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A Firm-Level Perspective on Migration

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A firm level perspective on migration

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Abstract

A production-theory approach to migration is adopted in this paper to address the role of migrant workers from extra-EU countries in Italian manufacturing production at the firm-level. The use of flexible functional forms to model firm-level technology lets us directly derive different measures of elasticity from the coefficients of the estimated production and cost functions.

Cross price and demand elasticities confirm the complementarity found in previous studies between migrants and natives. However, the two labour inputs prove to be substitute in terms of Morishima elasticity of substition.

The use of foreign labour is shown to affect also the industry composition. We find that, *ceteris paribus*, had migrant labour not grown in our sample period, the weight of Low Skill intensive sectors would have been approximately 2% lower and the white to blue collars ratio would have been slightly higher than observed, even accounting for the complementarity between natives and migrants.

Keywords: migrant workers, manufacturing production technology, elasticity of substitution.

JEL Classification: F22, D22, J61, L60.

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1 Introduction

Immigration, and specifically workers' mobility, is a wide and complex phenomenon that has long since drawn the attention of social sciences. Large inflows of immigrants, mainly from developing countries, have raised doubts on the absorbing capacity of developed economies: public opinion is often concerned that immigrants take jobs away from native workers, and burden on developed countries' welfare systems already fighting with population aging and birth rates decline.

Even if a consensus has not been reached yet as far as immigration impact on host countries' wages and employment is concerned, many empirical studies find only modest evidence of detrimental effects, or even no evidence at all (Card, 2001; Ottaviano and Peri, 2011). The crucial point in this context is whether immigrant workforce could substitute or complement the native one in terms of skill levels.

A mechanism of labour market segmentation might be at work: immigrant workers specialise in jobs that are typically manual and low-skill intensive, while native workers prefer high-skill intensive occupations, or simply jobs requiring different levels of ability in terms of language and communication tasks (Peri and Sparber, 2009). Moreover, it could be the case that the production structure is directly affected by immigration flows. Thanks to the increased availability of low-skilled workers, the industry composition might shift towards low-skill intensive sectors and technologies, and the consequent reallocation of resources may cushion the original impact on wages and employment rates (Lewis, 2011).

Although factor complementarity and substitutability actually depict firm's decision over production techniques, very little firm-level evidence exists on the role of immigrant labour inside the production process. The vast majority of the studies investigates the effects of immigration for native workers by means of Census or Labour Force Survey data[1].

Following Grossman (1982) and Kohli (1999) in this paper we adopt a production-theory approach to migration and treat foreign labour services as a technological input. However, to the best of our knowledge this is the first attempt to investigate the issue by means of estimations based on firm-level data instead of aggregate data. Making use of the 9^{th} wave of the Survey on Manufacturing Firms carried out by Capitalia in 2004 (with information on the period 2001-2003), our contribution is meant to add to the existing evidence

[1] To cite a few works, Card (2001), Borjas (2003), Borjas, Grogger, and Hanson (2008), Peri (2009) and Ottaviano and Peri (2011) are based on U.S. Census or Labour Force Survey and find mixed evidence on the effect of migrants on natives'employment and wage rates. For Europe there is some evidence of a small decrease in natives' wages in France (Hunt, 1992), while no significant impact emerges for Germany (Pischke and Velling, 1997; D'Amuri, Ottaviano, and Peri, 2010) and Spain (González and Ortega, 2011). Using data from the European Labour Force Survey for 14 EU countries, also D'Amuri and Peri (2011) find no evidence for a decrease in natives' employment rates due to immigration. Significant evidence is instead provided of a change in the occupational distribution of native workers that move from manual-routine tasks (now performed by immigrants) to more complex jobs. For Italy Gavosto, Venturini, and Villosio (1999) use administrative data and find a positive impact of immigration on the wages of natives. Immigrant workers seem to do those jobs that native workers do not will to accept anymore and in Northern Italy, where most immigrants are settled, the probability of finding a job is either positively affected or not affected at all by the share of immigrants in the region (Venturini and Villosio, 2006). As a consequence, no wage or employment assimilation emerges (Venturini and Villosio, 2008).

in two respects. On one hand, we investigate how immigrant workers directly contribute to the production process of Italian firms. On the other hand, we try to shed light on the type of relationship (complementarity/substitutability) existing between immigrant labour and the other inputs in the production process, especially native labour, by means of several measures of substitutability.

From the estimation of a production and a cost function we retrieve direct estimates of price and demand elasticities and from the latter we further derive the Morishima elasticity of substitution (*MES*). We start considering a technology with five inputs of production: domestic labour, foreign labour, capital, material and services. Since foreign labour employed in Italian manufacturing seems a rather homogeneous factor, the large majority of immigrant workers performing low skilled jobs, while domestic lavour is definitely not, we proceed with the estimation of a six-inputs function where domestic labour is split into high skilled and low skilled labour.

Analysing the role of foreign labour in Italian manufacturing production is an interesting empirical experiment since the country has experienced in recent years rapidly growing migration inflows from developing countries. Despite the labour market evidence of complementarity between migrants and natives (Gavosto, Venturini, and Villosio, 1999) and the fact that most of the immigrant workforce is employed in sectors such as construction and services (Istat, 2009) that domestic workers usually try to avoid, complaints about migrant workers stealing jobs to natives within the manufacturing sector are still frequent.

Additionally, it is useful to investigate which role foreign labour may play in shaping production techniques and hence the future prospects of Italian manufacturing whose decline is often ascribed to the lack of innovation and technological advances inside Italian firms. In this respect, an inflow of low skilled migrants might even stimulate the adoption of less skill intensive techniques and a further contraction of technological upgrading (Lewis, 2011).

Our work is organized as follows: Section 2 offers a review of the main contributions on the topic. The data and the empirical model are presented respectively in Sections 3 and 4. Results from the estimates are discussed in Section 5 while Section 6 concludes.

2 The literature

As already suggested in the introduction, one possible explanation for the fact that many studies fail to find a significant impact of immigration inflows on either employment or wages of native workers is strictly related to the structure of the production sector. An increased availability of low-skilled workers could generate a reallocation of resources in different directions: toward sectors where production is low-skilled labour intensive; inside sectors, towards firms that use low-skill intensive technology; or even inside firms, towards goods of such a kind.

Using data from the Spanish Labour Force Survey and Social Security records, González and Ortega (2011) find that in Spain migration inflows caused mainly within-industry adjustments. The inflow of unskilled migrant workers into a region is almost completely absorbed through an increase in the intensity of use of unskilled labour in the typical industry for that region, given the output mix, while changes in the scale of production in some industries at unchanged skill intensities (between-industry absorption) play a very minor role.

A similar result is presented in Dustmann and Glitz (2008) for Germany. Changes in relative labour supply due to immigration are shown to be accommodated within rather than between industries with technology adjustments (mostly of firms in tradable industries) taking place at firm level.

Similarly Card and Lewis (2005) and Lewis (2011) show that, while a change in the national industry composition is not supported by empirical evidence, inside different U.S. production sectors low qualified Mexican immigration has been absorbed mainly by the firms that were already using low-skill intensive technologies. An opposite effect (*i.e.* a shift towards more skill intensive firms) was sorted out in Israel because of the high-skilled immigrants coming from Russia (Gandal, Hanson, and Slaughter, 2004).

At the firm level, again Lewis (2011) analyses the relationship between the use of automation technologies and immigration in U.S. metropolitan areas and finds that the latter has a negative causal impact on the former. This means that an increase in the supply of low-skilled workers induces firms to downgrade the technology they are using in the production process, moving from capital-intensive to labour-intensive techniques.

A different perspective is adopted in Malchow-Møller, Munch, and Skaksen (2009). If labour markets are not fully competitive, the aggregate supply side approach is not able to capture the fact that an increased use of immigrants could influence wage formation at the firm level due to bargaining effects or efficiency wages. What matters is that immigrants, and typically those from less developed countries, have much worse outside options compared to native workers. By setting up an efficiency wage model with linked employer-employee data on Denmark, they test the empirical hypothesis that a higher share of immigrants from less developed countries hired in the firm reduces the firm-specific wages of native workers. Estimates show that this is indeed the case and that high-skilled and low-skilled natives are almost equally affected by the use of immigrant workers.

Campos-Vazquez (2008) instead analyses short and longer run displacement effects of an increased use of immigrant workers in German firms after 1989. By using both an instrumental variable and the propensity score matching approach, it is shown that the displacement effect for native workers is significant but modest in magnitude; most of the effect is anyway concentrated in the short run. Firms which increase foreign-born employment do not increase native employment as much as the rest of the firms. Moreover, an increase in immigrant employment comes together with a 2% reduction in the average immigrant wage at the firm level, with no corresponding effect to the average wage of native workers.

The impact of immigration to Italy on firm-level strategies is analysed in Accetturro, Bugamelli, and Lamorgese (2009), who consider investment decisions and hence adjustments in capital intensity as an endogenous response to the increase in the relative abundance of low-skilled workers due to immigration. They find that in a sample of Italian manufacturing firms over the period 1996-2006, a larger inflow of low-skilled immigrants has on average a positive impact on firms' investment rate in machinery. In particular, results are stronger for small firms and less technologically intensive industries.

Barba Navaretti, Bertola, and Sembenelli (2008) look at the relationship between the use of foreign labour and offshoring strategies, albeit from the opposite perspective, showing that Italian firms that offshore are usually less likely to employ immigrant workforce. Anyway, these findings do not exclude the opposite nexus, and leave room also for the possibility of a reduction in imports of inputs due to the availability of migrant work, that could substitute for foreign workers' activity abroad.

Summing up, the mentioned evidence shows that at the firm-level migration in some cases may result in a technology downgrading and in the direct substitution of native labour, while in other cases it seems to foster investment rates especially in small and less skill intensive firms. Within this framework, we mean to adopt a structural approach to evaluate the contribution of migrants to Italian manufacturing production and to assess how migrants interact with native labour and with the remaining factors of production inside the firm, both from a technological and an economic point of view.

The so called production-theory approach introduced by Grossman (1982) has been further developed in Kohli (1999) in a study concerning Swiss firms. The specific focus of the paper was in the attempt to integrate the production-theory approach to migration and to import determination. Estimation results derived from the GNP-function framework show that nonresident and resident workers are substitute for each other while imports and nonresident labour are found to be complements. This holds both in terms of Allen-Uzawa elasticities of substitution and in terms of Hicksian elasticities of complementarity.

Our paper makes an original contribution to the literature by showing an empirical application of the production-theory approach to migration with firm-level data which so far has never been exploited to assess if and how migrants contribute to production and differences in the performance of Italian manufacturing firms.

3 Data and descriptive evidence

The data used in the following analysis are retrieved from the 9^{th} wave of the Capitalia Survey, containing plenty of information on Italian manufacturing firms' characteristics and their activities for the period 2001-2003. Unfortunately we are not able to exploit either previous waves, since they include no information concerning immigrant workforce, or the following one where this piece of information - available just for one year - is coded differently and hence not directly comparable with data from the 9^{th} wave. The dataset includes all firms with more than 500 employees, while for firms with less than 500 employees a rotating sample is created stratifying by industry, size class and geographical area. Information concern firms' output, inputs, investments, innovation activities, internationalisation strategies and, more importantly for our aims, firms are asked about Extra European Community (EC)[2] employees hired in each year. From now on we will indifferently refer to these workers as migrant or foreign workers.

After a cleaning procedure[3], we end up with a sample of 3,264 firms for a

[2]The period of the analysis is prior to the Eastern EU enlargement so Extra European Community workers include also citizens from New Members.

[3]We drop observations with missing data for our variables of interest (output, value added, employment, capital, services materials, and labour costs), or with implausible negative values. We also delete firms which are considered as outliers for at least one year in the sample period. We consider as outliers observations from the bottom and top 1 percent of distribution of the ratios va/labour and capital/va.

total of 9,314 firm-year observations in the period 2001-2003; 1,403 firms have employed migrant workers at least in one year of the period 2001-2003 summing up to 3,822 firm-year observations.

Despite the short time dimension, we can notice an increase in the number of Italian manufacturing firms hiring immigrant workers, from 39.23% in 2001 to 42.89% in 2003[4]. The use of foreign employees in the manufacturing sector has increased in the last decades due to the higher availability of migrant workers but also to the tougher competitive pressure from developing countries that may have pushed Italian firms to use cheaper labour. Thus, the increased availability of low-wage unskilled employees may have affected firms' decisions about their workforce, and also their choices about production processes and techniques. It is important to stress that the use of foreign labour does not affect only the employment of native workers, but also the use of capital and other inputs inside firms. The presence in the market of cheap labour, in our case foreign labour[5], may for example stimulate firms to abandon capital intensive techniques and adopt labour intensive ones (Peri, 2009). For these reasons in our analysis we try to understand which are the substitution and complementarity linkages among the different production inputs.

About 43% of Italian manufacturing firms in the sample was employing immigrant workers in 2003, even if the average share of migrants on the total employment of those firms using foreign labour was low (9.33%).

Table 1 shows the distribution of firms employing foreign workers across sectors[6], size classes[7] and geographical areas[8]. The share of firms employing foreign labour ($MIGR$), the average share of foreign employees on the total employment for all firms (shL^M) and for firms making use of immigrants in their production process ($shL^M_{MIGR=1}$) are reported.

Focusing on the technological level, we cannot detect any strong pattern even

[4]Undocumented immigration and illegal employment clearly do not appear in the dataset. The rise in the share of immigrant workers in the sampled firms in 2003 may be partly due also to the large scale amnesty granted at the end of 2002 to undocumented migrants illegally employed even if at least half of the regularised immigrants were employed in the family and elderly care services (http://www.lavoro.gov.it/NR/rdonlyres/A8D198AF-983E-459F-9CD1-A59C14C0DEA9/0/Rapporto_Immigrazione_2011.pdf).

[5]It might be argue that in a country like Italy collective bargaining covering both unionised and non-unionised workers is pervasive and wages are basically set at the industry level. However, wage variability increased after the 1993 Income Policy Agreement which allowed firms to adjust their wage structure according to the local labour market conditions and their economic performance (Devicienti, Maida, and Pacelli, 2008). Faini, Strom, Venturini, and Villosio (2009) indeed show that despite native and immigrant workers start their career at the same wage level, the wage profiles of the two groups start to diverge as experience increases showing a wage gap of about 10% after 5 years of experience in the labour market and more than 15% after 10 years of experience. The authors read such a result as evidence of under-assimilation of foreigners.

[6]Sectors are classified as Low Skill intensive if they belong to the Traditional activities from the Pavitt's taxonomy. These activities are characterised by a lower skill ratio if compared with Non Traditional Sectors (Science-based, Scale-intensive and Specialised Suppliers) and their ratio is below the median value. Based on the 3 digit ATECO 2001 Classification of Economic Activities, Low Skill intensive sectors are 151-205, 212, 245, 246, 251, 286-287, 361-362, 364-366. High Skill intensive sectors are 211, 221-244, 247, 252-285, 291-355, 363.

[7]SMEs are firms with less than 250 employees and include 90% of the sample.

[8]Italy is divided into 20 administrative regions which are commonly grouped into four different areas characterised by similar geographic and economic conditions. The four areas and North-West, North-East, Center and South even if for convenience here we group the Northern regions against the Center and Southern once. The latter also inlcudes the two islands, Sardinia and Sicily. The North represents 68% of pur sample.

Table 1: Firms using immigrants by sector, size and area, %

	$MIGR$	shL_M	$shL_{M\ MIGR=1}$
Sector:			
High Skill intensive	40.98	3.72	9.07
Low Skill intensive	41.16	3.97	9.66
Size:			
SMEs	41.37	4.09	9.88
Large Firms	38.21	1.48	3.88
Area:			
North	48.46	4.65	9.60
Centre-South	25.59	2.12	8.27

if High Skill intensive sectors seem to be less likely to employ foreign workers and display a lower share of foreign employees. The use of foreign labour is more widespread in Northern regions, where the presence of immigrants is larger thanks to better job opportunities. Concerning firm's size, the smaller the firm, the higher the share of migrant workers in total employment. When crossing sector and firm size in Table 2, a lower share of migrant workers in large firms emerges as a general feature although in more traditional sectors it is twice as large as in High Skill intensive sectors.

Table 2: Migrant Labour by Sector and Firm Size, %

Sector/Size	Large Firms	SME
High Skill Intensive	1.1	4.0
Low Skill Intensive	2.2	4.1

Table 3: Migrant versus only-natives employers

	y	lp	l	sk	ky	c	p_L	$\frac{p_{L_{DW}}}{p_{L_{DB}}}$
$MIGR$	-0.032**	-0.060***	0.251***	-0.055***	0.063***	-0.038**	-0.080***	-0.110***
	[0.016]	[0.009]	[0.024]	[0.004]	[0.022]	[0.017]	[0.008]	[0.020]
Obs	9,298	9,298	9,298	9,298	9,298	9,179	9,179	9,104
R^2	0.689	0.079	0.038	0.107	0.1	0.675	0.153	0.101

y: log of output; lp: log of labour productivity; l:log of number of employees; sk: skill ratio; ky: log of capital over output; c: log of total cost; p_L: log of average wage; $p_{L_{DW}}/p_{L_{DB}}$: log native white to blue collars ratio. All regressions include sector, size, area dummies, the regional unemployment rate and the regional share of irregular workers.

In the present analysis, besides the firm's production function we also estimate its dual cost function which requires the use of input prices. Since we

Table 4: Average Output and Input Evolution, 2001-2003

Sector	Δy	ΔL	ΔL_D	ΔL_{DW}	ΔL_{DB}	ΔL_M	ΔK	ΔIM	ΔIS
High skilled	0.67%	1.22%	1.21%	1.97%	1.25%	2.95%	0.51%	1.28%	0.00%
Low skilled	-3.19%	0.36%	0.16%	2.12%	-0.15%	3.84%	-2.28%	-5.18%	-3.00%

y: log of output; L_D: log of labour; L_D: log of native labour; L_{DW}: log of native white collars; L_{DB}: log of native blue collars; L_M: log of migrants; K: log of capital; IM: log of materials; IS: log services.

have no firm level prices for production factors at our disposal, we make use of sectoral level prices. Material, capital and services price indices have been retrieved from EU-KLEMS Database[9] and are defined at NACE Rev.1 2 digit level. Concerning wages, from the Capitalia sample we are only able to compute an average wage regardless of workers' nationality[10]. Therefore, we compute the average wages for both native and immigrant workers by region and NACE division from the WHIP database[11]. In order to check the reliability of these external data, we tried to recalculate the labour share in total cost for the two categories of workers. The correlation between the total wage bill calculated using WHIP average weekly wages for domestic and migrant workers and the wage bill from balance sheet information available in Capitalia dataset is 96% and turns to 93% for firms employing migrants. Figure A in the Appendix compares the distribution of the logs of the different wage bills and shows that the two measures are fairly similar in the time interval, even when only firms employing immigrants are considered.

The WHIP datset is also employed to get information on the skill composition on the immigrant workforce employed in Italy. As a matter of fact, the Capitalia database provides information on the total number of white (directors and clerical workers) and blue (manual workers) collars, although it does not distinguish according to their nationality. The WHIP dataset shows that 91% of foreign-born workers is represented by extra EU-immigrants; on average, 94% of them is employed in low-skilled jobs between 2001 and 2003. Given this piece of evidence, and since migrant workers in our sample are all extra EU citizens, we assume that they are all employed as blue collars and, consequently, white collar jobs are performed only by natives.

To sum up and extend the above information, Table 3 shows that, once accounted for firms' sector, geographical area and size class, regional unemployment rate and the regional share of irregular workers[12], firms employing foreigners have on average lower output, productivity, skill intensity, total costs;

[9] http://www.euklems.net.

[10] The average wage is obtained as the ratio between the firm total labour cost from balance sheet and the number of employees.

[11] WHIP, "Work History Italian Panel", is a database of individual working histories, based on the INPS (National Institute of Social Security) administrative archives and consists in a representative sample of Italian employment.

[12] Both the regional unemployment rate and the regional share of irregular workers are from the National Institute of Statistics (Istat). The latter measure is computed as the percentage share of irregular workers on total workers in the region and its use in the estimation process allows us to account for the possible misreporting or underreporting of the number of foreign workers employed by the firms.

they also pay lower wages and display a lower high to low skilled wage ratio. On the other hand, they are larger in terms of number of employees and more capital intensive. A higher capital intensity, together with a lower skill intensity for firms using migrant labour may be supportive of the evidence that extra-EU workers are mainly blue collars performing unskilled tasks that possibly complement the use of machineries, as also suggested by the findings by Accetturro, Bugamelli, and Lamorgese (2009).

Finally, Table 4 shows the evolution of output and factor inputs over the period 2001-2003. Output, materials, services and capital decline for firms in Low Skill intensive sectors while skilled and migrant labour intensity especially tend to grow. On the other hand, the average growth of inputs and output in High Skill intensive sectors is positive. The growth in migrant employment is higher in the former group of firms where the production then becomes more labour intensive.

4 The empirical model

The substitutability/complementarity among factors of production can be assessed by the estimates of the technology parameters retrieved from a production function or its dual cost function. Our interest on the substitutability among factors and the availability of firm-level information on production inputs and output led us to choose a translog production function which imposes no *a priori* restrictions on the relationships among factor inputs. The function is specified as follows

$$lnY_f = \alpha_0 + \sum_i \alpha_i lnX_{fi} + \frac{1}{2} * \sum_i \alpha_{ii} lnX_{fi} lnX_{fi} + \sum_{i=} \sum_{j \neq i} \alpha_{ij} lnX_{fi} lnX_{fj} \quad (1)$$

For each firm f in our sample, lnY measures the logarithm of real output while lnX_i represents the log of the quantity of input i used in production. The index i respectively refers to materials (IM), services (IS), capital (K), domestic labour (L_D) and foreign labour (L_M). To improve estimation efficiency, the production function is usually augmented with the input share equations obtained as its first derivatives:

$$S_{fi} = \alpha_i + \alpha_{ii} lnX_{fi} + \sum_{j \neq i} \alpha_{ij} lnX_{fj}$$

Under the hypothesis of constant returns to scale and profit maximization S_i represents the share of input i in total output/cost:

$$\frac{\partial lnY}{\partial lnX_i} = \frac{\partial Y}{\partial X_i} * \frac{X_i}{Y} = S_i$$

To overcome the lack of information on the share of labour costs attributable to foreign workers, we follow Yasar and Morrison Paul (2008) and we express the share of the two inputs as a sum, then we include the share of overall labour which is something we actually observe:

$$\begin{aligned} S_{fL} = \; & S_{fL_D} + S_{fL_M} = (\alpha_{L_D} + \alpha_{L_M}) + (\alpha_{L_D L_D} + \alpha_{L_{L_M} L_D}) * ln(L_D) + \\ & +(\alpha_{L_M L_M} + \alpha_{L_M L_D}) * ln(L_M) + (\alpha_{L_D K} + \alpha_{L_M K}) * ln(K_f) + \\ & +(\alpha_{L_D IM} + \alpha_{L_M IM}) * ln(IM_f) + (\alpha_{L_D IS} + \alpha_{L_M IS}) * ln(IS_f) \end{aligned}$$

From the parameter estimates of the above system it is then possible to infer the substitutability/complementarity relationship among factors of production.

Making use of the predicted shares for each input, it is straightforward to calculate the elasticity of complementarity c_{ij} among input i and j, which, *ceteris paribus*, measures a percentage change in the price ratio p_i/p_j with respect to a change in the input ratio X_i/X_j (Hamermesh, 1993). From this, the partial price elasticity $\epsilon_{p_i x_j}$ can be obtained as

$$\epsilon_{p_i x_j} = c_{ij} * S_j = \frac{\alpha_{ij} + S_i * S_j}{S_i} \tag{2}$$

and describes the response of the price of input i to an increase of 1% in the availability of input j. If an increase in the availability of input j raises/reduces the return to input i the two factors are defined as *q-complements/substitutes*.

Partial price elasticities are particularly interesting in our case since they could tell us whether the increase in the availability of immigrants actually lowers the wage of native workers. Furthermore, they also show the complementarity/substitutability relationship between foreign and native labour and the remaining inputs in production.

However, another part of the story might be hidden in the response of the demand for foreign labour to an increase in the wage of domestic workers. In this respect, one could observe a null or positive response of the domestic wage to the increased availability of foreign workers while an increase in the wage of domestic workers could actually foster their substitution with immigrant workers. If an increase in the price of input j raises/lowers the demand of input i the two factors are classified as *p-substitutes/complements*. This piece of information is contained in the partial demand elasticities which are based on the estimates of the Allen elasticities of substitution (AES), σ. Despite indirect estimates could be retrieved also from the production function estimation, in our opinion the dual approach represents the most natural way to compute the AES (and consequently the partial demand elasticities) from the estimates of a cost function of the same form as the production function above (eq. 1) with prices substituting for inputs and the log of the cost substituting for the log of output (Kohli, 1999; Mundra and Russell, 2001). We use sector level prices of material and services and average wages for domestic and foreign labour at the region-sector level, keeping capital fixed. The cost function is estimated jointly with the cost shares of inputs and we adopt the strategy already mentioned to overcome the lack of information on the exact firm-level measure of the shares of domestic and foreign labour.

The partial demand elasticity of factor i with respect to factor j's price is calculated as follows:

$$\eta_{x_i p_j} = \sigma_{ij} * S_j = \frac{\beta_{ij} + S_i * S_j}{S_i} \tag{3}$$

with β_{ij} corresponding to the parameters retrieved from the cost function estimation. $\eta_{x_i p_j}$ therefore represents the percentage response of the demand of input i to an increase of 1% in the price of input j.

A further measure of substitutability, the Morishima elasticity of substitution (MES), is obtained as follows:

$$MES_{ij} = \eta_{x_i p_j} - \eta_{x_j p_j} = \frac{\partial ln(X_i/X_j)}{\partial ln P_j} \tag{4}$$

Whereas cross-price elasticities are absolute measures of substitution, the *MES* represents a relative substitution elasticity and measures the percentage change in the ratio of input i to j when only p_j varies and all other prices are constant. Two factors i and j are termed *MES-substitutes* if $MES_{ij} > 0$ and *MES-complements* if $MES_{ij} < 0$. In other words, one might observe that although an increase in natives' wages decreases the demand for both native and migrant labour, the latter declines less, thus causing production techniques to become more migrant labour intensive. In this sense two factors can be considered as substitutes even if, when dealing with absolute demand elasticities, they have been classified as complements. The issue has been widely discussed in the literature (Blackorby and Russell, 1989; Chambers, 1988; Nguyen and Streitwieser, 1997; Frondel, 2004) which points at MES as being the right informative elasticities to assess the curvature of an isoquant when the production technology employs more than two factors. As a matter of fact, in this case the traditional Allen-Uzawa elasticity of substitution is only imperfectly measuring how the ratio of factor quantities changes when their price ratio changes, i.e. is not informative on the curvature of the isoquant.

4.1 Estimation issues

In the following, we employ the Maximum Likelihood Zellner-efficient estimator to estimate the system of the production function (cost function) and revenue (cost) share equations. Combining the parameter estimates with the predicted factor shares elasticities are obtained, their respective standard errors being calculated by means of the delta method.

Homogeneity of degree one has been imposed both on the production and cost function[13] and all specifications include time, sector, area and firm size dummies together with the regional unemployment rate and the regional share of irregular workers in order to capture local economic conditions[14].

Since taking the log of migrant workers leads to miss those observations where this input is equal to zero, we restrict the sample to the firms using foreign labour. We control for sample selection including the OLS residuals from the estimation[15] of the probability of hiring migrant workers (Rivers and Vuong, 1988; Vella, 1998).

Similarly to most of the empirical contributes on the relationship among production factors (Berndt, 1991; Nguyen and Streitwieser, 1997; Kohli, 1991, 1999, 2002; Yasar and Morrison Paul, 2008) we are not really able to correct for the endogeneity of the right hand side variables. The use of the GMM

[13] Homogeneity and symmetry are imposed through the following restrictions: $\sum_i \alpha_i = \lambda$, $\sum_j \alpha_{ij} = 0$ and $\alpha_{ij} = \alpha_{ji}$ in the case of the production function and $\sum_i \beta_i = \lambda$, $\sum_j \beta_{ij} = 0$ and $\beta_{ij} = \beta_{ji}$ in the case of the cost function. For the linear homogeneity $\lambda = 1$. We estimated the production and cost function both for the λ homogeneity and linear homogeneity cases and results do not change substantially so we simply present the results for the constant returns to scale production technology. The remaining set of results is available from the authors upon request.

[14] We also added two dummy variables to account respectively for product and process innovation and results did not show any relevant change.

[15] The first-step model includes labour productivity, capital intensity, the firm's age and size with their squared value and several other firms' characteristics: dummies for investors, innovators, offshoring, import and export status and intensity, a dummy for the destination of offshoring and for the type of activity offshored, sector and area of activity. Results are not shown for the sake of brevity.

estimator is prevented by the short time dimension in our data and by the lack of valid instruments, other than lags of the variables, at the firm level. A larger and longer data set might help in the future to overcome these estimation constraints.

5 Results

For the sake of brevity, production function coefficient estimates are reported in Appendix B while Appendix C and D discuss how our empirical models satisfy the regularity conditions of monotonicity and quasi-concavity required by the theory. The cost function and the relative regularity conditions are not shown but readily available from the authors upon request. Results are presented for the whole sample of firms and for the two subsamples of High and Low Skill intensive sectors[16]. Each Table presents two sets of results: the former refers to a technology with five inputs - native and migrant labour, L_D and L_M respectively, materials, IM, services, IS and capital, K; the latter refers to a technology with six inputs since domestic labour is split into white collars, L_{DW}, and blue collars, L_{DB}.

Output elasticities Output elasticities for each input are reported in Table 5. In the whole sample (column 1) the doubling of migrant labour would correspond to an increase of only 1% in the output of Italian manufacturing, while the contribution of natives would be fifteen times larger. The output elasticities are pretty similar among the sub-groups of firms. However, it is worth noticing that a slightly higher contribution of foreign labour is shown for Low Skill intensive sectors while the contribution of domestic labour is slightly higher for firms in High Skill intensive sectors[17].

From these elasticities it is possible to assess how, *ceteris paribus*, the observed change in the employment of migrant labour may affect the distribution of economic activity between High and Low skill intensive sectors. The percentage growth in output explained by migrant workers can be obtained by simply multiplying the estimated elasticities by the effective average growth in the use of migrant labour.

Table 6 reports the observed percentage increase in the employment of migrant workers ($dlnL_M$) for the estimation sample, which turns into a contribution of around 0.05% to the average growth in manufacturing output (0.03% and 0.07%, respectively, for High and Low skill intensive sectors). This implies that the observed growth in migrant labour could explain 0.02% of the output increase of a low skill intensive firm with respect to the average manufacturing firm, and the relative decrease in the output of a high skill intensive firm by the same percentage. If the estimated elasticities are applied to each firm in our sample according to the sector it belongs to, the overall effect would approximately correspond to an increase of 2% of the weight of Low Skill intensive sectors in the aggregate of manufacturing. In other words, *ceteris paribus*

[16] We also investigated heterogeneity across other dimensions - firms' size, location and international exposure - but no significant differences resulted in elasticity estimates.

[17] Output elatsicities for domestic labour, capital and material are close to the ones found by Yasar and Morrison Paul (2008) for Turkey, even if their set of production inputs is slightly different from ours.

Table 5: Output elasticities

	$Y = F(L_D, L_M, K, IM, IS)$			$Y = F(L_{DW}, L_{DB}, L_M, K, IM, IS)$		
	All	High Skill intensive	Low Skill intensive	All	High Skill intensive	Low Skill intensive
	[1]	[2]	[3]	[4]	[5]	[6]
K	0.043***	0.042***	0.047***	0.043***	0.043***	0.046***
	[0.001]	[0.002]	[0.002]	[0.001]	[0.002]	[0.002]
L_D	0.159***	0.174***	0.144***			
	[0.002]	[0.003]	[0.003]			
L_{DW}				0.062***	0.070***	0.054***
				[0.002]	[0.003]	[0.003]
L_{DB}				0.081***	0.080***	0.081***
				[0.002]	[0.003]	[0.003]
L_M	0.010***	0.009***	0.012***	0.019***	0.015***	0.022***
	[0.001]	[0.001]	[0.002]	[0.001]	[0.002]	[0.002]
IM	0.513***	0.494***	0.529***	0.515***	0.504***	0.523***
	[0.001]	[0.002]	[0.002]	[0.001]	[0.002]	[0.002]
IS	0.275***	0.280***	0.268***	0.280***	0.288***	0.275***
	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.003]
Observations	3391	1865	1526	3368	1850	1518

*** p<0.01, ** p<0.05, * p<0.1. Robust S.E. in brackets. All specifications also include area, time and sector dummies together with controls for regional unemployment rate and share of irregular workers.

Table 6: Observed growth in labour input quantities and prices

	All	High Skill intensive	Low Skill intensive
$dln\bar{L}_D$	0.59%	1.05%	0.01%
$dln\bar{P}_D$	3.28%	3.19%	3.40%
$dln\bar{L}_M$	3.34%	2.95%	3.84%
$dln\bar{P}_M$	4.67%	4.32%	5.11%
$dln\bar{L}_{DW}$	2.13%	2.13%	2.12%
$dln\bar{P}_{DW}$	4.52%	2.82%	6.88%
$dln\bar{L}_{DB}$	0.34%	0.97%	-0.45%
$dln\bar{P}_{DB}$	2.15%	2.52%	1.67%

the observed increase in migrant labour could explain by itself an increase by approximately 2% in the weight of Low Skill intensive sectors.

When domestic labour is split into white and blue collars, the right side of Table 5 confirms the above results of a lower contribution of foreign labour to production when compared to native skilled and unskilled labour, and its relatively higher importance in Low Skill intensive sectors. As expected, the contribution of white collars is instead higher in High Skill intensive sectors.

Price and demand elasticities Table 7 shows partial price elasticities, which measure the degree of *q-substitutability* between each pair of inputs, and partial demand elasticities which instead refer to the degree of *p-substitutability*[18].

The general message is that domestic and foreign labour are complements in Italian manufacturing production. *q-complementarity* means that an increase in the availability of each type of workers does not threaten the earnings of the other, but is positively related to its wage. This result confirms the evidence provided by Gavosto, Venturini, and Villosio (1999) who showed that the stock

[18] We only show the estimated elasticities for the domestic and foreign labour with respect to each other and to the remaining inputs; by symmetry, their signs also tell the kind of relationship of the remaining inputs with respect to domestic and foreign labour.

Table 7: Partial Price and Demand Elasticities: Direct Estimates

Partial Price Elasticities from the Production Function				**Partial Demand Elasticities from the Cost Function**			
	All	High Skill intensive	Low Skill intensive		All	High Skill intensive	Low Skill intensive
	$Y = F(L_D, L_M, K, IM, IS)$				$C = F(p_{L_D}, p_{L_M}, K, p_{IM}, p_{IS})$		
$\epsilon_{p_{L_D}x_{L_D}}$	-0.217***	-0.237***	-0.208***	$\eta_{x_{L_D}p_{L_D}}$	-0.738***	-0.765***	-0.707***
	[0.010]	[0.013]	[0.016]		[0.035]	[0.049]	[0.051]
$\epsilon_{p_{L_D}x_{L_M}}$	0.030***	0.036***	0.046***	$\eta_{x_{L_D}p_{L_M}}$	-0.032***	-0.070***	0.01
	[0.005]	[0.007]	[0.008]		[0.012]	[0.016]	[0.017]
$\epsilon_{p_{L_D}x_K}$	0.101***	0.083***	0.122***	$\gamma_{x_{L_D}p_K}$	0.114***	0.107***	0.124***
	[0.006]	[0.008]	[0.009]		[0.009]	[0.013]	[0.013]
$\epsilon_{p_{L_D}x_{IM}}$	0.077***	0.082***	0.058***	$\eta_{x_{L_D}p_{IM}}$	0.598***	0.573***	0.690***
	[0.005]	[0.006]	[0.008]		[0.068]	[0.090]	[0.105]
$\epsilon_{p_{L_D}x_{IS}}$	0.009*	0.036***	-0.017*	$\eta_{x_{L_D}p_{IS}}$	0.171***	0.262***	0
	[0.005]	[0.006]	[0.009]		[0.060]	[0.077]	[0.093]
$\epsilon_{p_{L_M}x_{L_M}}$	-0.867***	-0.760***	-0.923***	$\eta_{x_{L_M}p_{L_M}}$	-1.279***	-0.932***	-1.827***
	[0.068]	[0.108]	[0.088]		[0.150]	[0.176]	[0.280]
$\epsilon_{p_{L_M}x_{L_D}}$	0.465***	0.711***	0.535***	$\eta_{x_{L_M}p_{L_D}}$	-0.485***	-0.899***	0.27
	[0.082]	[0.131]	[0.099]		[0.177]	[0.206]	[0.342]
$\epsilon_{p_{L_M}x_K}$	0.356***	0.341***	0.183**	$\gamma_{x_{L_M}p_K}$	0.176*	0.17	0.04
	[0.060]	[0.091]	[0.072]		[0.104]	[0.123]	[0.198]
$\epsilon_{p_{L_M}x_{IM}}$	0.103**	-0.133*	0.178***	$\eta_{x_{L_M}p_{IM}}$	2.540***	2.088***	3.616***
	[0.048]	[0.074]	[0.058]		[0.214]	[0.223]	[0.474]
$\epsilon_{p_{L_M}x_{IS}}$	-0.060	-0.160**	0.030	$\eta_{x_{L_M}p_{IS}}$	-0.777***	-0.26	-2.055***
	[0.043]	[0.065]	[0.057]		[0.183]	[0.187]	[0.407]
	$Y = F(L_{DW}, L_{DB}, L_M, K, IM, IS)$				$C = F(p_{L_{DW}}, p_{L_{DB}}, p_{L_M}, K, p_{IM}, p_{IS})$		
$\epsilon_{p_{L_{DW}}x_{L_{DW}}}$	-0.594***	-0.730***	-0.339***	$\eta_{x_{L_{DW}}p_{L_{DW}}}$	-0.835***	-0.600***	-1.385***
	[0.028]	[0.029]	[0.057]		[0.136]	[0.141]	[0.165]
$\epsilon_{p_{L_{DW}}x_{L_{DB}}}$	0.393***	0.404***	0.285***	$\eta_{x_{L_{DW}}p_{L_{DB}}}$	-0.130	-0.327**	0.413***
	[0.024]	[0.023]	[0.047]		[0.128]	[0.132]	[0.157]
$\epsilon_{p_{L_{DW}}x_{L_M}}$	0.02	0.0444***	-0.03	$\eta_{x_{L_{DW}}p_{L_M}}$	-0.06	-0.137*	0.080
	[0.012]	[0.013]	[0.027]		[0.071]	[0.075]	[0.084]
$\epsilon_{p_{L_{DW}}x_K}$	0.044***	0.160***	-0.03	$\gamma_{x_{L_{DW}}K}$	0.373***	0.364***	0.207**
	[0.016]	[0.018]	[0.031]		[0.073]	[0.079]	[0.083]
$\epsilon_{p_{L_{DW}}x_{IM}}$	0.073***	0.064***	0.054**	$\eta_{x_{L_{DW}}p_{IM}}$	0.18	0.439**	0.180
	[0.013]	[0.016]	[0.024]		[0.172]	[0.180]	[0.194]
$\epsilon_{p_{L_{DW}}x_{IS}}$	0.066***	0.059***	0.059**	$\eta_{x_{L_{DW}}p_{IS}}$	0.745***	0.533***	0.626***
	[0.013]	[0.014]	[0.026]		[0.145]	[0.150]	[0.163]
$\epsilon_{p_{L_{DB}}x_{L_{DB}}}$	-0.536***	-0.642***	-0.429***	$\eta_{x_{L_{DB}}p_{L_{DB}}}$	-0.839***	-0.660***	-1.155***
	[0.025]	[0.025]	[0.043]		[0.069]	[0.088]	[0.120]
$\epsilon_{p_{L_{DB}}x_{L_{DW}}}$	0.300***	0.352***	0.189***	$\eta_{x_{L_{DB}}p_{L_{DW}}}$	-0.050	-0.156**	0.231***
	[0.019]	[0.020]	[0.031]		[0.049]	[0.063]	[0.088]
$\epsilon_{p_{L_{DB}}x_{L_M}}$	0.104***	0.091***	0.137***	$\eta_{x_{L_{DB}}p_{L_M}}$	-0.117***	-0.162***	-0.095*
	[0.010]	[0.012]	[0.018]		[0.031]	[0.040]	[0.051]
$\epsilon_{p_{L_{DB}}x_K}$	0.163***	0.092***	0.226***	$\gamma_{x_{L_{DB}}K}$	0.167***	0.120***	0.246***
	[0.013]	[0.017]	[0.021]		[0.033]	[0.043]	[0.054]
$\epsilon_{p_{L_{DB}}x_{IM}}$	0.029***	0.085***	-0.010	$\eta_{x_{L_{DB}}p_{IM}}$	1.019***	0.713***	1.599***
	[0.010]	[0.014]	[0.016]		[0.113]	[0.137]	[0.207]
$\epsilon_{p_{L_{DB}}x_{IS}}$	-0.060***	0.023*	-0.115***	$\eta_{x_{L_{DB}}p_{IS}}$	-0.11	0.17	-0.667***
	[0.010]	[0.013]	[0.017]		[0.096]	[0.113]	[0.180]
$\epsilon_{p_{L_M}x_{L_M}}$	-0.917***	-0.915***	-0.877***	$\eta_{x_{L_M}p_{L_M}}$	-1.260***	-0.887***	-1.724***
	[0.036]	[0.054]	[0.060]		[0.200]	[0.241]	[0.363]
$\epsilon_{p_{L_M}x_{L_{DW}}}$	0.060	0.203***	-0.080	$\eta_{x_{L_M}p_{L_{DW}}}$	-0.160	-0.373*	0.340
	[0.040]	[0.061]	[0.066]		[0.175]	[0.204]	[0.355]
$\epsilon_{p_{L_M}x_{L_{DB}}}$	0.439***	0.478***	0.509***	$\eta_{x_{L_M}p_{L_{DB}}}$	-0.753***	-0.927***	-0.713*
	[0.043]	[0.066]	[0.066]		[0.199]	[0.229]	[0.385]
$\epsilon_{p_{L_M}x_K}$	0.157***	0.153***	0.103**	$\gamma_{x_{L_M}K}$	0.303*	0.29	0.2
	[0.032]	[0.050]	[0.048]		[0.169]	[0.248]	[0.232]
$\epsilon_{p_{L_M}x_{IM}}$	0.186***	0.030	0.258***	$\eta_{x_{L_M}p_{IM}}$	2.955***	2.334***	4.446***
	[0.026]	[0.043]	[0.038]		[0.237]	[0.255]	[0.497]
$\epsilon_{p_{L_M}x_{IS}}$	0.079***	0.050	0.084**	$\eta_{x_{L_M}p_{IS}}$	-0.878***	-0.24	-2.433***
	[0.025]	[0.039]	[0.038]		[0.198]	[0.210]	[0.423]

*** p<0.01, ** p<0.05, * p<0.1. S.E. in brackets. $\gamma_{x_{L_M}K}$, $\gamma_{x_{L_D}K}$, $\gamma_{x_{L_{DW}}K}$, and $\gamma_{x_{L_{DB}}K}$, actually represents the demand elasticity of L_M, L_D, L_{DW} and L_{DB}, respectively, when the fixed factor increases.

of immigrants had a positive impact on natives' wages, with an elasticity equal to 0.01. Domestic and foreign workers may perform different tasks in the firm production process without competing against each other. Even when natives are employed as blue collars, they may be involved in more specialised tasks, while firms may hire immigrant workers for manual and routine jobs with the lowest skill content (Peri and Sparber, 2009; Ottaviano and Peri, 2011). The highest elasticity of domestic wage with respect to foreign workers is registered in Low Skill intensive sectors.

Taking into account the figures in Table 6, the higher availability of migrant workers might explain on average about 3% of the growth in natives' wages. The share increases up to 5.2% when Low Skill intensive sectors are considered[19]. Our results therefore echo other empirical evidence according to which the fear of the harmful labour market effects of immigration from developing countries seems to be groundless. Quite surprisingly, this turns to be even more evident for domestic workers of Low Skill intensive sectors, which might be considered the most exposed to the detrimental effects of immigration. Migrants' wages are instead more sensitive to changes in the domestic labour inputs: on average, the observed increase in native labour may explain about 6% of the observed increase in migrants' pay.

The negative demand elasticities reported in the right side of Table 7 implies that the native and foreign labour are also *p-complements*. The elasticity of the demand of migrant workers with respect to domestic wages is shown to be higher than the elasticity of domestic labour with respect to the wage of foreign workers. From this, the observed change in the price of native labour accounts for 48% of the total variation in foreign employment while the variation in migrants' wages accounts only for 25% of the change in the use of domestic labour[20].

The own elasticities are shown to be generally higher in absolute value for the "weaker" group - i.e. foreign workers - and this supports the evidence on segmented labour markets provided by Hamermesh (1993) which also corroborates the estimates of the own elasticity of natives around 0.23 in absolute value.

Domestic white and blue collars seem to be *p-substitutes* in Low Skill intensive sectors. The same relationship, although not significant, concerns foreign labour and domestic white collars, thus generally hinting at substitutability between high and low skilled labour in the most traditional sectors of Italian manufacturing.

Turning to the relationship with the other inputs, foreign labour seems to be at the same time *q-complement* and *p-substitute* with respect to materials. Since *p-substitutability* with respect to materials involves also domestic blue collars, we could read such results as evidence of potential vertical integration processes in response to increasing costs for materials. This could partially recall the finding by Barba Navaretti, Bertola, and Sembenelli (2008) on Italian offshorers as less likely to employ immigrant workforce.

Both *p-* and *q-complementarity* hold between foreign labour and services in the overall sample and in Low Skill intensive sectors. Anyway, it is difficult to

[19]The calculations are as follows: for the whole sample $\epsilon_{p_{L_D} x_{L_M}} * (dlnL_M/dlnP_{L_D}) = 0.030 * (3.34/3.28) = 0.030$ and for the Low Skill intensive sectors $0.046 * (3.84/3.40) = 0.052$.

[20]From Table 6 $dln\hat{L}_D = |\eta_{x_{L_D} p_{L_M}}| * dlnP_{L_M}/dlnL_D = 0.032 * 4.67/0.59 = 0.253$ and $dlnL_M = dln\hat{L}_M = |\eta_{x_{L_M} p_{L_D}}| * dlnP_{L_D}/dlnL_M = 0.485 * 3.28/3.34 = 0.476$.

deepen these findings on the linkages between services and labour without any description of the kind of services we are dealing with. The different impact of the changes in the price of services on foreign and domestic labour demand might well be related to the different high-tech or high-quality content of the services purchased by firms.

Finally, all types of labour result being *q-complements* with respect to capital and, from the cost function estimates, their demand increases with an increase in the availability of the fixed factor, even if the migrant demand is not importantly related to the increase of capital. Although such a result may seem in contrast with the findings by Accetturro, Bugamelli, and Lamorgese (2009), it is worth reminding that this is only found for given output and input prices, while when the scale of production is free as from the price elasticities, migrants and capital are complement.

Morishima elasticities of substitution Although domestic and foreign labour appear to be complements according to the traditional definitions of complementarity that have usually been addressed in the literature, it may well happen that factor price variations - through changes in the absolute demands - induce significant changes in the relative use of inputs and hence in the production techniques adopted at the firm-level. Table 8 shows that domestic and foreign labour are indeed *MES-substitutes* since an increase in the wage of migrants increases the natives/migrants ratio: a 1% increase in the price of migrant labour causes the demand of migrants to decrease more than the demand of natives. Anyway, it is interesting to highlight that an increase in the wage of natives is followed by a change in the migrants/natives ratio only in Low Skill intensive sectors where the positive sign suggests that labour techniques may become more migrant labour intensive as domestic wages increase.

Turning to the remaining elasticities, they all show a positive sign. It is interesting to notice that a 1% increase in the price of materials is followed by an increase of 5.05% in the migrants/materials ratio. The findings might point again at the vertical integration process that firms undertake as a cost-saving strategy when material suppliers apply higher prices. In general, the *MES* elasticities with respect to materials are higher for foreign than for domestic labour. The reverse holds true as far as elasticities with respect to services are taken into account.

Skill ratio Finally, an interesting point is to assess how the white-collar/blue-collar ratio, $SR = \frac{L_{DW}}{(L_{DB}+L_M)}$, changes in response to a 1% change in the availability of migrants. From the derivation of the skill ratio with respect to the price of migrant labour we have:

$$\frac{dlnSR}{dlnP_{L_M}} = \eta_{L_{DW}L_M} - \eta_{L_{DB}L_M} * \frac{L_{DB}}{(L_{DB}+L_M)} - \eta_{L_M L_M} * \frac{L_M}{(L_{DB}+L_M)}$$

from which follows

$$\frac{dlnSR}{dlnL_M} = \frac{\eta_{L_{DW}L_M}}{\eta_{L_M L_M}} - \frac{\eta_{L_{DB}L_M}}{\eta_{L_M L_M}} * \frac{L_{DB}}{(L_{DB}+L_M)} - \frac{L_M}{(L_{DB}+L_M)} \tag{5}$$

Table 9 shows that an increase by 1% in foreign labour causes a reduction of 0.17% in the skill ratio for the overall sample, and of 0.21% for Low Skill

Table 8: Morishima Elasticities of Substitution, $\frac{\partial ln(X_i/X_j)}{\partial lnp_j}$

	All [1]	High Skill intensive [2]	Low Skill intensive [3]		All [4]	High Skill intensive [5]	Low Skill intensive [6]
$C = F(p_{L_D}, p_{L_M}, K, p_{IM}, p_{IS})$				$C = F(p_{L_{DW}}, p_{L_{DB}}, p_{L_M}, K, p_{IM}, p_{IS})$			
$\frac{\partial ln(L_D/X_j)}{\partial lnp_j}$				$\frac{\partial ln(L_{DW}/X_j)}{\partial lnp_j}$			
$mes_{L_D L_M}$	1.247***	0.862***	1.840***	$mes_{L_{DW} L_{DB}}$	0.714***	0.332*	1.568***
	[0.159]	[0.189]	[0.292]		[0.171]	[0.189]	[0.241]
$mes_{L_D IM}$	3.106***	2.424***	3.580***	$mes_{L_{DW} L_M}$	1.196***	0.750***	1.804***
	[0.171]	[0.274]	[0.233]		[0.242]	[0.286]	[0.410]
$mes_{L_D IS}$	4.056***	3.020***	4.335***	$mes_{L_{DW} IM}$	2.711***	2.402***	2.982***
	[0.298]	[0.468]	[0.398]		[0.237]	[0.318]	[0.291]
				$mes_{L_{DW} IS}$	4.819***	3.627***	4.822***
					[0.325]	[0.479]	[0.411]
				$\frac{\partial ln(L_{DB}/X_j)}{\partial lnp_j}$			
				$mes_{L_{DB} L_{DW}}$	0.787***	0.444**	1.616***
					[0.172]	[0.187]	[0.234]
				$mes_{L_{DB} L_M}$	1.143***	0.725***	1.629***
					[0.217]	[0.265]	[0.387]
				$mes_{L_{DB} IM}$	3.546***	2.676***	4.402***
					[0.195]	[0.301]	[0.294]
				$mes_{L_{DB} IS}$	3.964***	3.267***	3.529***
					[0.301]	[0.457]	[0.440]
$\frac{\partial ln(L_M/X_j)}{\partial lnp_j}$				$\frac{\partial ln(L_M/X_j)}{\partial lnp_j}$			
$mes_{L_M L_D}$	0.250	-0.130	0.973***	$mes_{L_M L_{DW}}$	0.677***	0.230	1.721***
	[0.178]	[0.209]	[0.340]		[0.263]	[0.292]	[0.450]
				$mes_{L_M L_{DB}}$	0.090	-0.270	0.440
					[0.234]	[0.278]	[0.429]
$mes_{L_M IM}$	5.048***	3.938***	6.506***	$mes_{L_M IM}$	5.482***	4.298***	7.250***
	[0.270]	[0.354]	[0.522]		[0.287]	[0.377]	[0.540]
$mes_{L_M IS}$	3.108***	2.503***	2.277***	$mes_{L_M IS}$	3.196***	2.854***	1.764***
	[0.357]	[0.496]	[0.603]		[0.354]	[0.485]	[0.607]
$\frac{\partial ln(L_{IM}/X_j)}{\partial lnp_j}$				$\frac{\partial ln(L_{IM}/X_j)}{\partial lnp_j}$			
mes_{IML_D}	0.984***	1.021***	0.974***	$mes_{IML_{DW}}$	0.845***	0.635***	1.398***
	[0.0544]	[0.0770]	[0.0783]		[0.138]	[0.145]	[0.167]
				$mes_{IML_{DB}}$	0.993***	0.777***	1.366***
					[0.0759]	[0.0972]	[0.132]
mes_{IML_M}	1.348***	1.005***	1.895***	mes_{IML_M}	1.329***	0.954***	1.802***
	[0.150]	[0.177]	[0.281]		[0.200]	[0.242]	[0.364]
$\frac{\partial ln(L_{IS}/X_j)}{\partial lnp_j}$				$\frac{\partial ln(L_{IS}/X_j)}{\partial lnp_j}$			
mes_{ISL_D}	0.860***	0.963***	0.709***	$mes_{ISL_{DW}}$	0.912***	0.673***	1.466***
	[0.0570]	[0.0785]	[0.0825]		[0.136]	[0.142]	[0.165]
				$mes_{ISL_{DB}}$	0.809***	0.709***	1.000***
					[0.0731]	[0.0928]	[0.127]
mes_{ISL_M}	1.242***	0.917***	1.760***	mes_{ISL_M}	1.223***	0.875***	1.649***
	[0.150]	[0.176]	[0.280]		[0.200]	[0.242]	[0.363]

*** p<0.01, ** p<0.05, * p<0.1. S.E. in brackets.

Table 9: Changes in the Skill ratio explained by observed migration changes

	All	High Skill int. sectors	Low Skill int. sectors
$\frac{dlnSR}{dlnL_M}$	-0.166**	-0.147	-0.206***
	[0.065]	[0.101]	[0.062]
$\frac{dlnSR}{dlnL_M} * dln\bar{L}_M$	-0.553**	-0.433	-0.790***
	[0.216]	[0.297]	[0.239]

$\frac{dlnSR}{dlnL_M}$ is computed as in equation 5.

intensive sectors (the coefficient turns to be non significant for High Skill intensive sectors). When we take into account the observed average yearly growth in the availability of migrant blue collars in the second row of the Table, migrant labour growth is associated, *ceteris paribus*, to a decline in the skill ratio around 0.55%, mainly driven by the result on Low Skill intensive sectors (-0.79%). Had the availability of migrants not increased in these sectors, the growth in the skill ratio could have been higher (4% instead of the actual 3.2%).

Summing up the evidence from the dual approach, the higher elasticities of the demand of migrant labour with respect to its own and other input prices reveal once again that this factor may be considered an element of flexibility in the process of manufacturing production. In particular, foreign labour is shown to be *p-substitute* with respect to materials and *p-complement* with respect to services. When turning to the relationship with domestic labour, the two types of employment are *p-complements*, but they are *MES-substitutes* at the same time. As a matter of fact, migrant wage increases seem to affect domestic labour less than migrant labour itself and this causes production to become less migrant labour intensive. This, however, implies that, if migrants are ready to accept a lower pay, the ratio of domestic to foreign labour might decrease. Finally, from our estimates, migrants contribute to reduce the skill intensity of production in only Low Skill intensive sectors even if their role is not as large as one might expect.

6 Conclusion

With this paper we contribute to the existing firm-level evidence on the use of foreign labour in manufacturing production. Exploiting the information on the migrant workforce hired in Italian manufacturing firms we model a flexible functional form for the firm-level technology with five inputs: domestic labour, foreign labour, materials, services and capital. In a second stance, native labour is further split according to the skill contents of the job into white and blue collars. From the coefficients of the estimated production and cost function we retrieve the partial price and demand elasticities and the Morishima elasticity of substitution among the inputs trying to highlight the role of foreign labour in the Italian manufacturing production. The focus is on both its contribution to the overall production and its interplay with respect to the remaining factors of production, especially native labour.

We show that each 1% increase in migrant labour contributes for about 0.1% of the overall manufacturing output growth, with a higher contribution recorded in Low Skill intensive sectors. *Ceteris paribus*, the observed increase in the adoption of foreign labour is associated to a 2% growth in the weight of Low Skill intensive sectors in manufacturing.

When turning to the evidence on the complementarity/substitutability nexus between foreign and domestic labour, foreign workers seem to be both *q*- and *p-complements* with respect to blue collar natives and, in High Skill intensive sectors, they are also complements with respect to high skilled native labour.

In general, foreign labour seems to represent an element of flexibility in technology and production: its own and cross estimated elasticities are much higher than the ones estimated for native labour and it is also more responsive to what happens to non-labour variable factors such as materials and services.

When we investigate the Morishima elasticities of substitution, the foreign/domestic labour ratio in production only increases if migrants are ready to accept lower wages, while it never changes in response to an increase in the wage of native workers. However, when splitting domestic labour into high and low skilled workers, white collars are *MES-substitutes* for blue collars (both native and migrant) and vice-versa. This suggests that when the price of skilled labour increases, firms tend to downgrade their production techniques towards less skill intensive techniques. Turning to the effect of an increased availability of blue collar migrants on the ratio of white to blue collar workers, we find that an 1% increase in the presence of migrants *ceteris paribus* reduces the ratio by about 0.2% in Low Skill intensive sectors.

From the above evidence it emerges that, although in our sample period migrants account for a small share of labour in Italian manufacturing production and they seem not to represent a direct threat for native employment in manufacturing, a sharp increase in their availability might foster production in less skill intensive sectors and push firms towards the use of less skill intensive techniques.

National data show that in 2006 only 9% of the whole foreign employment was represented by skilled workers. In 2008 this share decreased to 8%. Unfortunately our data have a short time coverage that represents a serious limit to analyse structural issues. However, were detailed information available, further work could investigate the relationship between innovative activity and the increased availability of low skilled migrants and evaluate their contribution to the growth of total factor productivity. If innovative activity goes hand in hand with production skill intensity, our results would suggest that innovation activity can be discouraged by the availability of cheap low skilled migrant labour; in addition, the specialisation of firms could move, within the same sector, towards less sophisticated and skill intensive goods.

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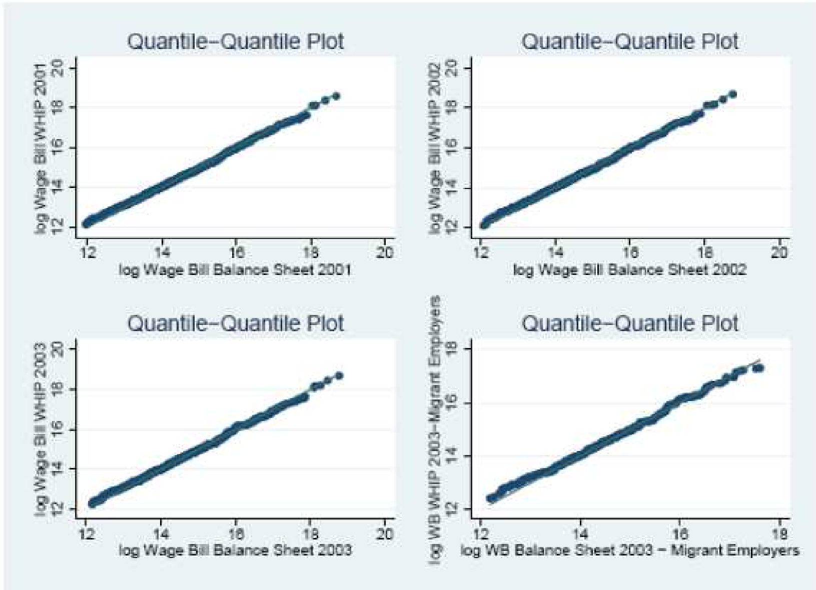
Appendices

A Wage Bill - Comparison WHIP Balance sheet



B Production Function Estimates

	$Y = F(L_D, L_M, K, IM, IS)$			$Y = F(L_{DW}, L_{DB}, L_M, K, IM, IS)$		
	All	High Skill intensive	Low Skill intensive	All	High Skill intensive	Low Skill intensive
	[1]	[2]	[3]	[4]	[5]	[6]
α_{L_D}	0.557***	0.583***	0.533***			
	[0.00634]	[0.00888]	[0.00855]			
$\alpha_{L_{DW}}$				0.262***	0.266***	0.245***
				[0.00893]	[0.0111]	[0.0144]
$\alpha_{L_{DB}}$				0.315***	0.306***	0.314***
				[0.00779]	[0.0103]	[0.0117]
α_{L_M}	0.0383***	0.0372***	0.0445***	0.0768***	0.0668***	0.0809***
	[0.00436]	[0.00520]	[0.00669]	[0.00536]	[0.00669]	[0.00837]
α_{IM}	0.114***	0.0925***	0.118***	0.0561***	0.0431***	0.0714***
	[0.00418]	[0.00588]	[0.00560]	[0.00566]	[0.00780]	[0.00813]
α_K	0.102***	0.102***	0.105***	0.114***	0.136***	0.108***
	[0.00401]	[0.00564]	[0.00529]	[0.00580]	[0.00796]	[0.00836]
α_{IS}	0.189***	0.185***	0.199***	0.176***	0.182***	0.180***
	[0.00446]	[0.00596]	[0.00641]	[0.00633]	[0.00819]	[0.00979]
$\alpha_{L_D L_D}$	0.088***	0.096***	0.080***			
	[0.00162]	[0.00217]	[0.00227]			
$\alpha_{L_{DW} L_{DW}}$				0.022***	0.017***	0.032***
				[0.00169]	[0.00190]	[0.00315]
$\alpha_{L_{DB} L_{DB}}$				0.020***	0.022***	0.024***
				[0.00170]	[0.00203]	[0.00293]
$\alpha_{L_M L_M}$	0.002**	0.003***	0.001	0.002**	0.002**	0.002
	[0.000767]	[0.000854]	[0.00125]	[0.000770]	[0.000858]	[0.00137]
α_{IMIM}	0.193***	0.199***	0.192***	0.195***	0.200***	0.192***
	[0.000678]	[0.000939]	[0.000947]	[0.000710]	[0.000976]	[0.00101]
α_{KK}	0.013***	0.015***	0.013***	0.010***	0.011***	0.010***
	[0.000855]	[0.00117]	[0.00116]	[0.00101]	[0.00133]	[0.00145]
α_{ISIS}	0.161***	0.166***	0.155***	0.160***	0.165***	0.155***
	[0.000912]	[0.00113]	[0.00142]	[0.00101]	[0.00123]	[0.00161]
α_{IML_D}	-0.062***	-0.066***	-0.060***			
	[0.000802]	[0.00108]	[0.00114]			
$\alpha_{IML_{DW}}$				-0.028***	-0.031***	-0.024***
				[0.000833]	[0.00104]	[0.00129]
$\alpha_{IML_{DB}}$				-0.030***	-0.029***	-0.031***
				[0.000814]	[0.00103]	[0.00126]
α_{IML_M}	-0.005***	-0.004***	-0.006***	-0.008***	-0.007***	-0.009***
	[0.000520]	[0.000621]	[0.000819]	[0.000537]	[0.000657]	[0.000856]
α_{IMK}	-0.014***	-0.015***	-0.015***	-0.014***	-0.015***	-0.015***
	[0.000551]	[0.000741]	[0.000770]	[0.000577]	[0.000787]	[0.000827]
α_{IMIS}	-0.113***	-0.114***	-0.112***	-0.115***	-0.117***	-0.114***
	[0.000562]	[0.000735]	[0.000843]	[0.000595]	[0.000782]	[0.000898]
α_{ISL_D}	-0.037***	-0.039***	-0.033***			
	[0.000891]	[0.00113]	[0.00137]			
$\alpha_{ISL_{DW}}$				-0.011***	-0.014***	-0.009***
				[0.000863]	[0.00102]	[0.00147]
$\alpha_{ISL_{DB}}$				-0.021***	-0.019***	-0.021***
				[0.000836]	[0.00101]	[0.00136]
α_{ISL_M}	-0.003***	-0.003***	-0.003***	-0.004***	-0.003***	-0.006***
	[0.000474]	[0.000549]	[0.000792]	[0.000528]	[0.000619]	[0.000884]
α_{KL_D}	0.007***	0.008***	0.007***			
	[0.000899]	[0.00126]	[0.00121]			
$\alpha_{KL_{DW}}$				0.002*	0.008***	-0.001
				[0.000999]	[0.00124]	[0.00160]
$\alpha_{KL_{DB}}$				0.009***	0.006***	0.010***
				[0.00103]	[0.00137]	[0.00152]
α_{KL_M}	0.003***	0.003***	0.002**	0.002***	0.002**	0.002**
	[0.000601]	[0.000746]	[0.000887]	[0.000646]	[0.000790]	[0.000991]
α_{KIS}	-0.008***	-0.011***	-0.007***	-0.008***	-0.011***	-0.006***
	[0.000540]	[0.000689]	[0.000812]	[0.000584]	[0.000747]	[0.000893]
$\alpha_{L_D L_M}$	0.003***	0.001	0.006***			
	[0.000889]	[0.00109]	[0.00133]			
$\alpha_{L_{DW} L_M}$				0.001	0.003***	-0.002*
				[0.000816]	[0.000945]	[0.00145]
$\alpha_{L_{DB} L_M}$				0.008***	0.004***	0.012***
				[0.000824]	[0.00101]	[0.00127]
$\alpha_{L_{DW} L_{DB}}$				0.014***	0.016***	0.005**
				[0.00131]	[0.00146]	[0.00253]
Observations	3391	1865	1526	3368	1850	1518
R-squared	0.992	0.993	0.992	0.993	0.993	0.993

*** p<0.01, ** p<0.05, * p<0.1. Robust S.E. in brackets. All specifications also include area, time and sector dummies together with controls for regional unemployment rate and regional share of irregular workers.

C Regularity Conditions - Monotonicity

Share	$Y = F(L_D, L_M, K, IM, IS)$ Mean	%Viol.	$Y = F(L_{DW}, L_{DB}, L_M, K, IM, IS)$ Mean	%Viol.
S_L	0.200		0.19	
$\hat{S}_L$	0.185		0.19	
S_{L_D}	0.132			
$\hat{S}_{L_D}$	0.159	1.00%		
$S_{L_{DW}}$			0.05	
$\hat{S}_{L_{DW}}$			0.06	2.10%
$S_{L_{DB}}$			0.08	
$\hat{S}_{L_{DB}}$			0.08	1.00%
S_{L_M}	0.010		0.01	
$\hat{S}_{L_M}$	0.010	4.00%	0.02	3.41%
S_{IM}	0.466		0.47	
$\hat{S}_{IM}$	0.513	0.00%	0.51	0.00%
S_{IS}	0.249		0.25	
$\hat{S}_{IS}$	0.275	1.00%	0.28	1.00%
S_K	0.034		0.03	
$\hat{S}_K$	0.043	2.00%	0.04	1.00%

The columns "Mean" contain the computed (S) and estimated ($\hat{S}$) revenue share of inputs. The columns "%Viol." contain the percentage of observations violating the monotonicity condition.

Monotonicity entails non-negative estimated share equations and Appendix C shows the shares computed from balance sheet data, S_i, and their predicted values, $\hat{S}_i$, as obtained from the estimation of the production function and cost function, respectively with five and six inputs. The two sets are pretty similar confirming the goodness of the estimation. To verify the reliability of our predicted shares, we made use of the average wages from WHIP, calculated the shares of migrant and domestic workers in total output and compared them to the average of their prediction from the estimates of the empirical model. The total % of violation of monotonicity, i.e. the number of negative predictions, is fairly low in general and slightly higher for the predicted share of migrants from the cost function. However, comparing the predicted and "actual" shares of foreign and domestic workers in total output and in total cost we find that, although not exactly equal, the prediction reflects our calculations (a little worse performance is shown for domestic labour shares, especially white collar, from the cost function). Sample averages and the average predictions for material, services and capital are very similar too. In order to proceed with the estimations, the observations that violate monotonicity have been dropped from the sample.

D Regularity Conditions - Own Partial Price elasticities

	$Y = F(L_D, L_M, K, IM, IS)$				
	$\epsilon_{p_i x_j}$ based on:				
	mean ϵ_{ij} **across** i	**median** ϵ_{ij} **across** i	**estimated shares**	**calculated shares**	**Violations**
$\epsilon_{p_{L_D} x_{L_D}}$	-0.05	-0.28	-0.22	-0.12	13.86%
$\epsilon_{p_{L_M} x_{L_M}}$	-0.62	-0.8	-0.87	-0.87	0.00%
$\epsilon_{p_K x_K}$	-0.59	-0.65	-0.61	-0.53	1.53%
$\epsilon_{p_{IM} x_{IM}}$	0.22	-0.1	-0.09	-0.09	9.35%
$\epsilon_{p_{IS} x_{IS}}$	0.16	-0.14	-0.1	-0.07	19.05%
	$Y = F(L_{DW}, L_{DB}, L_M, K, IM, IS)$				
	$\epsilon_{p_i x_j}$ based on:				
	mean ϵ_{ij} **across** i	**median** ϵ_{ij} **across** i	**estimated shares**	**calculated shares**	**Violations**
$\epsilon_{p_{L_{DW}} x_{L_{DW}}}$	-0.41	-0.59	-0.59	-0.49	3.55%
$\epsilon_{p_{L_{DB}} x_{L_{DB}}}$	-0.62	-0.67	-0.54	-0.52	0.50%
$\epsilon_{p_{L_M} x_{L_M}}$	-0.83	-0.89	-0.92	-0.86	0.00%
$\epsilon_{p_K x_K}$	-0.68	-0.73	-0.73	-0.67	0.56%
$\epsilon_{p_{IM} x_{IM}}$	-0.01	-0.1	-0.09	-0.09	9.65%
$\epsilon_{p_{IS} x_{IS}}$	0.4	-0.15	-0.11	-0.07	17.56%

ϵ is the Partial Price elasticity computed as in Eq. 2.

Sufficient condition for quasi-concavity is that the bordered Hessian is negative semi-definite and this is validated both at the mean and the median of the sample. The elements on the main diagonal of the matrix, i.e. the own partial price elasticities f_{ii}, need therefore to be non positive and Appendix D shows that this is the case for our sample. The columns respectively report the sample mean and median elasticities[21] computed according to formulas 2 and 3, and the elasticities evaluated at the mean of the prediction of the shares and at the mean of the shares calculated using WHIP wages. The four sets of elasticities are negative and bear consistent insights, in particular the own price and demand elasticities are often very similar.

The average of the predicted own price elasticity is surprisingly positive for services and domestic white collars, but since we are going to work with elasticities calculated at the mean of the predicted shares this will not represent a problem in the analysis. Finally, the last column displays the share of observations with positive estimated elasticities: a few violations occur for some observation, especially in the case of the production function, however they do not affect the results shown below[22].

[21]In this case we calculated the elasticity for each observation in the sample and then took respectively the average and the median together with the average and the median significance level.

[22]Wales (1977) discusses how the rejection of either monotonicity or concavity does not necessarily imply that the elasticity estimates are incorrect.