both for the periods 1995 and 2002, regions in Spain differ widely in the composition of labour force by education and by occupation categories relative to the national average. Despite the growth rates differ across regions, for the 1995-2002 period, there was a general increase in the relative supply of medium and high-educated workers. In the same way, the positive growth rates of occupations with medium skills requirements, and in a lower extent the increase in high-skill requirements occupations, point to a generalised medium-skill-biased technological change in Spanish regions.

<INSERT TABLE 1 HERE>

Table 2 shows the variation between 1995 and 2002 of factor intensities across industries measured by the ratio of employment of medium and high-education/occupation workers to employment of low education/occupation workers. Industries are ranked according to high-educated factor intensity in 1995. In that year

[9] We make no attempt to distinguish between legal and illegal immigrants. However, EPA includes all the labour force, independently of its legal status.

the most education intense sector was Education and health and the least one was Household services. The variation of factor intensities differs substantially across industries. And it can be easily observed that those sectors that have experienced larger variation in high-low education intensity are those that had greater high-low education intensity in 1995. A similar but less clear pattern of inter-industrial variation arises for medium-low education intensities. When we constrain our analysis to tradable sectors the pattern again is consistent with the endowment-mix output-mix hypothesis.

<INSERT TABLE 2 HERE>

Regional Endowment Mixes and Regional Output Mixes

The model.

Openness to international trade in products and ideas creates mechanisms other than wage changes through which an economy can adjust to factor-supply shocks: the adoption of national-wide changes in production technology, and regional-specific changes in the mix of goods produced. We formalize these two mechanisms by using an accounting decomposition derived from the production side of HO trade theory.

In each region, let there be N industries and F primary factors of production. For each industry assume technology is constant returns to scale, free of externalities and identical across regions. In each region, factor-market equilibrium at each point in time implies supply equals demand,

$$V = CX \tag{1}$$

where **X** is a Nx1 vector of industry value-added output, **V** is a Fx1 vector of factor-endowments, and **C** is a FxN matrix of unit factor requirements (industry production techniques) in the region, such that element c_{fi} shows the units of factor *f* required to produce one unit of real value added in industry *i*.

To convert Eq. (1) into the accounting decomposition we desire, we take first differences over time to obtain

$$\Delta V = \overline{C}\Delta X + \Delta C\overline{X} \tag{2}$$

where Δ is the time-differences operator and $\bar{Y}$ is the mean of Y across time. Equation (2) decomposes a region's change in factor supplies into two portions: that accounted for by output-mix changes and that accounted for by production-technique changes. Since Eq. (2) holds as an identity, it yields no insights about causal relationship between ΔV , ΔX and ΔC . For instance, X depends on endowments, product prices and technology, and C depends on technology and factor prices, which in turn depend on endowment, product prices and technology. Since we construct Eq (2) on a region-by region basis, we can control for changes in production techniques at the national industry level, which is an indirect way of controlling for national shocks to technology, product prices and factor prices. This will reveal idiosyncratic changes in production techniques across regions and thus possible violations of relative FPE.

To examine the role of technology flows and regional trade in factor absorption, Eq (2) needs two modifications. First it is necessary to distinguish between changes in production techniques attributable to national shocks from those idiosyncratic to a region. Second, it is necessary to separate output adjustment in traded sectors from those in non-traded sectors.

To identify the possible role of national shocks in regions factor absorption, we distinguish changes in production techniques that are generalised across regions, ΔC_G, from those that are idiosyncratic to each region, ΔC_I. We calculate ΔC_G as the region C matrix in the initial year times the percentage changes in production techniques (on a by industry and by-factor basis) for all the other Spanish regions over the given time period. ΔC_I is then the residual change:

$$\Delta C_I = \Delta C - \Delta C_G \tag{3}$$

Substituting (3) into (2) we obtain a new decomposition,

$$\Delta V = \bar{C}\Delta X + \Delta C_G \bar{X} + \Delta C_I \bar{X} \tag{4}$$

In Eq. (4), $\Delta C_I \bar{X}$ captures factor–demand shifts accounted for by any regional-specific changes in production techniques as well as wages, meaning it also changes in product prices and other shocks. What might cause these regional-specific shifts? One possibility is wage adjustments associated with the immigration shock and other factor supply changes. We expect these wage adjustment to induce substitution away from more-skilled workers towards less-skilled workers in those regions with larger immigration shock –those regions would experience less skilled biased technological change than the rest-. A second possibility is the existence of changes in technology that are region-specific. Without further evidence we cannot identify technological changes alone.

Having accounted for regional-specific technological shocks, next consider the role of output-mix changes among traded goods. Since traded sectors' output is not constrained by domestic demand, one economy can absorb factor-supply changes by shifting into traded-sectors that use intensively factors whose supplies are expanding, while factor prices remain unaltered. However, when the economy grows (i.e. due to growing factor supplies) consumer preferences mandate changes in non-traded output which in turn mandate changes in factor demand. For the case of Spain, the obvious example is the boom in housing demand reinforced by the immigration wave.

To assess the portion of the factor-supply shift absorbed by changes in regional traded output, we must account for factor absorption due to non-traded goods. Define $I^{NT}(I^{T})$ to be a NxN matrix with zero off-diagonal elements and diagonal elements equal to one if the row and column correspond to a non-traded (traded) sector and zero otherwise. Also, define $X^{NT} \equiv I^{NT}X$ and $X^{T} \equiv I^{T}X$. We then rewrite (4) as

$$\Delta V - \left[\overline{C}\Delta X^{NT} + \Delta C\overline{X}^{NT}\right] = \overline{C}\Delta X^{T} + \Delta C_{G}\overline{X}^{T} + \Delta C_{I}\overline{X}^{T} \tag{5}$$

Finally, we can abstract from the nation-wide technological changes and focus on the relative contributions to factor absorption of changes in traded output and idiosyncratic changes in traded production techniques. We rewrite (5) as

$$\Delta V - \left[\overline{C}\Delta X^{NT} + \Delta C\overline{X}^{NT}\right] - \Delta C_{G}\overline{X}^{T} = \overline{C}\Delta X^{T} + \Delta C_{I}\overline{X}^{T} \tag{6}$$

On the left of (6) we have the effective factor-supply change facing the traded sector (ΔV^{E} in Table 4 below). This may be absorbed through changes in either traded output or regional-specific production techniques. Traded-output-mix changes are captured by $\overline{C}\Delta X^{T}$; and both regional-specific technology shocks and immigration related wage changes are captured by $\Delta C_{I}\overline{X}^{T}$. As we show in the previous sections, immigrants arriving to Spanish regions are some-educated workers, which would imply a substitution away from low-skilled workers towards mainly medium-skilled. In the same way, regional-specific technology shocks imply the same movement away from low-skilled towards medium-skilled workers. Therefore, both changes imply the same change in $\Delta C_I \bar{X}^T$, but immigration-related adjustments would imply a declining (medium) skill premium and SBTC-related adjustment would imply a rising (medium) skill premium.

Results

The first three columns of Table 3A-3C show the three components of Eq. (2) for low-educated workers, medium-educated workers and high-educated workers, respectively, for the 17 regions. There are 25 industries in each region and the change in variables is over the period 1995-2002. Column (1) shows the change in regional factor supplies, column (2) shows mean unit factor requirements times the change in value added (summed over industries in a region), and column (3) shows the change in unit factor requirements times mean industry value added (summed over industries in a region). To control for regional business cycles, we divide both sides of Eq (1) by total regional employment and then perform the first difference in Eq (2). This makes the factor supply changes in column (1) equal to the change in the share of a given labour type in total regional employment.

Consider first the results for low-educated workers in Table 3A. The negative values in column (1) show that there was a decline in the share of employment for low-educated workers in all regions, despite regional differences remain significant. All regions but two (Balearic and Canary Islands) has positive real value added growth on average, which increased demand for all factors as indicated by the positive values in column (2). What allowed regions to accommodate that fall in the relative labour supply of less-educated workers was a decline in unit labour requirements for these workers, an indicated by the sign of column (3). Given that the relative wage of these workers fell over the period 1995-2002, this is consistent with skill-biased technological change.

Next, consider the results for those workers with medium-education and high-education, shown in Table 3B and 3C. Rising employment shares for medium and high-educated workers was accommodated by an increase in demand due to growth in real value added (positive values in column (2), except for Balearic and Canary Islands and Andalusia) and increases in unit labour supply (all of them positive in column (3)).

Table 3 indicated that changes in the supply of different labour types have been accommodated by a combination of output changes and factor usage changes. It says nothing, however, about the shocks that caused these changes. Changes in factor usage at a regional level could be due to changes in factor prices –resulting from a technological change, product price changes or other shocks– that differed across regions. Such a scenario would be inconsistent with output-mix hypothesis, since it would violate relative FPE across regions.

<INSERT TABLE 3 HERE>

To examine whether changes in unit labour requirements vary across regions, we implement the decomposition described in Eq (4). The last two columns of Table 3 report the results for Eq (4). Column (4) shows the generalised factor usage changes and column (5) shows the idiosyncratic changes in factor usage. The values in column (4) are similar to column (3) for all three education categories, and all idiosyncratic changes reported in column (5) are smaller in absolute value relative to generalised changes. So, Table 3 indicates that changes in regions' employment are accounted for by changes in production techniques that are common to all the Spanish economy and not by region-specific changes.

Table 4 shows the decomposition of changes in regions' labour supply by occupation categories. As by education categories, changes in regional factor supplies show a decrease in the share of employment for low-occupations and a rise in medium and high occupations. However, the pattern is not so clear than in the case of education levels. First, changes in employment shares are small and, second, there are a few regions were the share of employment in high occupations has decreased: Andalucía, Cantabria, Castilla-La Mancha, C. Valenciana, País Vasco and La Rioja. Nevertheless, as in Table 3, changes in the supply of different labour types have been accommodated by a combination of output and factor usage changes, mainly generalised product techniques changes.

<INSERT TABLE 4 HERE>

Thus, both according to educational and, to a lesser extent, according to occupational categories, the labour supply shock decomposition allow us extract some main ideas. Firstly, there are significant regional differences in labour supply shocks. Secondly, the evidence provides weak support to the idea that the labour supply shifts are absorbed by changes in the output mix (i.e. the Rybczynski effect). Finally, there is robust evidence mainly supporting a general, not region-specific, skill biased technological change in production techniques across Spanish regions which fits the decreasing trend of low-educated workers supply and the increase in medium-educated labour supply.

According to the Rybczynski Theorem, trade helps a region to adjust factor-supply shock by shifting their production towards traded goods that employ intensively the factors with expanding supplies. Therefore, it would be possible that the output mix absorption effect would be more evident in tradable outputs. Table 5 reports the decomposition in Eq. (6) for both education levels and occupational categories. Columns (1) and (5) show changes in the effective supply of different labour types, ΔV^E. Columns (2) and (6) show changes in traded output-mix, $\Delta X^T \overline{C}$. Columns (3) and (7) show idiosyncratic changes in traded product techniques. Finally, Columns (4) and (8) show the ratio between changes in traded output-mix and changes in the effective labour supply that is, $\Delta X^T \overline{C} / \Delta V^E$, which measures the relative contribution to factor absorption of changes in traded output. The first result which is shown by Table 5 is that effective supply shocks do not reflect a generalised education upgrading in the Spanish regions as the raw changes in factor supplies (ΔV in Tables 3 and 4) did. Moreover, the main feature from Table 5 is that ΔV^E has been accommodated, in a large proportion, by output changes in tradable sectors. Moreover, the proportion of endowment mix changes explained by output mix changes in tradable sectors is smaller for medium and high education and occupation categories than for low education and occupation categories.

<INSERT TABLE 5 HERE>

Table 6 reports the synthesis of Eq.(6) decomposition results shown in Table 5. The first four columns in Table 6 refer to labour-supply changes according to education categories. The effective factor-supply changes ΔV^{E} are matched by changes in output mix in tradable industries, in 43 of the 51 cases, and the correlation between both factors is around 0.5. The relevance of changes in the output mix in the absorption of labour supply changes, the ratio $\Delta X^{T}\overline{C}\ /\ \Delta V^{E}$, in average equals 1.37 (standard deviation of 3.4) but it is affected by some outliers, and its median value is 0.4. When we analyse each educational category separately, the relevance of changes in traded output accounting for most of factor absorption slightly decreases with the education level with a median value of the ratio of 0.52 for low-educated workers to 0.46 for high-educated labour. Therefore, the results point to a weak Rybczynski effect in Spanish regions, mainly in the less-educated categories, together with a non irrelevant idiosyncratic change in technology.

A similar picture arises when occupation categories are considered in the last four columns of Table 6. In this case, evidence points to a very weak Rybczynski effect -the mean of the ratio between the output mix changes and the effective labour supply shifts is 0.3 (standard deviation 2.32) and its median is 0.21- and mainly in low occupations, being the ratio median of 1.06.

<INSERT TABLE 6 HERE>

Therefore the relevance of changes in the output mix in the absorption of labour supply changes is larger in the educational and occupational categories in which immigrants are enclosed. This fact suggests the idea that a Rybczynski effect is observed in the Spanish regions but its magnitude is not very large given that Spanish regions are still immerse in the immigration wave that begun in the second half of the nineties. Additionally, Moreover, the higher rigidity of labour markets in Spanish regions does not facilitate the homologation of immigrant educational attainments and the fast response of production facing relative factor endowments shocks. These facts would suggests the idea that immigrants in Spanish regions are occupied in jobs that require less educational attainments that they have, reinforcing the over-education problem, and either pointing to the relative novelty of the immigration shock in Spanish regions' labour markets .

Testing for relative FPE across Spanish regions

In the previous section, we use an *accounting decomposition (shift-share)* method to test indirectly if the FPE theorem holds across Spanish regions. We saw that in all regions there was a shift away from the use of less-educated workers during the period 1995-2002 and that in most regions this shift matched the national shift away from these workers. Surprisingly the contribution of regional-specific technological changes to explain changes in factor endowment composition was large, which is an indication of regional-specific changes in relative factor prices. This finding raises a question: Is the variation in unit labour requirements across regions consistent with FPE? If we find this to be the case, then variation across regions in changes in unit labour requirements may reflect variation across regions in changes in factor prices, indicating that one way in which regions adjust to endowment shocks is through changes in factor prices relative to the rest of the country. The key idea is that FPE is consistent with wage differentials across regions, as long as these differentials are due to differences in regional technology or average factor quality that are uniform across industries. For example, wages are relatively high in Madrid as long as this is due to the fact that factors in Madrid are uniformly more productive in all industries (for whatever reason).

In this section we propose to test directly whether variation in unit labour requirement across regions is consistent with FPE[10]. The FPE theorem holds between two regions R and R' if

$$C^{R}(\bullet, W^{R})W^{R} = C^{R'}(\bullet, W^{R'})W^{R'}$$

[10] This analysis complements existing studies for factor price variation within Spain by Requena et al (2006, 2007). Using different techniques and data, both papers show that there are sufficient conditions to support the existence of FPE within Spain. Requena et al (2006) use a HOV equation across 14 Spanish regions in 1995 and Requena et al (2007) implement a "dynamic lens condition" across 50 Spanish provinces over the 1964-1998 period to test for the existence of FPE.

where W^R is a vector (Fx1) of factor remuneration in region *R*. In other words, unit labour cost for any production factor -or the product of unit input requirement and factor wage- must be the same for any pair of regions. In this setting, any supply shock (i.e. a factor endowment change, a technological change or a final goods price change) should have the same impact on the wage structure across regions. Therefore, we could test whether the FPE theorem holds in Spain by examining whether the Spanish regions have the same factor requirement matrix C.[11] But, considering that regional nominal wage differences may reflect differences in unobserved worker abilities, differences in regional technologies or factor immobility, controlling for inter-regional wage differences will be also important to test for FPE.

Consider that the technology of production in the industry i, in the region R is given by a CES production function:[12]

$$x_{iR} = \left(\sum_{f=1}^{F} \left(\pi_{fR} L_{fiR} \right)^{\rho_i} \right)^{\frac{1}{\rho_i}} \tag{7}$$

were π_{fR} is a productivity or quality adjustor of unities of factor *f* in region R in terms of productivity equivalent units of factor, which is industry-neutral, and L_{fiR} is the observed quantity of factor *f* used in region R and industry i. Under these conditions, the productivity-adjusted units of factor *f* used in regions *R* and *R'* are equivalent:

$$\pi_{fR} L_{fiR} = \pi_{fR'} L_{fiR'} \tag{8}$$

In the competitive case, both product prices P_R and observed factor prices W_{fR} in region *R* are exogenously given for firms. Under these conditions from the factor *f* first-order condition of the profit maximisation problem we obtain:

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[11] Notice that this is a sufficient, but not necessary, condition for FPE. If there are increasing returns to scale, regional differences in production technologies, or externalities in production, then regional unit factor requirements may not be equalized, even if there is regional FPE. Equal unit factor requirements across regions requires not just equal factor prices, but also the absence of significant scale effects, externalities, or arbitrary cross-regional differences in production technologies. Therefore, by comparing unit factor requirements across regions to test for FPE, we are forced to assume that these additional effects are inconsequential for relative regional factor prices

[12] We omit temporal sub-indexes in order to simplify the notation.

$$P_R\left(\frac{L_{fiR}}{x_{iR}}\right)^{\rho_i-1}\pi_{fR}^{\rho_i-1}=\frac{W_{fR}}{\pi_{fR}} \tag{9}$$

Proceeding in a similar way for region *R'*, we can compare productivity adjusted factor prices in both regions in relative terms:

$$\frac{P_R\left(\frac{L_{fiR}}{x_{iR'}}\right)^{\rho_i-1}\pi_{fR}^{\rho_i-1}}{P_{R'}\left(\frac{L_{fiR}}{x_{iR'}}\right)^{\rho_i-1}\pi_{fR'}^{\rho_i-1}}=\frac{\frac{W_{fR}}{\pi_{fR}}}{\frac{W_{fR'}}{\pi_{fR'}}} \tag{10}$$

Taking log in both sides of the expression (10) and re-arranging terms we obtain:

$$\ln c_{fiRt}=\ln\frac{\pi_{fR't}}{\pi_{fRt}}+\ln c_{fiR't}+\gamma_i\ln\left[\frac{W_{fR't}}{W_{fRt}}\frac{\pi_{fRt}}{\pi_{fR't}}\right] \tag{11}$$

where $\gamma_i = 1/(1-\rho_i)$.

Pooling all observations across region pairs, labour types, industries and years, we obtain the following empirical specification (including the sub-index t):

$$\ln c_{fiRt}=\alpha_{fRR't}+\beta\ln c_{fiR't}+\sum_i\gamma_i\ln\left(W_{fR't}/W_{fRt}\right)+\eta_{fiRt} \tag{12}$$

where $\alpha_{fRR't}=\ln(\pi_{fR't}/\pi_{fRt})$ and η_{fiRt} is the error term. For each of the 136 pairs of regions (R,R´) we have information about direct labour requirements in 25 sectors (i), three education (or occupational) levels (*f*) and two years (t), 1995 and 2002. For each pair (R,R´) the dependent variable is the unit factor requirements of region with the highest productivity and the explanatory variable is the unit factor requirements of the region with the lowest productivity. The number of dummy variables $\alpha_{fRR't}$ is equal to the combinations of region pair, labour type and year in each industry (816=136x3x2). The inclusion of fixed effects controls for Hicks-neutral differences in productivity across regions pairs. Finally, we include the interregional nominal wage differences, $\ln\left(W_{fR't}/W_{fRt}\right)$, as explanatory variable, which enters in equation (12) with an industry-specific coefficient, γ_i. The information on nominal wages is obtained directly from the *Survey of Wage Structure* (*Encuesta de Estructura de Salarios*). By pooling the 25 available industries, the maximum number of observations is 20400

(=816x25). However there are region pairs with no employment in some industries, labour types or years. Moreover, we lose additional observations when we use industry-specific regional nominal wages since the *Survey of Wage Structure* does not provide information for the following sectors: agriculture, social and personal services, public administration and home services. Appendix 1 provides more details. In that case, the maximum number of observations is 17136.

We use equation (12) to test three hypotheses. First, if all the fixed effects are equal to zero, then there are no Hicks-neutral productivity differences across Spanish regions. Second, if the industry-specific dummies γ_i are different from zero, then it would imply that part of the interregional differences in industry production techniques are due to region-specific causes associated to observed differences in nominal wages across regions.[13] Third, if we cannot reject the null of $\beta = 1$, then unit input requirements are the same across regions for the period 1995-2002 and the *FPE* condition holds.

There are two estimation issues related to equation (12). The first problem is that the OLS estimation method may be not efficient since the error term captures technological perturbations that could be correlated with labour types for each region pair, sector and year. A feasible solution is to allow the error terms to be correlated for those observations that have the same region, sector and year. The second problem is due to heterogeneity in the selection of region pairs. There are regions pairs for which the FPE condition will be more easily satisfied due to greater factor mobility or high similarity in their factor endowment distribution. The first sample includes all the regions pairs with non-zero observations of $\ln c_{fiR't}$. The second sample includes the 25 percent of those regions with the most similar factor endowment distribution in 1995. The sample is obtained using the least of the Euclidian distances.[14] The idea is to reduce the heterogeneity in the sample eliminating region pairs with high differences in the

[13] Hanson and Slaughter (2002) emphasized the importance of taking into account interregional differences in nominal wages to analyse interregional differences in production techniques. However, they lacked of information on wages.

[14] For two regions with factor employment *f*, v_{fR} y $v_{fR'}$ (normalised by total regional employment), the degree of similarity is measured as $\left[\sum_f (v_{fR} - v_{fR'})^2\right]^{1/2}$.

composition of activities within industries. We expect that the estimated β will be closer to 1 for the last sample.

Table 7 reports the estimation results. In the first three columns, labour is divided into three education categories while in the last three columns labour is divided into three occupation categories. The table contains two sections, one corresponding to the full sample of regions (A) and the other to the sub-sample of similarly endowed regions (B). Firstly, consider the full sample of regions (A) and the labour type by education levels (columns (1)-(3)). In column (1) the fixed effects for region-pair/factor/year grouping are jointly significantly different from zero (as they are in all the regressions), which is consistent with factor-specific, industry-neutral productivity differences across regions. The industry-specific coefficients on interregional differences on nominal wages are jointly significantly different from zero (as they are in all the regressions), suggesting that variation in the interregional differences in industry production techniques is due partly to region-specific causes associated to observed interregional differences in nominal wages[15].

The fixed effect coefficient β estimate when we include interregional differences in nominal wages is 0.854, which is significantly different from one at standard confidence levels. In column (2), the fixed effect coefficient estimate, when we include interregional differences in industry nominal wages is 0.896, still far from one. In column (3) we drop interregional nominal wage differences (so we estimate the Hanson and Slaughter specification) and the fixed effect coefficient β estimate is 0.850, which suggests that the omission of the interregional wage differences term does not generate a severe downward bias in the fixed effect coefficient estimate. Columns (4)-(6) reports similar results when we categorised labour types by occupation rather than by education. The fixed effect coefficient β estimates are slightly smaller (0.83) so they also suggest that FPE does not hold.

The section B of Table 7 reports results for the sub-sample of similarly endowed regions. We expect FPE to be more likely to hold within this sub-sample thanks to

[15] In column (1), 18 out of 25 industry-specific coefficients γ_i were negative and statistically significant. None of the positive coefficients was statistically significant except one.

stronger product-market linkages. However, in all the specifications we reject again the null that the slope coefficient equals to one. So far these results suggest that FPE does not hold. In addition, we also show that including interregional nominal wage differences in our specification (panel B, column (2)) is not enough to alleviate the lack of evidence in favour of FPE across Spanish regions.

Up to now our results derive the same conclusions as Hanson and Slaughter (2002) for a sample of US states. They investigated whether FPE may hold but is obscured by measurement error in the variables. The direct labour requirements are calculated using two different statistical sources, *Contabilidad Regional* for value added and employment and *Encuesta de Población Activa* for the percentage of participation of workers by region, sector and type of education (or occupation). It could be a measurement error if the average skill of workers varies across regions or if the composition of activities within each industry is very different across regions. In that case the OLS coefficient β will be bias towards zero when unit factor requirements are measured with error, rejecting systematically the *FPE* hypothesis. As we lack of appropriate variables to implement IV estimation methods, we follow Hanson and Slaughter approach. If there is only one regressor in the equation (as it is the case in column (3) and (6) of Table 7) we can use the "*inverse regression*" (Klepper and Leamer, 1984) and the "*extraneous information variance*" (EIV) method (Judge et al. 1980).[16]

Table 8 reports the estimation results to evaluate the importance of measurement error. The first column shows the forward regression estimates that are the same as those reported in columns (3) and (6) of Table 7. The second column presents the results of the reverse fixed-effect specification. All the coefficients are close to one

[16] In the "*inverse regression*" approach, asymptotically the true coefficient β will lie between the OLS coefficient from the original regression and the inverse of the OLS coefficient from the inverse regression. We want to test if the true β is equal to 1. In the EIV method, if we know the ratio between the variance of the true and the observed value of $\ln c_{fiR't}$, then it is possible to obtain a consistent estimator of β. Asymptotically, $\beta_{EIV} = \beta_{MCO} / \text{ratio of variances}$. If we assume that the unit factor requirement matrix for Spain as a whole is measured without error and the variance of the Spanish unit factor requirements is equal to the true variance of $\ln c_{fiR't}$, we can calculate the ratio of variances dividing the variance of the Spanish unit factor requirements and the variance of the observed values of $\ln c_{fiR't}$.

compared to those of the forward regression, but again we reject the null of the fixed effect coefficients being equal to one at standard confidence levels. The final column combines the information from the forward and reverse fixed-effect estimates, defining the asymptotic range in which lies the true value of β. In the specifications for the full sample and labour divided by education categories the range is [0.85, 1.02], indicating that the data are consistent with the hypothesis of FPE. When we use the second method of addressing measurement errors, the asymptotic range based on the coefficients of the forward EIV regression and the inverse of the reverse of the EIV regression is [0.93, 1.12]. This provides additional support for FPE. Moreover, we stronger confirm our previous hypothesis when we examine the sub-sample of similarly endowed regions given that in the EIV regressions the asymptotic range is narrower, [0.99, 1.01]. Furthermore, in all the specifications with labour divided by occupational categories the asymptotic range of the estimated fixed-effect coefficients contains the value of $\beta = 1$.

Conclusions

In this paper we analyze in a Heckscher-Ohlin framework the effects in the productive structure of the Spanish economy due to the immigrants' labour supply shock it is experiencing. This shock is being asymmetric across Spanish regions suggesting that the effect of immigration on labour markets could be different among Spanish regions and that adjustments mechanism to this supply shock could also differ. Moreover, there are differences in the qualification-mix between natives and immigrants, which may have leading to a change in the skill composition in the labour force across Spanish regions towards medium and high educated workers. Indeed there has been an increase in the use of medium and high-educated workers relative to low-educated workers over the period 1995-2002. However, this trend is not matched by a relative increase in medium and high qualified occupations.

We consider regions as small open economies and examine whether they have absorbed immigrant inflows by changes in output mix (Rybczynski effect) or changes in factor usage both at the national and regional level. We test "directly" for the output-mix hypothesis by means of a shift-share decomposition that allows us to identify whether regional output growth was relatively high in sectors that were intensive in the use of factor whose relative supplies were expanding. We extend the previous literature by considering not only education categories but qualification requirements of occupation so we can analyse up to which point the phenomenon of over-education in the labour force is important. Our results provide weak support to the idea that the labour supply shifts are absorbed by changes in the output mix. We find robust evidence supporting a general, not region-specific, skill biased technological change in production techniques across Spanish regions which fits the decreasing trend of low-educated workers supply and the increase in medium-educated labour supply. If we go deeper in our analysis and address directly to the effective factor-supply change faced by the tradable sectors, through which the Rybczynski effect is supposed to act, we find that a large proportion is explained by output changes in tradable sectors. Second, the proportion of endowment mix changes explained by output mix changes in tradable sectors is smaller for medium and high education and occupation categories than for low education and occupation categories. Third, our results point to the fact that the relevance of changes in output mix in the absorption of labour supply changes is larger in the educational and occupational categories in which immigrants are enclosed. Finally, we find that the contribution of regional-specific technological changes to explain changes in factor endowment composition is still large, opening the possibility that regional labour markets adjust not only by output mix changes but also though wages variation or interregional factor mobility.

Since our results point to a weak Rybczynski effect in the Spanish regions, we asked if that variation in unit labour requirements across regions is consistent with the FPE theorem. Our findings are consistent with productivity-adjust FPE across regions, after controlling for interregional nominal wage differences.

These findings raise the question whether it is possible that immigration wave is contributing to sustain wage and employment differentials across Spanish regions delaying their convergence. According to the Rybczynski Theorem, we should expect a shift to tradable goods in output-mix. However, the Spanish economy is highly specialized on services activities, especially those related to tourism. According to employment data, this pattern of specialization is being reinforced by immigration. Immigration, being accepting the low wages commonly paid on these services sectors, could be relieving relative cost pressure to change the pattern of specialization of the Spanish economy towards more technology intensive activities such as business services or high quality manufactures. So it would be also possible to find evidence of an output-mix shift towards non traded goods, shift that may be increase divergences across Spanish regions.

Finally we must interpret our results cautiously since Spanish regions are still immerse in the immigration wave that begun in the second half of the nineties. Moreover, the higher rigidity of labour markets in Spanish regions does not facilitate the homologation of immigrant educational attainments and the fast response of production facing relative factor endowments shocks. These facts would suggest the idea that immigrants in Spanish regions are occupied in jobs that require less educational attainments that they have, reinforcing the over-education problem and either pointing to the relative novelty of the immigration shock in Spanish regions' labour markets. Therefore the effects of the immigration shock may be fulfilled in a longer period of time that the one we cover at this paper.

Appendix 1. Data sources and variables

Value added and employment by industry and region

Industry real value added and employment at the regional level (NUTS II, Comunidades Autónomas) are from the *Contabilidad Regional de España* (CRE), published by INE. We measure industry value added at the regional level as real value added in 2002 euros. For all the non-market industries, we use the same value added deflator to measure the industry real value added. Industry employment at regional level is calculated using total number of full and part-time jobs. For both value added and employment, we use data for 1995 and 2002. The raw data are available at the two digit CNAE level (27 sectors). To ensure concordance with the EPA data (described below), we reduce the CRE industries into 25 sectors (listed in Table 4). The sectors "Education and health services” and “Social and personal services” include both the market and non-market activities.

Regional labour supplies by education category

We measure the total labour force by three education categories: workers with no education, primary school or some high school education (low); workers with completed high school or equivalent (medium); workers with a completed university degree or higher (high). We also divide total labour force into three occupational categories: white collar [managers, professionals, commercial and clericals] (low); skilled blue collar (medium); unskilled blue collar (high). These data come from the Spanish Labour Force Survey (*Encuesta de Población Activa* [EPA]). The EPA is a large micro dataset that reports information about 200,000 individuals on a quarterly basis. We concentrate on the second quarters of the EPA as they contain more detailed information on the labour market status of the individuals. We calculate the regional labour supply by education (or occupation) category by summing the population weights given in the EPA across all individuals that live in a given region and belong to a given educational (or occupation) category.

Employment and unit labour requirements by region, industry and education (or occupation)

To calculate employment by region, industry and education category, we combine data from CRE and EPA. First we calculate the employment weights using all individuals currently employed (or employed in the past, if unemployed) in a given region-industry that belong to each education category. We then used these totals to calculate the share of individuals in a given region-industry that belong to each education (or occupation) category. To reduce the measurement error in the labour composition by region, industry and education category, we use the average of the EPA 1995:II and 1996:II for the year 1995 and EPA 2002:II and 2003:II for the year 2002. To obtain unit labour requirements by region, industry and education (or occupation) category, we simply take the ratio of employment by region, industry and education (or occupation) category to value added by region and industry.

Nominal wages by region, industry and education (or occupation)

Data on nominal wages were obtained directly from the INE´s *Survey of Wage Structure* (*Encuesta de Estructura de Salarios*) in years 1995 and 2002. Our data set was elaborated on request by INE for the 17 regions, 25 industries, three education levels and three occupational categories. We use two nominal wages in the paper. First we refer to regional nominal wage as the average wage across all industries in each region. Second, we also use industry-specific nominal wages for each region in our estimations. In that case, the number of observations is reduced by tow facts. EES only provides disaggregated data for 21 out of 25 industries. We have no information for agriculture, government, personal and social services, household services. We do also lack of information for many industries due to statistical secrecy.

Appendix 2. Additional tables

Table A1.

Table A2.

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Table 1. Composition of regional labour supply by education and occupational level.

		EDUCATION			OCCUPATION		
		Low	Medium	High	Low	Medium	High
(A) Composition in 1995 and 2002							
España	1995	69.3	16.6	14.1	63.9	17.6	18.6
	2002	51.3	28.6	20.1	59.9	20.1	20.0
Andalucia	1995	75.1	12.8	12.1	64.8	15.4	19.8
	2002	59.6	23.7	16.7	63.7	17.1	19.1
Aragón	1995	68.1	16.1	15.8	63.6	17.6	18.8
	2002	49.1	30.1	20.8	61.4	18.2	20.4
Asturias	1995	66.5	19.0	14.5	65.7	15.9	18.4
	2002	48.1	31.8	20.1	62.9	17.7	19.4
Baleares	1995	74.1	16.2	9.7	65.1	19.0	15.9
	2002	55.2	30.3	14.5	61.0	20.5	18.5
Canarias	1995	71.5	15.8	12.7	66.6	16.3	17.1
	2002	55.6	28.1	16.3	63.4	19.0	17.6
Cantabria	1995	67.7	18.9	13.4	68.3	13.5	18.2
	2002	50.7	32.9	16.4	66.2	17.4	16.4
C-Leon	1995	67.6	18.1	14.3	67.1	14.1	18.7
	2002	51.0	28.2	20.8	63.1	16.8	20.1
C-Mancha	1995	79.0	11.2	9.8	70.2	12.2	17.6
	2002	61.4	23.6	15.1	66.8	15.1	18.0
Cataluña	1995	68.3	18.4	13.3	59.1	21.1	19.9
	2002	49.5	31.8	18.7	56.9	23.4	19.8
C. Valenciana	1995	74.0	14.3	11.7	65.7	16.4	17.9
	2002	58.7	24.2	17.1	64.3	17.7	18.0
Extremadura	1995	80.8	9.9	9.4	68.8	12.7	18.4
	2002	64.2	19.2	16.6	63.7	13.9	22.4
Galicia	1995	76.7	13.1	10.3	71.9	12.3	15.9
	2002	57.0	27.2	15.8	64.2	16.3	19.5
Madrid	1995	53.9	22.3	23.8	50.8	27.3	21.9
	2002	38.7	31.2	30.1	48.5	28.0	23.5
Murcia	1995	76.6	14.0	9.5	68.2	14.3	17.5
	2002	54.5	25.7	19.8	62.2	17.6	20.2
Navarra	1995	61.6	21.6	16.8	64.0	15.8	20.2
	2002	44.1	31.6	24.3	61.0	17.1	21.9
Pais Vasco	1995	60.0	22.6	17.4	58.6	19.9	21.5
	2002	38.7	37.3	24.0	58.3	20.6	21.1
Rioja	1995	66.9	17.9	15.1	66.0	15.0	19.0
	2002	52.8	28.1	19.1	63.0	16.5	20.6
(B) Change over the period 1995-2002							
España		-17.3	11.6	5.6	-2.7	2.0	0.8
Andalucia		-15.5	10.9	4.6	-1.0	1.7	-0.7
Aragón		-19.0	14.0	5.1	-2.2	0.6	1.6
Asturias		-18.4	12.8	5.7	-2.8	1.8	1.0
Baleares		-18.9	14.1	4.8	-4.1	1.5	2.6
Canarias		-15.9	12.3	3.6	-3.2	2.7	0.5
Cantabria		-17.0	14.0	3.0	-2.1	3.9	-1.8
C-Leon		-16.6	10.1	6.5	-4.0	2.6	1.4
C-Mancha		-17.6	12.3	5.3	-3.3	2.9	0.4
Cataluña		-18.8	13.4	5.5	-2.2	2.3	-0.1
C. Valenciana		-15.3	9.9	5.4	-1.4	1.4	0.0
Extremadura		-16.5	9.3	7.3	-5.1	1.1	4.0
Galicia		-19.6	14.1	5.6	-7.7	4.0	3.7
Madrid		-15.2	8.9	6.4	-2.3	0.7	1.6
Murcia		-22.0	11.7	10.3	-6.0	3.3	2.7
Navarra		-17.5	10.0	7.5	-3.0	1.3	1.7
Pais Vasco		-21.3	14.6	6.6	-0.3	0.7	-0.4
Rioja		-14.1	10.2	3.9	-3.0	1.4	1.6

Note: Own elaboration using Encuesta Población Activa. Education levels: Low=primary education or less; Medium=high school or equivalent; High=university degree or equivalent. Occupational level: Low = blue collar workers; Medium =clerical, administrative, technical; High = professionals and managers.

Table 2. Spanish industry factor intensity, 1995 and 2002

		EDUCATION		OCCUPATION	
	Tradable?	Medium/Low	High/Low	Medium/Low	High/Low
Education and health		0.92	1.72	0.09	0.15
Financial intermediates		1.26	2.02	22.05	5.86
Real state services and firm services		0.38	0.43	0.05	0.09
Public Administration		0.63	0.58	0.03	0.18
Enery and water		0.54	0.33	0.11	0.08
Chemicals	T	0.34	0.55	0.25	0.15
Electric, electronic and optic products	T	0.70	0.29	0.07	0.05
Social and personal services		0.48	0.22	0.11	0.05
Paper, printing, editing	T	0.47	0.20	0.09	0.09
Transport and communications		0.34	0.18	0.11	0.06
Extractives		0.30	0.08	0.03	0.05
Transport equipment	T	0.51	0.17	0.01	0.04
Mechanical machinery	T	0.51	0.16	0.12	0.04
Plastic, rubber	T	0.46	0.11	0.08	-0.01
Sales and distribution		0.42	0.09	0.05	-0.06
Metallic products	T	0.29	0.04	0.01	-0.01
Food, drink, tobacco	T	0.22	0.04	0.02	0.01
Non-metallic minerals	T	0.23	0.04	0.06	0.01
Construction		0.15	0.03	0.02	0.01
Hotels and restaurants		0.23	0.06	0.01	-0.07
Textil, clothing, leather	T	0.09	0.04	0.07	0.01
Other manufactures	T	0.22	0.05	0.09	0.03
Wood products	T	0.20	0.04	0.02	0.01
Agriculture	T	0.09	0.03	0.01	0.02
Household services		0.16	0.03	-0.01	-0.01

Note: Each cell reports the variation in the ratio of national employment of the tertiary and secondary educated (high white collar and medium white collar) workers with respect to the employment in primary educated (manual) workers for the industry during the period 1995-2002.Sectors are ranked accordingly to high-educated factor intensity in 1995. T stands for tradable sectors. Education levels: Low=primary education or less; Medium=high school or equivalent; High=university degree or equivalent. Occupational level: Low = blue collar workers; Medium =clerical, administrative, technical; High = professionals and managers.

Table 3. Employment decompositions by education levels

A. Low education	ΔV	$\bar{C}$ ΔX	ΔC $\bar{X}$	$\Delta C_G \bar{X}$	$\Delta C_I \bar{X}$
Andalucia	-12.41	0.19	-12.59	-18.01	5.42
Aragón	-18.04	1.43	-19.47	-17.30	-2.18
Asturias	-18.06	1.88	-19.94	-16.29	-3.65
Baleares	-15.41	-3.81	-11.60	-15.49	3.89
Canarias	-13.75	-2.54	-11.20	-16.28	5.07
Cantabria	-14.29	1.37	-15.66	-16.28	0.62
C-Leon	-15.64	3.15	-18.78	-16.44	-2.35
C-Mancha	-14.88	2.30	-17.17	-19.16	1.98
Cataluña	-16.02	1.26	-17.28	-15.50	-1.78
C. Valenciana	-13.24	1.16	-14.40	-17.91	3.51
Extremadura	-15.30	5.78	-21.09	-20.07	-1.02
Galicia	-16.54	6.27	-22.81	-18.63	-4.18
Madrid	-13.79	1.34	-15.13	-13.97	-1.16
Murcia	-14.70	2.70	-17.39	-18.11	0.71
Navarra	-18.67	2.40	-21.08	-15.87	-5.20
Pais Vasco	-19.69	2.09	-21.78	-15.58	-6.20
Rioja	-14.99	4.24	-19.23	-18.31	-0.92
B. Medium education	ΔV	$\bar{C}$ ΔX	ΔC $\bar{X}$	$\Delta C_G \bar{X}$	$\Delta C_I \bar{X}$
Andalucia	10.45	-0.65	11.10	9.20	1.90
Aragón	13.19	0.59	12.61	11.86	0.74
Asturias	12.16	1.47	10.69	14.62	-3.93
Baleares	13.63	-0.72	14.36	12.00	2.35
Canarias	12.15	-1.04	13.19	11.69	1.49
Cantabria	12.94	0.43	12.51	14.30	-1.79
C-Leon	9.55	1.79	7.77	13.22	-5.45
C-Mancha	10.92	1.10	9.83	8.33	1.50
Cataluña	11.47	0.47	11.00	10.42	0.58
C. Valenciana	9.78	0.17	9.60	10.17	-0.57
Extremadura	9.31	1.21	8.10	7.91	0.19
Galicia	12.32	2.34	9.99	10.73	-0.74
Madrid	9.34	0.85	8.49	14.86	-6.36
Murcia	8.91	0.22	8.69	10.16	-1.47
Navarra	10.88	1.45	9.43	17.15	-7.72
Pais Vasco	14.94	1.07	13.87	17.38	-3.51
Rioja	10.10	1.36	8.74	13.32	-4.58
C. High education	ΔV	$\bar{C}$ ΔX	ΔC $\bar{X}$	$\Delta C_G \bar{X}$	$\Delta C_I \bar{X}$
Andalucia	1.96	-0.72	2.68	4.41	-1.73
Aragón	4.85	0.33	4.52	6.03	-1.52
Asturias	5.84	0.66	5.18	4.69	0.49
Baleares	2.78	-0.30	3.07	5.17	-2.09
Canarias	1.59	-1.30	2.89	4.93	-2.04
Cantabria	1.35	-0.62	1.97	5.75	-3.78
C-Leon	6.08	0.99	5.09	5.32	-0.23
C-Mancha	3.95	0.39	3.56	3.68	-0.12
Cataluña	4.55	0.06	4.49	5.95	-1.46
C. Valenciana	3.46	0.41	3.05	4.65	-1.59
Extremadura	5.99	0.87	5.12	3.13	1.99
Galicia	4.21	1.37	2.85	4.13	-1.29
Madrid	4.45	0.58	3.87	9.80	-5.93
Murcia	5.79	0.42	5.37	3.28	2.09
Navarra	7.80	0.47	7.32	5.52	1.80
Pais Vasco	4.75	0.05	4.70	7.53	-2.83
Rioja	4.89	0.78	4.11	8.51	-4.40

Decomposition based on equations (2) and (4). Education levels: Low=primary education or less; Medium=high school or equivalent; High=university degree or equivalent.

Table 4. Employment decompositions by occupation categories

Low occupation	ΔV	$\overline{C}$ ΔX	ΔC $\overline{X}$	$\Delta C_G \overline{X}$	$\Delta C_I \overline{X}$
Andalucia	-0.03	0.34	-0.37	-3.76	3.39
Aragón	-1.40	1.58	-2.98	-4.13	1.15
Asturias	-3.14	1.77	-4.91	-3.49	-1.42
Baleares	-3.38	-4.09	0.71	-0.97	1.68
Canarias	-2.18	-2.76	0.58	-1.76	2.34
Cantabria	0.12	1.54	-1.42	-3.60	2.18
C-Leon	-3.59	3.79	-7.37	-3.77	-3.61
C-Mancha	-1.13	1.94	-3.07	-4.60	1.53
Cataluña	-2.35	1.51	-3.85	-2.92	-0.93
C. Valenciana	-0.54	1.11	-1.65	-3.77	2.11
Extremadura	-4.14	5.47	-9.61	-5.32	-4.29
Galicia	-5.44	6.64	-12.08	-6.82	-5.26
Madrid	-1.88	1.42	-3.31	-1.84	-1.47
Murcia	-1.50	2.36	-3.87	-4.47	0.61
Navarra	-2.00	3.43	-5.43	-3.57	-1.86
Pais Vasco	0.82	2.85	-2.03	-2.61	0.58
Rioja	-1.26	5.09	-6.35	-4.46	-1.88
Medium occupation	ΔV	$\overline{C}$ ΔX	ΔC $\overline{X}$	$\Delta C_G \overline{X}$	$\Delta C_I \overline{X}$
Andalucia	0.86	-0.70	1.56	1.38	0.19
Aragón	0.08	0.48	-0.39	1.95	-2.34
Asturias	2.01	0.94	1.07	1.61	-0.54
Baleares	1.05	-0.16	1.21	2.39	-1.18
Canarias	2.12	-0.84	2.96	1.64	1.33
Cantabria	2.27	-0.28	2.55	1.08	1.47
C-Leon	2.03	1.32	0.71	1.37	-0.65
C-Mancha	1.62	0.83	0.78	1.00	-0.21
Cataluña	2.21	0.39	1.82	3.08	-1.27
C. Valenciana	1.27	0.04	1.23	2.27	-1.04
Extremadura	0.80	0.78	0.02	0.92	-0.90
Galicia	2.65	1.65	1.00	1.31	-0.30
Madrid	0.32	1.03	-0.71	2.74	-3.45
Murcia	0.78	0.09	0.69	1.55	-0.86
Navarra	1.36	0.60	0.76	2.07	-1.31
Pais Vasco	0.06	0.26	-0.20	2.82	-3.01
Rioja	1.42	0.54	0.88	1.68	-0.80
High occupation	ΔV	$\overline{C}$ ΔX	ΔC $\overline{X}$	$\Delta C_G \overline{X}$	$\Delta C_I \overline{X}$
Andalucia	-0.83	-1.21	0.38	0.80	-0.41
Aragón	1.32	0.29	1.03	1.25	-0.23
Asturias	0.91	0.84	0.07	0.77	-0.70
Baleares	2.44	-0.53	2.97	1.58	1.39
Canarias	0.03	-1.36	1.39	0.80	0.59
Cantabria	-2.13	-0.03	-2.10	1.01	-3.11
C-Leon	1.56	0.82	0.74	0.69	0.05
C-Mancha	-0.48	1.02	-1.50	0.63	-2.13
Cataluña	0.14	-0.22	0.36	1.64	-1.28
C. Valenciana	-0.73	-0.23	-0.50	1.35	-1.85
Extremadura	3.07	1.27	1.80	0.41	1.39
Galicia	2.78	1.67	1.11	0.67	0.44
Madrid	1.57	0.32	1.25	3.28	-2.03
Murcia	0.75	-0.06	0.81	0.70	0.11
Navarra	0.64	0.29	0.35	1.47	-1.13
Pais Vasco	-0.54	-0.02	-0.52	1.58	-2.10
Rioja	-0.34	0.57	-0.92	1.41	-2.32

Decomposition based on equations (2) and (4). Occupational level: Low = blue collar workers; Medium =clerical, administrative, technical; High = professionals and managers.

Table 5. Extended employment decompositions by education and occupation categories

	Education levels				Occupational categories			
A. Low	ΔV^E	ΔX^T	$\Delta C_I X^T$	ratio	ΔV^E	ΔX^T	$\Delta C_I X^T$	ratio
Andalucia	1.50	0.70	0.80	0.47	1.02	0.74	0.28	0.73
Aragón	-0.95	0.10	-1.05	-0.10	0.86	0.07	0.79	0.08
Asturias	-5.39	-0.76	-4.63	0.14	-4.30	-1.21	-3.09	0.28
Baleares	-0.04	-0.85	0.81	20.98	-0.37	-0.87	0.50	2.35
Canarias	-1.86	-2.61	0.75	1.40	-2.67	-2.82	0.15	1.06
Cantabria	-1.02	-1.43	0.40	1.39	0.13	-0.88	1.51	-6.54
C-Leon	-1.09	-0.27	-0.83	0.24	-0.44	-0.09	-0.35	0.21
C-Mancha	1.81	-0.56	2.37	-0.31	1.55	1.67	-0.11	1.07
Cataluña	0.26	0.52	-0.26	2.01	0.15	0.63	-0.49	4.25
C. Valenciana	-0.63	-1.70	1.07	2.70	-1.32	-1.78	0.46	1.35
Extremadura	1.61	3.41	-1.80	2.12	1.27	3.39	-2.11	2.66
Galicia	-2.03	-1.56	-0.47	0.77	-2.52	-1.82	-0.70	0.72
Madrid	-0.07	-0.01	-0.06	0.14	-0.79	0.06	-0.85	-0.08
Murcia	1.01	0.71	0.30	0.70	2.19	0.58	1.61	0.27
Navarra	0.11	1.19	-1.07	10.62	2.09	1.89	0.21	0.90
Pais Vasco	-1.76	1.04	-2.79	-0.59	1.35	1.50	-0.16	1.12
Rioja	1.09	2.26	-1.17	2.07	0.95	2.71	-1.76	2.85
B. Medium	ΔV^E	ΔX^T	$\Delta C_I X^T$	ratio	ΔV^E	ΔX^T	$\Delta C_I X^T$	ratio
Andalucia	0.29	0.00	0.28	0.01	-0.01	-0.06	0.06	9.80
Aragón	0.66	0.31	0.35	0.47	-0.74	-0.31	-0.44	0.41
Asturias	0.03	0.27	-0.24	8.36	-0.64	0.21	-0.85	-0.32
Baleares	-0.49	-0.19	-0.30	0.39	0.24	-0.13	0.37	-0.56
Canarias	-0.90	-0.36	-0.54	0.40	-0.29	-0.15	-0.13	0.54
Cantabria	0.70	0.09	0.61	0.12	0.29	0.09	0.19	0.33
C-Leon	-0.76	0.47	-1.22	-0.62	-0.03	0.29	-0.32	-8.58
C-Mancha	0.51	0.07	0.45	0.13	0.14	0.15	-0.01	1.04
Cataluña	-0.55	-0.31	-0.24	0.56	-0.30	0.18	-0.48	-0.58
C. Valenciana	-0.36	-0.20	-0.17	0.54	-0.62	-0.10	-0.52	0.16
Extremadura	0.62	0.41	0.21	0.66	0.06	0.07	0.00	1.07
Galicia	1.01	0.81	0.20	0.80	-0.02	-0.03	0.01	1.30
Madrid	-1.93	-0.24	-1.69	0.12	-1.43	-0.07	-1.36	0.05
Murcia	1.14	0.18	0.96	0.16	-0.68	0.12	-0.80	-0.18
Navarra	1.07	1.12	-0.05	1.04	-0.64	0.44	-1.08	-0.68
Pais Vasco	0.25	0.81	-0.56	3.21	-1.26	0.35	-1.61	-0.28
Rioja	-0.80	0.79	-1.60	-0.98	-0.17	0.32	-0.50	-1.86
C. High	ΔV^E	ΔX^T	$\Delta C_I X^T$	ratio	ΔV^E	ΔX^T	$\Delta C_I X^T$	ratio
Andalucia	-0.42	-0.01	-0.41	0.03	-0.42	-0.11	-0.31	0.27
Aragón	0.12	0.10	0.01	0.88	-0.29	0.14	-0.43	-0.48
Asturias	-0.37	-0.06	-0.31	0.16	0.21	0.01	0.20	0.05
Baleares	-0.28	-0.07	-0.20	0.26	-0.71	-0.07	-0.64	0.10
Canarias	-0.23	-0.11	-0.12	0.48	-0.10	-0.20	0.10	2.00
Cantabria	-0.53	0.11	-0.64	-0.21	-0.53	0.10	-0.63	-0.19
C-Leon	0.24	0.14	0.10	0.59	-0.19	0.15	-0.33	-0.78
C-Mancha	-0.24	0.01	-0.25	-0.06	-0.60	0.04	-0.63	-0.07
Cataluña	-0.71	-0.11	-0.60	0.16	-0.90	0.13	-1.03	-0.15
C. Valenciana	-0.47	-0.07	-0.41	0.15	-0.78	-0.08	-0.69	0.11
Extremadura	0.32	0.07	0.25	0.23	0.21	0.10	0.11	0.48
Galicia	0.04	0.25	-0.21	5.75	0.22	0.32	-0.10	1.45
Madrid	-1.76	-0.09	-1.67	0.05	-0.42	-0.06	-0.36	0.13
Murcia	0.88	0.04	0.84	0.04	0.28	0.12	0.16	0.43
Navarra	0.31	0.28	0.03	0.92	-0.87	0.26	-1.13	-0.30
Pais Vasco	0.21	0.11	0.10	0.53	-0.30	0.20	-0.49	-0.67
Rioja	-1.09	0.12	-1.21	-0.11	-0.15	0.27	-0.43	-1.80

Decomposition based on Eq. (6). Education levels: Low=primary education or less; Medium=high school or equivalent; High=university degree or equivalent. Occupational level: Low = blue collar workers; Medium =clerical, administrative, technical; High = professionals and managers. Ratio= $\Delta X^T \overline{C} / \Delta V^E$.

Table 6. Changes in the output mix relative to labour supply changes ($\Delta X^T \overline{C} / \Delta V^E$).

	Educational categories				Occupational categories			
	Total	Low	Medium	High	Total	Low	Medium	High
Median	0.40	0.77	0.40	0.16	0.21	1.06	0.05	0.05
Mean	1.37	2.63	0.90	0.58	0.30	2.35	0.10	0.04
S.d.	3.40	5.37	2.11	1.37	2.32	6.73	3.34	0.84
$\text{corr}(\Delta V^E, \Delta X^T \overline{C})$	0.50	0.52	0.50	0.46	0.72	0.77	-0.07	0.17
Sign Test	43 / 51	14 / 17	15 / 17	14 / 17	33 / 51	15 / 17	9 / 17	11 / 17

Note: We report a synthesis of the decomposition based on Eq. (6) according to both education and occupation categories. The table is elaborated using the results in Table 5. The first four columns refer to labour-supply changes according to education categories. The last four columns refer to labour-supply changes according to occupation categories. The sign test counts the number of times that the sign of ΔV^E coincides with $\Delta X^T \overline{C}$. The median, mean and standard deviation (S.d.) are computed based on the results for the ratio $\Delta X^T \overline{C} / \Delta V^E$, that measures the relevance of changes in the output mix in the absorption of labour supply changes.

Table 7. Regressions testing for FPE

	By education			By occupation		
	(1)	(2)	(3)	(4)	(5)	(6)
	Regional wage	Regional and industry wage	No regional wage	Regional wage	Regional and industry wage	No regional wage
A. Sample with all regions						
FE coefficient β estimate	0.854	0.896	0.850	0.833	0.839	0.829
Standard error	(0.021)	(0.021)	(0.021)	(0.020)	(0.022)	(0.022)
R-squared	0.93	0.94	0.92	0.93	0.90	0.92
P-value fixed effects	0.00	0.00	0.00	0.00	0.00	0.00
P-value ind-specific wages	0.00	0.00	-	0.00	0.00	-
N	18335	11254	18335	17805	8324	17805
B. Sample with similarly endowed regions						
FE coefficient β estimate	0.862	0.885	0.825	0.832	0.842	0.822
Standard error	(0.019)	(0.030)	(0.022)	(0.024)	(0.030)	(0.025)
R-squared	0.94	0.96	0.92	0.95	0.90	0.94
P-value fixed effects	0.00	0.00	0.00	0.00	0.00	0.00
P-value ind-specific wages	0.00	0.00	-	0.00	0.00	-
N	4540	2738	4540	4422	1953	4422

Note: The table reports regressions of equation (12) in which the dependent variable is the log production technique for the high-productivity region and the production techniques of the other region (the low-productivity one) is the explanatory variable. Data are pooled across unique region pairs (136), industries (24), education (or occupation) categories (3), and years (2). The full sample includes all region pairs; the sample of similarly endowed regions includes the 34 region pairs (25% of pairs) with the most similar relative labour supplies in 1995. All regressions include dummy variables for region pair, education (or occupation) category and year combinations and are weighted by employment in the region industry. The reported standard errors are corrected for covariation in the errors across observations that have the same region, industry and year.

Table 8. Robustness analysis.

BY EDUCATION		Forward regression	Reverse regression	Asymptotic range	
All regions N=18335	FE coefficient β estimate	0.850	0.981	0.85	1.02
	standard error	(0.021)	(0.030)		
	R-squared	0.92	0.92		
	P-value fixed effects	0.00	0.00		
	EIV coefficient estimate	1.115	1.079	1.12	0.93
Similarly endowed regions N=4540	FE coefficient β estimate	0.825	0.971	0.83	1.03
	standard error	(0.030)	(0.044)		
	R-squared	0.89	0.94		
	P-value fixed effects	0.00	0.00		
	EIV coefficient estimate	1.012	1.007	1.01	0.99

BY OCCUPATION		Forward regression	Reverse regression	Asymptotic range	
All regions N=17805	FE coefficient β estimate	0.829	0.971	0.83	1.03
	standard error	(0.022)	(0.023)		
	R-squared	0.92	0.92		
	P-value fixed effects	0.00	0.00		
	EIV coefficient estimate	1.003	1.026	1.00	0.97
Similarly endowed regions N=4422	FE coefficient β estimate	0.822	0.967	0.82	1.03
	standard error	(0.023)	(0.037)		
	R-squared	0.94	0.90		
	P-value fixed effects	0.00	0.00		
	EIV coefficient estimate	1.120	1.098	1.12	0.91

Note: The table reports regressions of equation (12) without the regional wage difference term. In the the forward regressions we regress the log production techniques for high-productivity regions on log production techniques for low-productivity regions. In the reverse regressions, the dependent variable and independent variable are interchanged. Data are pooled across unique region pairs (136), industries (24). education (or occupation) categories (3), and years (2). The full sample includes all region pairs; the sample of similarly endowed regions include the 34 region pairs (25% of pairs) with the most similar relative labour supplies in 1995. All regressions include dummy variables for region pair, education (or occupation) category and year combinations and are weighted by employment in the region industry. The reported standard errors are corrected for covariation in the errors across observations that have the same region, industry and year. Errors-in-variables (EIV) coefficient estimates adjust OLS estimates by the ratio of the variance of the "true" regressor (i.e. measured without error) to the variance of the observed regressor, where this variance ratio is calculated using sample data and data on production techniques for Spain as a whole.

Appendix

Table A1. Distribution of immigrants by region

	1995	2002
Cataluña	21.20	24.88
Madrid	20.62	20.65
Andalucia	13.12	12.42
C. Valenciana	11.12	10.48
Canarias	10.43	6.98
Baleares	5.70	4.60
Galicia	3.27	2.30
Castilla-Leon	2.79	2.72
Pais Vasco	2.44	1.83
Murcia	1.47	4.01
Castilla-Mancha	1.24	1.91
Asturias	1.21	0.93
Aragón	1.17	1.97
Navarra	0.87	1.44
Extremadura	0.84	1.04
Cantabria	0.57	0.65
La Rioja	0.35	0.78
Ceuta-Melilla	0.34	0.40
Total immigrants	499733	1324001
Total population	39343100	40847371
% immigration	1.27	3.24
Top four	66.06	68.43
Top six	82.19	80.01

Source: Anuario de Extranjería 1996 y 2002.
Total population comes from INE.

Table A2. Composition of labour supply by education and occupation categories

Labour force	Year	Share	Share by educational level			Share by occupational level		
			Low	Medium	High	Low	Medium	High
Total	1995	100	69.3	16.6	14.1	63.9	17.6	18.6
	2002	100	51.3	28.6	20.1	59.9	20.1	20.0
Immigrants	1995	1.0	46.9	23.9	29.2	58.2	12.4	29.5
	2002	3.6	44.9	35.3	19.9	75.0	11.6	13.4
Rest of	1995	99.0	69.5	16.6	13.9	63.9	17.6	18.4
labour force	2002	96.4	51.6	28.3	20.1	59.8	20.1	20.1

Notes: Own elaboration using Encuesta Población Activa (EPA). Education levels: Low=primary education or less; Medium=high school or equivalent; High=university degree or equivalent. Occupational level: Low = blue collar workers; Medium =clerical, administrative, technical; High = professionals and managers.