

High-Skilled Out, Low-Skilled In? The Link Between Foreign Workers and Firm-Level Total Factor Productivity

Abstract

Leveraging firm-level administrative labour data from Emilia-Romagna, Italy, alongside financial records covering the period 2008–2015, this study quantifies total factor productivity (TFP) at the firm level and examines its relationship with the sector of economic activity and the proportion of high-skilled jobs within firms. Adopting a two-stage approach consistent with established literature, the analysis first addresses the potential endogeneity of foreign worker presence using a shift-share instrumental variable technique, after which the estimated TFP is regressed on the share of foreign workers to assess its impact. The findings reveal a statistically significant negative association between TFP and the presence of foreign workers, suggesting that their potentially lower skill profile may not contribute favourably to firm performance when cost-containment strategies are prioritized. These results may point towards a potential realignment within the labour market whereby foreign, low-skilled workers fill vacancies left by domestic, high-skilled workers who transition to better employment opportunities and higher wages.

Keywords: foreign workers, firm-level TFP, labour market

Statements and Declarations: see page 26

JEL Classification: F22, D22, J61, R10

1. Introduction

During the last three decades, the world's most advanced economies have seen increasing levels of migration and persistent globalization, spurring an ongoing and lively debate about the role played by immigrants in several facets of the labour market, as well as about policies to cope with new migratory pressures and challenges (OECD 2012, 2018). Among the aspects investigated by scholars, we find the impact on the cultural environment (Ottaviano and Peri 2006), the crime rate (Bianchi et al. 2012; Moehling and Piehl 2009), employment (Martins et al. 2018; Ottaviano and Peri 2006) and the attitudes of natives (Card et al. 2012; Mayda 2006). Several studies have focused on immigration's effect on wages and inequalities, but less attention has been paid to firms' productivity (Mitaritonna et al. 2017; Peri 2012) or firms' performance in general (Mayda et al. 2023). Even fewer studies, moreover, have concentrated on the Italian case (Vittori et al. 2023; Casacchia and Polli 2021). The approach to migration differs across European countries. Whereas Northern European regimes tend to facilitate the entry of highly skilled immigrants for labour, restrict the low-skilled to temporary programs and oppose mass regularization of irregular migrant workers, Southern European countries are known for their immigrant quotas, permanent low-skilled labour immigration, high levels of irregular immigration and cyclical amnesties (Devitt 2023; Baldwin Edwards 1998; Castles 2006; Finotelli and Sciortino 2009; Sciortino 2009; Pastore 2010; Salis 2012; Bonizzoni 2018; Boucher and Gest 2018; Colombo and Dalla-Zuanna 2019; Geddes and Pettrachin 2020). Paralleling immigration patterns observed in Spain and Greece, Italy has historically served as a magnet for low-skilled foreign workers. This dynamic raises the potential for interactions of substitution or complementarity with native and previously immigrated worker populations (Bratti and Conti 2018; Del Boca and Venturini 2005; Brunello et al. 2020).¹ The dearth of appeal among highly skilled immigrants to a specific country can be attributed to two primary factors: the pervasiveness of traditional industries within the economy (De Benedictis 2005; Larch 2005) and the diminished returns on education for immigrants relative to nationals (Bratti and Conti 2018). Considering the documented skill mismatch between labour demand and supply in Italy for native workers (McGowan and Andrews 2015; Piracha and Vadean 2013), this study investigates whether the presence of foreign workers, typically characterized by lower skill levels, presents a net benefit for firms within the northern Italian region of Emilia-Romagna.² Assuming that low-skilled foreign workers constitute a complementary

¹ Notably, Italy not only exhibits the lowest proportion of university-educated immigrants within the European Union (13%), but also possesses the second-lowest share of natives with tertiary education (21%), trailing only Romania (19%) (Centro Studi Luca d'Agliano and Collegio Carlo Alberto, 7th Migration Observatory Report, 2023).

² Emilia-Romagna (ER) consistently demonstrates economic leadership within Italy, boasting one of the highest per capita incomes and earning recognition as one of Europe's most affluent regions. The region's industrial prowess is widely acknowledged, particularly in the globally renowned automotive and motorcycle sectors, with iconic brands like Ferrari,

resource able to fill vacancies left by native workers possessing higher qualifications than the positions require, then a positive contribution to firm productivity may be observed. Moreover, we focus on the differentiated impact of foreign workers across NACE sectors and between knowledge-intensive (KIA) and non-KIA sectors. An economic activity is classified as ‘knowledge-intensive’ if tertiary-educated persons employed (according to ISCED97, levels 5 and 6 or ISCED11, levels 5 to 8) represent more than 33% of the total employment in that activity. The definition is based on the average number of employed persons between 15 and 64 years of age at aggregated EU-27 level in 2008 and 2009, according to the two-digit NACE Rev. 2 codes, using the EU Labour Force Survey data. (The list of KIA sectors is reported in the Appendix.) Under the assumption that low-skilled foreign workers complement the native labour force, thereby enhancing firm productivity, we would expect to observe lower numbers of such workers employed in KIA sectors compared to non-KIA sectors. The impact on firm performance remains uncertain. Non-KIA sectors might leverage lower foreign worker salaries, potentially experiencing productivity gains. Conversely, KIA firms might incur higher labour costs due to employing more skilled (and expensive) native workers, leading to either improved or diminished performance. To shed light on the topic, we calculate firm-level total factor productivity (TFP) – as an indicator of performance – in the 2008–2015 time frame, to detect the specific contribution of foreign workers by sector in Emilia-Romagna, in a sample of more than 69,000 firms.³ This study fills a critical gap in the scant literature examining the regional-level influence of foreign labour on firm-level productivity within Italy. It achieves this by employing a unique, firm-level dataset meticulously constructed by matching detailed employee information (covering domestic/foreign citizenship, age, gender, part-time status, economic sector, and other relevant labour market indicators) with corresponding financial statements over an eight-year period. This comprehensive approach facilitates a nuanced understanding of the complex interplay between foreign labour and firm performance at the regional level. Financial data comes from the AIDA⁴ dataset compiled by Bureau Van Dijk, while labour data comes from SIL-ER,⁵ an administrative

Maserati, Ducati, and Lamborghini calling ER home. Additionally, food production and the ceramic industry flourish, characterized by successful industrial districts strategically distributed across the territory. ER's population sits at approximately 4.4 million, with a remarkably high labour market participation rate of 50%, outpacing all other Italian regions. This translates to around 2.2 million individuals actively contributing to the economic landscape. Notably, ER's industrial value index witnessed the highest growth among major Italian industrial regions between 1990 and 2019, surpassing Veneto and significantly outperforming Piedmont, Lombardy and Tuscany. Throughout the past three decades, ER consistently maintained the lowest unemployment rate among Italy's major industrial regions. Although the Great Recession pushed the unemployment rate from 3% in 2007 to nearly 9% in 2013 (exceeding that of Veneto and Lombardy), a remarkable recovery ensued over the subsequent six years, bringing the rate down to 5.5%. This figure remained lower than in any other major Italian region, solidifying ER's leadership in this crucial metric (Bianchi et al. 2021). ER also ranked first among Italian regions in the best-performing regions in Europe (Milken Institute 2017).

³ Our initial sample consists of 69,000 firms, but the effective number decreased, as we proceeded with matching different databases, as detailed below.

⁴ *Analisi Informatizzata delle Aziende Italiane*. Collects yearly balance sheets for those firms obliged by law in Italy (public and private limited companies) to deposit their official financial results at the local chamber of commerce.

⁵ *Sistema Informativo Lavoro Emilia-Romagna*.

dataset on dependent workers in Emilia-Romagna. The article is structured as follows. The next paragraph briefly reviews the literature on the relationship between foreign labour and productivity. Section 3 describes the data. Section 4 presents the methodological approach to compute TFP. Section 5 presents and discusses the TFP estimation results. Section 6 evaluates then impact of foreign workers over estimated TFP through regression analysis. Section 7 concludes.

2. Literature

Current research on migration focuses primarily on macroeconomic-level impacts. Limited microeconomic studies on individual firm productivity are hampered by data scarcity and often yield mixed results. Macroeconomic theory diverges on the impact of immigration on productivity. The neoclassical Solow (1957) model predicts decreased productivity due to labour supply exceeding capital stock. Conversely, endogenous growth models by Romer (1990) and Lucas (1988) suggest increased productivity from workforce growth and human capital returns. Additionally, immigration's positive influence on savings and reduction in dependency ratio could lead to higher productivity growth rates (Boubtane et al. 2016). Crucially, human capital contributions from immigrants balance potential drawbacks of population growth: As shown in the Solow model, increased human capital from immigrants counteracts, to some extent, the dilution effect on per capita capital. Viewed as heterogeneous labour supply additions, immigrants act as differentiated production function inputs, with education level as the key differentiator (Peri 2016). A further consideration concerns the indirect effects when immigrants trigger reactions by native workers and firms to changes in the labour supply; Peri (2016) defined such mechanisms as ‘margins of adjustment’. On one hand, native workers modify their education strategies, usually by extending the duration of their studies and opting for different subjects, as a reaction strategy to new immigrant workers who typically have lower educational levels and are deployed primarily in manual-labour jobs. Thus, the competition between native and foreign workers diminishes. On the other hand, firms also modify their choices in relation to the features of the available labour force, such as by shifting to different operative technologies according to the changing features and skills of the workforce. These adjustments allow for an increase in the productivity of the more abundant production factor. This point is illustrated in Dustmann et al. (2008), who demonstrate how an increase in the low-skilled labour supply can foster capital accumulation and shift the output mix towards the production of goods that use unskilled workers more intensively, as predicted by the Rybczynski (1955) effect. The endogenous selection of technologies that more intensively use unskilled labour – a kind of directed technical change – has

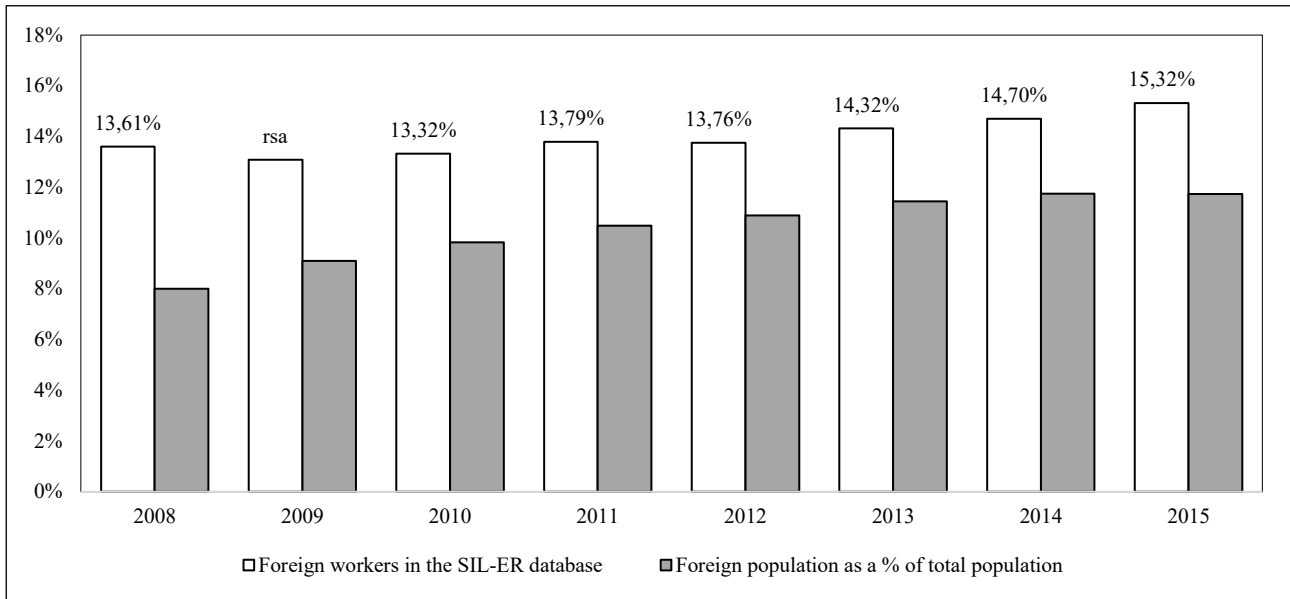
been highlighted by Acemoglu (2002). Bettin et al. (2014) found that the output elasticity of foreign labour is rather small, and that extra-EU migrants especially contribute to output in low-skill-intensive sectors, thus favouring, *caeteris paribus*, an increasing weight of these activities in the Italian manufacturing output. Immigration's 'productive externalities' include increased density of economic activity and related benefits in urban areas. Additionally, diverse nationalities foster the exchange of ideas, goods and services, thus enhancing productivity. Immigrant workers' mobility, coupled with their acquired skills and diverse experiences, further contributes to firm growth and innovation (Gidehag and Lodefalk 2016). Kangasniemi et al. (2012) evaluated the impact of migrant labour on GDP growth and labour productivity in the U.K. and Spain, finding that although the impact on gross value added is positive, the impact on overall labour productivity in both countries is negative. Spain's results may be influenced by its more recent experience with large-scale immigration compared to the UK's established and longstanding immigration patterns. Different results were reached by Smith (2018), who reported that in the U.K., an increased migrant share in the region where firms operate is correlated with higher productivity. A few studies have tackled the effects of immigration on micro-level productivity, producing heterogeneous results (OECD 2018). Some studies have found positive effects of either the dimension or the heterogeneity of the immigrant group in the local area or firm (Mitaritonna et al. 2017; Peri 2012; Trax et al. 2015), whereas others find negligible (Ortega and Peri 2009) or even negative effects (Ortega and Peri 2014) and differences by sector (Paserman 2013). In the U.S., Peri (2012) found that immigration has a strong and positive association with TFP and a negative association with the high skill bias of production technologies. Also in the U.S., Peri and Sparber (2009) found that the difference in skills between native and immigrants workers triggers increases in wages for native workers shifting to more skilled tasks. By contrast, a study of the Federal Reserve, conducted by Quispe-Agnoli and Zavodny (2002) for the U.S. manufacturing sector at the state level, indicated that changes in the labour supply due to immigration appear to lower labour productivity in both the low- and high-skilled sectors. As for service-producing firms in the U.K., Ottaviano et al. (2018) found that immigrants increase overall productivity, whereas Kangasniemi et al. (2012) found that immigration in the U.K. exerts a negative but negligible contribution on labour productivity. Using micro-level data for French manufacturing firms, Mitaritonna et al. (2017) showed that a supply-driven increase in foreign-born workers in a department increases the productivity of firms in that department at all percentiles of the distribution, and that the effect is significantly stronger for firms with an initially zero level of foreign employment. Mayda et al. (2023) found that in the U.S., large negative effects on firm growth in terms of employment, sales and profits resulted from a restriction in employers' ability to hire the specific foreign skilled workers they desire. Research from other countries have reached conflicting results.

Examining firm and individual data across sectors in Barcelona and Madrid, Nicodemo found a negative impact of immigration on productivity in Spain (Nicodemo, 2013). Education and occupation positively affect productivity, whereas contract type (permanent, public or full-time) shows no association. This aligns with Kangasniemi et al. (2012), who similarly reported a negative contribution of immigration to Spanish labour productivity growth. The adoption of new technologies and innovation can also lead to productivity gains from immigration, as found for Israel (Gandal et al. 2004) and as highlighted for the case of immigration in the U.S., where manufacturing automation complements middle-skilled workers more than low-skill workers (Lewis 2011). Studies of the granting of work permits to immigrants and their impact on innovation and productivity have produced mixed results as well. Gosh et al. (2014) found a positive correlation between a decrease in permits and productivity at firms that usually hire large numbers of qualified foreign workers, whereas Doran et al. (2014) found no effect from lesser intakes of qualified foreign immigrants on innovation among selected firms. Ismail (2015) found that for the case of Malaysia, skilled foreign workers do not contribute significantly to labour productivity, whereas unskilled and semiskilled foreign workers have a significant and negative impact on labour productivity. In Italy, research on immigration's impact on productivity is limited. De Arcangelis et al. (2015) explored this at the provincial level, finding that a higher share of immigrants adds more value added in manufacturing than in services. Brunello et al. (2020) examined the effect of immigration on manufacturing firms' profits, costs, capital stock and TFP, utilizing variations in local immigrant supply over time; they found no significant impact on TFP. A recent contribution at the national level by Vittori et al. (2023) found that an increase in the share of extra-EU workers leads to a decline in labour productivity, but the decline differs between firms located in centre-north regions and those in southern regions.

3. Foreign labour in Emilia-Romagna: Stylized facts and data

Foreign immigration in Emilia-Romagna has become a well-established demographic feature. Figure 1 illustrates the temporal dynamics of both the region's foreign population percentage (2008–2015) and the percentage of foreign workers captured within the SIL-ER database. Notably, the observed convergence between these two series suggests two potential explanations: (1) the arrival of non-working family members to reunite with foreign workers already present in Emilia-Romagna, or (2) an increasing trend of undocumented foreign workers engaging in informal employment and thereby eluding official administrative records.

Figure 1. Percentage of foreign workers vs. total workers in the SIL-ER dataset and foreign population vs. total population in Emilia-Romagna, 2008–2015



Source: ISTAT and SIL-ER

Emilia-Romagna's foreign population hails primarily from Romania, Morocco and Albania (Regione Emilia-Romagna 2022), mirroring a trend prevalent across most Italian regions. A noteworthy exogenous shock to foreign labour supply occurred pre-2008 with the 2007 European Union enlargement to encompass Romania and Bulgaria. This event triggered a significant 15% increase in Emilia-Romagna's foreign residents between 2007 and 2009, followed by continued growth until 2013 and stabilizing thereafter. The EU enlargement holds significant historical importance for Italian immigration, considering that Romanian immigrants now constitute approximately one-quarter of all foreign residents in Italy (2024) and have enjoyed facilitated mobility since Romania's EU accession.⁶ Emilia-Romagna's SIL-ER database constitutes a proprietary collection of mandatory firm-level labour contract communications within the region, encompassing new contracts, extensions, transformations and cessations.⁷ It offers robust analytical capabilities for labour force trends and dynamics, preceding the availability of nationally processed data; the database captures virtually all

⁶ As early as 2004, Romania surpassed all other nationalities to become the largest group of legal foreign residents in Italy. By 2007, the number of Romanians residing legally in Italy was significantly higher than that of any other ethnic group. This significant growth was attributed to a regularization program implemented by the Italian government in 2004, under which an estimated 267,051 Romanian citizens were granted legal status. A substantial informal economy, the ease of communication in Romanian, strong economic ties between the two countries, and the notable presence of Italian entrepreneurs in various Romanian towns contributed to this trend (Ban 2012).

⁷ By law, employers are obligated to communicate such changes to the Ministry of Labour.

individuals⁸ active in the region's dependent labour market, thus enabling longitudinal tracking of individual work experiences from entry to exit. Consequently, researchers can examine the correlations between diverse characteristics like age, education, citizenship and industry with contractual parameters such as duration and type. Furthermore, the database facilitates firm-level analysis, which enables researchers to examine worker movements (e.g. hiring, termination, contract transformations) within a specified timeframe, considering various individual characteristics as previously described, all linked to the firm's unique tax code.⁹ Significantly, the SIL-ER database offers the distinct advantage of capturing workdays performed by high-skilled workers, thereby providing an indirect but valuable proxy for the firm's overall employee skill level.¹⁰ This approach permits the identification of firms actively influencing labour market dynamics, and additionally facilitates their classification based on location and industry. The corresponding firm-level financial data comes from the AIDA database by Bureau Van Dijk and represents all active firms in Emilia Romagna with available financial data for 2015, for all sectors of economic activity except banking and the public sector. We merged the SIL-ER database with the AIDA data and obtained a final matched sample of 69,609 firms observed in the 2008–2015 period.¹¹ Descriptive statistics of the matched SIL-ER – AIDA database are reported in Table 1.¹² Our sample exhibits an average share of 13% of foreign workers and an average share of 43% of workdays performed by high-skilled workers. Whereas the share of foreign workers is effectively constant from 2008 to 2015, the high-skilled workdays increase from 2008 to 2015 (Figure 7 in the Appendix). Among the industrial sectors, 18% of firms belong to the KIA group and only a small percentage are involved in international activities.

⁸ Encompassing individuals who have registered, terminated, transformed or extended contracts in Emilia-Romagna since 2008.

⁹ This code, known as the Partita IVA, uniquely identifies entities subject to value-added tax within Italy.

¹⁰ The skill-level classification employed aligns with the established ISTAT (2013) classification.

¹¹ The matching process led to a loss of observations in both the master and appended file; not all of the firms moving the market in our time span were still active in 2015, or perhaps some firms were not obligated by law to present their balance sheets to the chamber of commerce, and were consequently missing in AIDA – whereas among the AIDA firms, a number did not move the labour market at all in the observed time span and therefore did not trigger the event to be captured by the mandatory communications about employees, and so were absent from the SIL-ER.

¹² Although we have all data from 2008 to 2015, for some variables, like the international position, we only have data for 2015.

Table 1. SIL-ER – AIDA descriptive statistics (2015)

<i>Variable</i>	<i>Mean</i>	<i>Standard deviation</i>
Firm age	15.187	14.028
ln(employees)	1.734	1.287
ln(sales)	12.825	2.053
Share of foreign workers	0.130	0.224
Share of high-skilled workers	0.244	0.317
Share of female workers	0.275	0.339
Share of young workers (< 25 years old)	0.420	0.352
Share of part-time workers	0.164	0.220
Knowledge-intensive activities	0.180	0.385
ln (valued added per employee)	10.508	0.960
ln (sales per employee)	11.822	1.170
ln (labour costs per employee)	9.819	1.347
Exporter firm	0.038	0.192
A) Firm participating in a foreign entity	0.035	0.184
B) Firm participated by a foreign entity	0.022	0.147
Both A) and B)	0.004	0.064
Share of workdays performed by high-skilled workers in a year	0.436	0.319

Source: SIL-ER – AIDA

The majority of firms operate within non-KIA sectors, and a significant disparity exists in the prevalence of foreign workers across sectors, with 91% of firms employing foreign workers belonging to the non-KIA sector. Conversely, only 9% of firms within the KIA sector utilize foreign labour. Table 2 reports firms' distribution, displaying the breakdown of firms with and without foreign workers in both KIA and non-KIA sectors for the year 2015.

Table 2. Firms by KIA sector and foreign worker presence (2015)

	Without foreign workers	With foreign workers
Non-KIA sectors	76%	91%
KIA sectors	24%	9%

Source: SIL-ER – AIDA

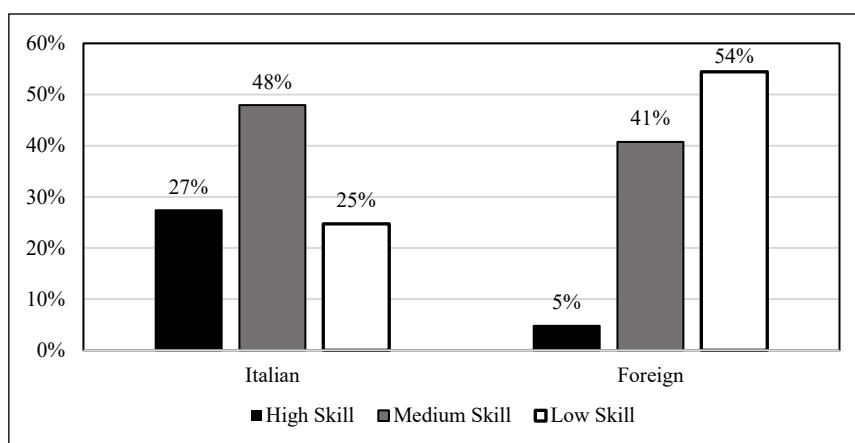
Foreign workers in the region are mainly concentrated in hotels and restaurants (26.6%), construction sites (18.5%) and water management utilities (16.6%); information and communication services (3.1%) and finance and insurance (2.3%) account for the smallest shares (see Table 3). Most female foreign workers are employed as caregivers, housemaids and in hotels and restaurants, whereas male workers concentrate in agriculture and construction activities (Regione Emilia-Romagna 2022)

Table 3. Foreign workers by sector of economic activity

<i>Sectors</i>	<i>Percentage of foreign workers</i>
Hotels and restaurants	26.6%
Construction	18.5%
Water	16.6%
Transport and storage	16.3%
Renting, travel agencies, supporting services	14.2%
Manufacturing	14.2%
N.A.	13.0%
Health	11.3%
Arts, sports, entertainment	10.9%
Real estate	10.3%
Extra-territorial organizations	8.2%
Other services	8.1%
Wholesale trade	7.2%
Education	6.3%
Energy	4.7%
Professional, scientific, technical	4.4%
Mining	3.9%
Information and communication	3.1%
Finance and insurance	2.3%

Source: SIL-ER – AIDA database

Our analysis reveals a significant disparity in skill distribution between foreign and national workers. As depicted in Figure 2, more than 50% of foreign workers fall within the low-skilled category, whereas this applies to only 25% of national workers, indicating a marked concentration of foreign workers in low-skilled occupations.

Figure 2. Skill composition of Emilia-Romagna workforce, 2008¹³

Source: own elaboration from the SIL-ER database

¹³ The matched SIL-ER – AIDA database does not permit assessing the skill level of the single worker employed by each firm; we observe the individual skill level in another – unmatchable – version of the proprietary database for a sample of workers in 2008 so that we know the *distribution* of the skill level but cannot observe the individual worker's skill level.

Integrating the insights from Figure 2 with the observed rise in high-skilled workdays (see Appendix) suggests a compelling interpretation. Considering the documented prevalence of low-skilled foreign workers, the growth in high-skilled workdays may be attributable to an increase in the number of high-skilled Italian employees. This phenomenon could be a result of (1) advancements in educational attainment among the Italian workforce and (2) the previously discussed substitution mechanism, where low-skilled foreign workers fill vacancies left by upskilled Italian individuals.

4. Methodological approach – TFP estimation

The impact of foreign labour over TFP is evaluated through a procedure in two steps (Smarzynska Javorcik 2004; Smith 2018; Devicienti et al. 2018; Mariotti et al. 2013; Brunello et al. 2020). In the first step, to determine each firm's annual TFP, we eliminate the influence of labour and capital inputs on output using AIDA data. In the second step, we analyse the productivity impact of foreign work matching estimated TFP with indicators of foreign labour from the SIL-ER database. Estimating TFP is fundamental in empirical research, capturing unobserved factors influencing output beyond capital and labour. It serves as a firm-level efficiency metric, reflecting residual output growth after accounting for contributions from explicitly measured production factors (i.e. labour, capital, materials) within the given production technology (potentially more advanced in KIA sectors). Among the most widely used estimation methods in TFP literature are OLS, fixed effects, Olley and Pakes (OP 1996), Levinsohn and Petrin (LP 2003), and Akerberg et al. (2015). The OLS methodology was excluded due to concerns about potential bias for shocks affecting both TFP and inputs. For instance, a firm introducing an innovation would likely increase the use of capital and labour. The fixed effects method implies that there are time-invariant idiosyncratic effects, potentially identifying firm-level TFP. The Olley and Pakes method usually applies if some firms exit the market, whereas we required that all firms be active at the moment of extraction. Moreover, investment – the variable used as a proxy for productivity shocks – tends to be ‘lumpy’ (Petrin et al. 2004) and is often negative, such that taking logarithms ultimately provides a very large number of missing values. Levinsohn and Petrin (2003) build on Olley and Pakes (1996) by suggesting that material inputs may be a better proxy for the firm’s reaction to productivity shocks than investment and use intermediate inputs by the firm as a proxy for TFP. Akerberg et al. (2015) further refine the previous estimator to resolve some functional dependence issues. Wooldridge (2009) proposes a novel estimation setting, showing how to obtain a Levinsohn and Petrin estimator within a system GMM econometric framework, which can be estimated in a single step, and shows the appropriate moment conditions

(Rovigatti and Mollisi 2017). A number of previous empirical studies (Smarzynska Javorcik 2004; Smith 2018; Devicienti et al. 2018; Mariotti et al. 2013; Brunello et al. 2020) adopt a two-step procedure, first estimating total factor productivity (TFP_{it} for each firm i at time t) to be used as the dependent variable in the next step. The estimated TFP is then regressed over various variables, to measure their marginal effect on firms' performance. Among these variables we find, for instance, the presence of foreign and backward linkages with multinational firms, or the proportion of part-time workers among all workers (Devicienti et al. 2018; Mariotti et al. 2013). The issue with the standard OP and LP estimators is that they are implemented under the identifying crucial assumption that the unobserved log-TFP (commonly defined as ω) is an exogenous first-order Markov process, from where it holds that:

$$\omega_{it} = g(\omega_{it-1}) + \xi_{it}, \quad (1)$$

where the idiosyncratic shock to productivity at time t (i.e. ξ_{it}) does not affect the choice of the level of state variables, but only that of free variables. Therefore, ξ_{it} is uncorrelated to the contemporaneous value of the state and to all the lagged values of the free and state variables. This forms the basis for the identification of the capital coefficient in a final stage of the OP/LP procedure and must be correct to obtain valid estimates of ω . The problem arises in case of endogeneity of ω , because foreign workers may be attracted by top-performing firms or sectors; therefore, the estimates will be biased. This problem has been underlined by, for example, Doraszelski and Jaumandreu (2013), who account for R&D expenditure in estimating ω , and De Loecker (2007; 2013), who uses lagged export quotas as drivers of productivity dynamics while estimating TFP in the case of innovative and exporting firms. In addition, Konings and Vanormelingen (2015) have evaluated the impact of workforce training on both output and productivity. If foreign workers' presence is endogenous in our set-up (for various reasons that we will discuss below), the TFP estimation must permit a structure of ω that allows for the presence of an endogenous variable, in order to obtain unbiased estimates. If any variable a_{it} influences productivity level at time t , the law of motion (1) should read as

$$\omega_{it} = g(\omega_{it-1}, a_{it-1}) + \xi_{it} \quad (2)$$

(i.e. ω_{it} follows a first-order Markov chain process and $g(\cdot)$ is a nonparametric function of ω_{it-1} and a_{it-1}). This model is able to capture productivity changes conditional on the level of the endogenous variable; that is, it accounts for firms updating their expectation of the productivity level and adjusting their investment based on the optimal level of the endogenous variable. Given the potential endogeneity bias, the choice of the a_{it} variable represents the fulcrum of our analysis, as using an

instrument for foreign labour in the region allows for readily measuring the impact of foreign labour on TFP by contrasting at the same time the endogeneity issue. If we allow for a standard Cobb–Douglas to be our production function

$$Y_{it} = A_{it} L_{it}^{\alpha_l} K_{it}^{\alpha_k}, \quad (3)$$

where Y_{it} is the output, and $L_{it}^{\alpha_l}$ and $K_{it}^{\alpha_k}$ represent labour and capital employed in the production process by firm i observed at time (year) t , the term A_{it} is TFP, which simultaneously increases the marginal productivity of both inputs. Heterogeneity in TFP can stem from diverse firm-level factors, including organizational strategies, access to privileged inputs or markets, and locational advantages. Additionally, the nationality mix of the workforce and potential skill/nationality complementarity or substitution due to the presence of low-skilled foreign workers may influence TFP. Foreign labour influences firms' performance through diverse channels. One direct effect stems from complementarity with national labour. As low-skilled and high-skilled workers reallocate across firms and sectors, this complementarity can enhance overall productivity (Mitaritonna et al. 2017). An indirect effect arises through externalities generated by foreign labour clustering in specific areas due to pre-existing networks; this clustering can impact surrounding firms positively or negatively depending on various factors (Card 2001; Altonji and Card 1991). Taking logarithms of (3), we obtain a standard empirical specification:

$$\ln Y_{it} = \alpha \ln L_{it} + \beta \ln K_{it} + u_{it}, \quad (4)$$

where the estimated residual of the equation u_{it} incorporates both an idiosyncratic output shock distributed as white noise, ε_{it} , and the unobservable productivity or technical efficiency (i.e. the TFP of firm i at time t , ω_{it}). To consider the several variables that affect the performance of the firm and deal with the endogeneity bias, in the empirical specification we include – together with labour and capital, as control variables X – the age of the firm and the unemployment rate at the provincial level of the firm at time t . The empirical specification is, therefore:

$$\ln Y_{it} = \alpha \ln L_{it} + \beta \ln K_{it} + \gamma X + u_{it} \quad (5)$$

with

$$X = \vartheta_0 \text{Age}_{it} + \vartheta_1 \text{Unemployment}_t + \varepsilon_{it} + \omega_{it} \quad (6)$$

The relationship between TFP and firm age is a complex one, with the existing literature presenting diverse and sometimes contradictory findings. Older firms may have accumulated knowledge,

experience, and established routines that contribute to higher TFP; they also may have overcome initial challenges and inefficiencies, leading to improved performance over time. Furthermore, a selection effect may be at work, because more efficient firms may survive longer, thus resulting in a positive correlation between age and TFP. On the negative side, older firms may become rigid and resistant to change, thus hindering innovation and TFP growth; also, legacy systems and entrenched practices may lead to inefficiencies. Firms may struggle to adapt to evolving technologies and market demands (Hannan and Freeman, 1984). The relationship could also be non-linear: TFP could initially increase with age due to learning and experience, but eventually decline as inertia and rigidity take hold (Coad et al. 2018). The unemployment variable controls for the economic cycle and proxies for local labour demand: An increase in the unemployment rate reduces workers bargaining power (Shapiro and Stiglitz 1984) and is associated with poorer businesses outcomes (Bosco and Valeriani, 2023). The instrument we devised to control for potential endogeneity¹⁴ (i.e. the a_{it} variable in (2)) is modelled as a ‘shift-share’¹⁵ formulation inspired by Mitaritonna et al. (2017) and Vittori et al. (2023) and considers the number of pre-existing immigrants in the nine provinces of Emilia-Romagna, taking into consideration an exogenous policy shock that characterized Italy before 2008: the 2002 Bossi-Fini law, which introduced the obligation for an extra-EU immigrant to have a contract of dependent employment to obtain a residence permit. With respect to the study of Mitaritonna et al. (2007), we observe foreign workers at firm level and not at the departmental level; with respect to the study of Vittori et al. (2023), we do not have survey data for three years, but rather yearly observational administrative data at firm level for the entire 2008–2015 time span. Referring to 2002 as ‘benchmark year’, we computed $\widehat{Immi}_{p,t}$ as follows:

$$\widehat{Immi}_{p,t} = Immi_{ER,t} \cdot \frac{Immi_{p,2002}}{Immi_{ER,2002}}, \quad (7)$$

where $Immi_{ER,t}$ is the number of immigrants in the whole Emilia-Romagna region at time t , $Immi_{p,2002}$ is the number of immigrants in the province p in 2002, and $Immi_{ER,2002}$ is the total number of immigrants in the Emilia-Romagna region in 2002. Because the law represents a cornerstone in the management of migration flows, and dates back to six years before our observation

¹⁴ Endogeneity concerns may also stem from two additional sources: (1) establishments with higher concentrations of foreign workers might strategically locate in areas with lower transaction costs, subsequently drawing from the local labour market; or (2) inherently more productive firms might exhibit a greater propensity to hire both domestic and foreign workers, creating a spurious correlation. (We will discuss this issue in the second step.)

¹⁵ This refers to the existing proportion of immigrants in the province as a possible factor in attracting other immigrants, with respect to a benchmark year, because family groups are being reconstituted or because a given area has become a hub for foreign workers of a given nationality.

period, it could have worked as a facilitator of legal migration flows, helping to create enclaves at local level. The expression in (7) is based on official ISTAT data.¹⁶ The instrument is included together with the state variable in the estimation, while its lagged value controls for endogeneity (Rovigatti and Mollisi 2018).

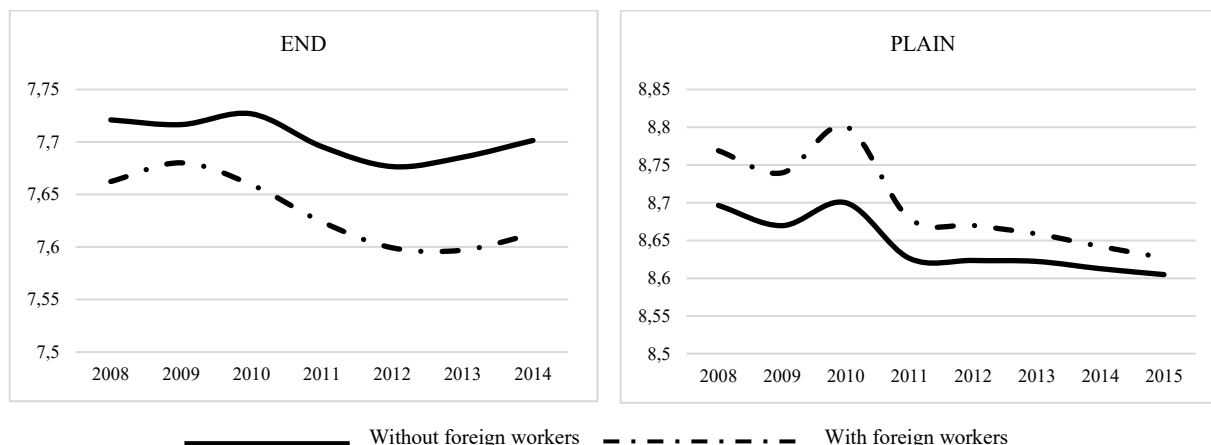
5. TFP estimation: Empirical results

We estimated TFP through the LP methodology, with and without the enclave instrument for the endogeneity-adjusted estimation of ω_{it} , as elaborated by Rovigatti and Mollisi (2018). Figure 3 illustrates the difference in average TFP estimates¹⁷ for firms with and without foreign workers. (Estimation tables are reported in the Appendix, Table 8). Firm-level TFP decreases between 2008 and 2015. The left-hand panel of Figure 3 depicts TFP estimation with the endogenous correction (END), while the right-hand panel depicts the PLAIN version of the TFP estimation, without correction. To assess the robustness of these results, we also performed an LP TFP estimation without controls and without the instrument (7) among the state variables and obtained a pattern similar to our PLAIN estimation. The employed endogeneity correction results in a reversal of estimated TFP levels between firms with and without foreign workers. Surprisingly, although this implies the potential existence of an ‘enclave effect’, the observed impact on TFP is negative. This preliminary finding aligns with the distribution in Figure 2 concerning skill levels. Assuming that foreign workers within these firms exhibit lower average skill levels compared to their domestic counterparts, and that their recruitment stems from an enclave effect driven by established immigrant networks within the same provinces, their arrival may have contributed to a decline in average TFP. This decline could be associated with either a scarcity of available, more highly skilled domestic workers, or to cost-saving strategies implemented by the firms. However, it is crucial to acknowledge that these firms may harbour other sources of inefficiency unrelated to a preference for lower-cost, less-skilled foreign workers, thereby contributing to their observed lower TFP.

¹⁶ Italian National Statistical Institute.

¹⁷ Monetary variables were deflated using the GDP Deflator by OECD (2019).

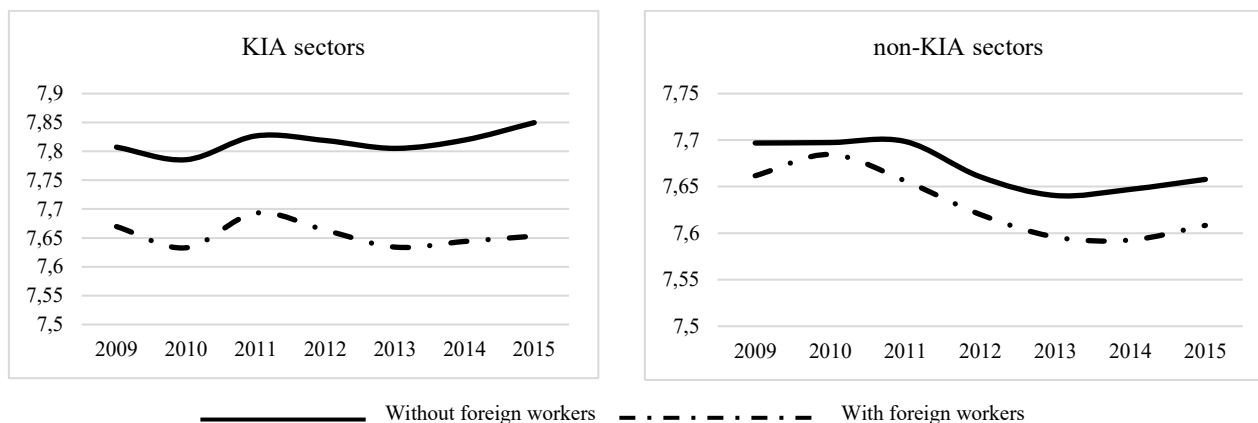
Figure 3. Average estimated TFP by foreign worker presence, 2008–2015



Source: own estimates

A sectoral breakdown enables the assessment of how the presence of foreign workers is associated with overall TFP reported in Figure 3. Figure 4 reports the TFP estimates for KIA/non-KIA sectors,¹⁸ whereas Figure 5 reports the detailed two-digit NACE sectors' TFP estimates.

Figure 4. Average estimated TFP by KIA sectors and foreign worker presence, 2008–2015



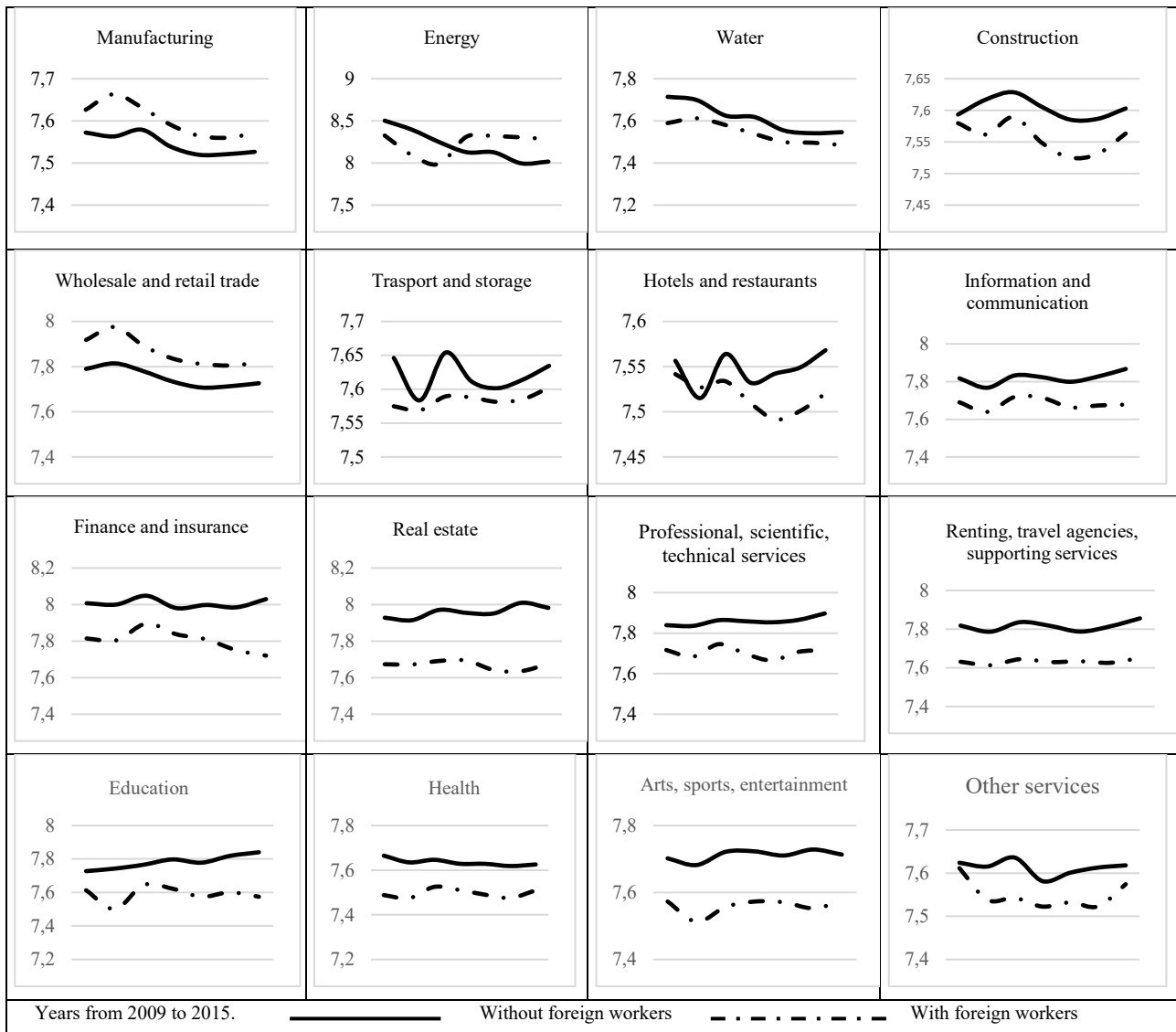
Source: own estimates

The disaggregation by KIA sectors aligns with the broader findings of Figure 3. Within non-KIA sectors, firms employing only domestic workers consistently exhibit higher TFP than those employing foreign workers during the 2009–2015 period. Interestingly, the magnitude of this disparity is amplified within KIA sectors. Firms without foreign workers boast an average TFP advantage of 0.16 over those employing foreign workers, whereas the same differential in non-KIA

¹⁸ Here we report figures based on the estimates with the endogenous correction (7) only.

sectors amounts to only 0.03. One potential interpretation posits that KIA firms actively reshape the labour market, strategically hiring foreign workers while simultaneously redeploying higher-skilled domestic workers into roles demanding greater expertise. This dynamic, as suggested by Devadas (2017), can contribute to enhanced production efficiency. Additionally, the inter-panel comparison reveals a generally higher average TFP within KIA sectors compared to their non-KIA counterparts.

Figure 5. Average estimated TFP by NACE sectors and foreign worker presence, 2008–2015

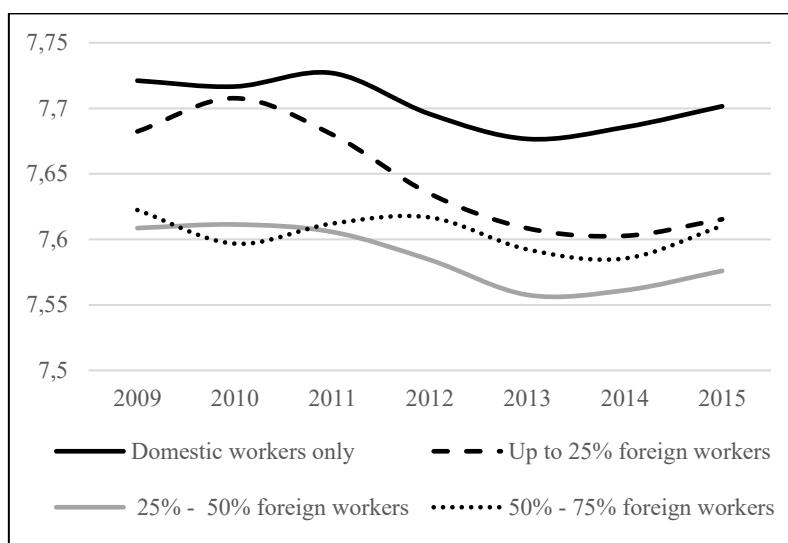


Source: own estimates

Figure 5 reports 16 two-digit NACE sectors, where only in the case of manufacturing and wholesale trade do firms employing foreign workers always have higher TFP than firms employing only domestic workers. The manufacturing sector encompasses a diversified array of production activities, ranging from agri-food and textiles to chemicals, machinery and furniture. This sector is characterized

by the presence of numerous traditional industries lacking significant economies of scale, often comprising small and medium-sized enterprises. Conversely, the wholesale and retail trade sector encompasses service-oriented businesses competing directly with global giants. This competitive landscape may have incentivized firms within this sector to adopt cost-saving strategies, potentially including the recruitment of low-skilled and low-cost foreign labour to maintain economic viability. Significantly, the disparity in TFP between firms employing only domestic workers and those employing foreign labour is especially pronounced within most service sectors, including finance, real estate and professional services. Furthermore, this disparity exhibits no discernible trend of narrowing over time. This phenomenon may indicate a transformation in the skillset of domestic workers. As suggested by Ottaviano et al. (2018), the substitution of low-skilled tasks by foreign labour may enable domestic workers to transition into occupations in different sectors or requiring higher skill levels. Comparative analysis of Table 3 and Figure 5 reveals several key insights. The sector with the highest percentage of foreign workers – hotels and restaurants – is a low-TFP sector with a widening divide between firms with and without foreign workers; the latter perform better in the 2009–2015 time lapse. The tourism industry in Emilia-Romagna has faced increasing competition from alternative destinations in recent years. However, it has remained competitive by offering low-cost options, despite its outdated infrastructure and traditional tourist offerings. Few sectors (i.e. finance and insurance and real estate) have higher TFP than the rest, and the TFP gap is widening between firms employing foreign workers and those employing only domestic workers. The initial interpretation suggested by this evidence prioritizes industry structure over the presence of foreign workers. This interpretation is supported by the significant performance disparities observed across sectors. These disparities likely stem from inherent characteristics such as: (1) being traditional/mature sectors lacking economies of scale, (2) operating in industries with significant economies of scale, or (3) exhibiting high sensitivity to the business cycle, as exemplified by the construction sector. Previous analyses count only the presence of foreign employees in the workforce, rather than the effective number of foreign workers. Instead, Figure 6 presents the detail of the effective weight of foreign workers across firms. Once again, our findings indicate that firms employing only domestic workers consistently exhibit higher TFP compared to those employing foreign labour. Interestingly, a downward trend in TFP emerges from 2012 onwards for firms whose foreign worker share exceeds 25%. Further analysis, examining the relative proportion of foreign workers to the total workforce in relation to TFP, indicates a weak negative correlation (-0.08). This aligns with the observations of Mitaritonna et al. (2017), who report a similar negative correlation for French firms (p. 69).

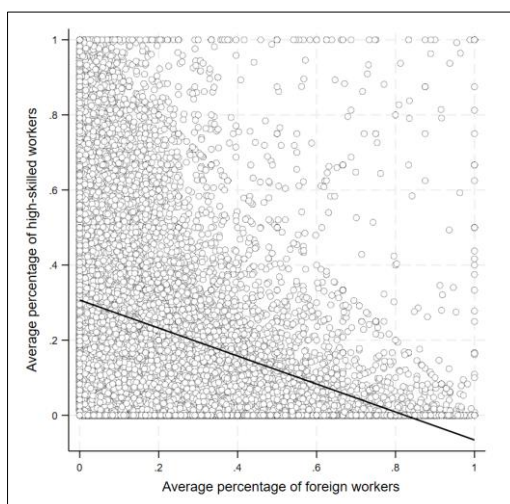
Figure 6. Average TFP and increasing percentages of foreign workers.



Source: own estimates

Our data reveal an inverse relationship between TFP and exporting activity: Firms engaged in exporting show declining TFP over time. Additionally, exporting firms employing foreign labour consistently demonstrate lower TFP compared to those employing only domestic workers. This contradicts findings by Andrews et al. (2017) and Hatzigeorgiou and Lodefalk (2016), who reported a positive association between the proportion of foreign workers and exporting. However, firms hosting foreign capital (indicating inward foreign direct investment) boast higher TFP compared to exclusively domestic firms. This pattern extends to domestic firms investing abroad and those participating in both inward foreign direct investment and outward foreign direct investment. Remarkably, these three categories of firms also employ a higher share of foreign workers compared to completely domestic firms. The SIL-ER – AIDA database offers valuable information for exploring the hypothesis that evolving skill requirements within occupational positions could be driving a shift of more skilled workers towards higher-paying jobs or tasks, with less-skilled foreign workers subsequently filling the vacated positions. However, although the database provides data on high-skilled workers by firm and year, it does not allow for disaggregating high-skilled workers and foreign workers within the same category (we cannot disentangle *being foreign* and *being high-skilled*). Figure 7 depicts the negative correlation between the percentage of high-skilled workers and foreign workers. (This is the cumulated data from the all-years average; further details are provided in Table 7.)

Figure 7. High-skilled workers vs. foreign workers, 2008–2015 averages.



Source: own elaboration

The negative correlation in Figure 7 supports the hypothesis put forward by Ottaviano et al. (2018). As the weight of foreign workers increases, the weight of high-skilled workers decreases, hinting for a replacement of vacant less-skilled jobs by less-skilled workers. To match the industry-based correlations with the previous analysis, we computed the separate correlations for the Figure 5 NACE sectors and for the Figure 4 KIA sectors (see Table 4).

Table 4. Correlation between percentages of foreign workers and high-skilled workers

<i>NACE sector</i>	<i>Correlation coefficient</i>
Renting, travel agencies, supporting services	-0.2904
Manufacturing	-0.2528
Transport and storage	-0.2464
Water	-0.2391
Construction	-0.2254
Health	-0.218
Energy	-0.1559
Professional, scientific, technical services	-0.1147
Wholesale trade	-0.113
Hotels and restaurants	-0.0501
Information and communication	-0.0375
Education	-0.0086
<i>KIA sectors</i>	<i>-0.2214</i>
<i>Non-KIA sectors</i>	<i>-0.0941</i>

Source: own elaboration

Correlation coefficients are all negative, and among the top five highest coefficients we find four of the five sectors at the top of the distribution in Table 3. Combining the evidence from the TFP estimation with the sector-based correlation, we may suppose that for these specific sectors there's been an ongoing process of adjustment of tasks and skills: low-skilled foreign workers replacing previous roles held by national workers contribute to improved productivity, with firms minimizing their costs while paying lower wages to less productive foreign workers and paying higher wages to more productive, high-skilled workers. In this framework, the labour market might be featured by an increasing dualism between foreign workers and national workers; and we cannot forget the overall negative performance of TFP through 2008–2015, so that a deteriorating economic environment can be both the cause and the effect of the change in the labour market composition. As for the KIA/non-KIA partition, we observe a higher negative correlation for KIA sectors, another hint in the direction of a changing skill mix.

6. Impact of foreign work over TFP: Methodology and results

In this second step, we follow Devicienti et al. (2018) to explore the impact of foreign work on estimated TFP. We consider alternative specifications of the following regression model:

$$\widehat{TFP}_{it} = \alpha + \beta FW_{it} + \gamma HS_{it} + \vartheta X_{it} + \lambda_{st} + \mu_{pt} + u_{it}, \quad (8)$$

where $\widehat{TFP}_{it}$ is the estimated firm-level TFP from the previous step; FW_{it} is the share of foreign workers over the firm's total number of employees, and is our regressor of interest; HS_{it} is the share of high-skilled workers over a vector the firm's total number of employees; and X_{it} collects some variables included as controls (shares of female workers, temporary workers and workers younger than 25; a factor $Distance_{it}$, capturing the difference between each firm's revenue at time t and the average revenue of the industrial sector as to control for idiosyncratic shocks). The potential foreign enclave-determined endogeneity of TFP has already been considered under the first step, but to further consider the presence of common shocks in TFP, as in Vittori et al. (2023), we also introduce the parameters λ_{st} and μ_{pt} – sector-by-period and province-by-period fixed effects, respectively. This also helps fight endogeneity in case the top-performing sectors or provinces were also those that were hiring more workers in general (or in case workers were more attracted to top-performing sectors or provinces). Moreover, sectors and firms are tightly interconnected because of the economic interactions between them; a typical by-product of this fact is the transmission of TFP shocks from one sector to another (for example, through user–supplier interactions). The equation was estimated

though pooled OLS, random effects (RE), instrumental variables (IV) and IV-RE. In these two latter instances, we instrumented foreign work with its two-year lag (as we already included the shift-share instrument (7) on the first step of TFP estimation). Results for estimates of (8) are included in Table 5.

Table 5. Impact of foreign work on TFP (estimation methods: OLS, RE, IV, IV-RE)

<i>Dependent variable: TFP</i>	<i>Pooled OLS 1</i>	<i>Pooled OLS 2</i>	<i>IV-2SLS</i>	<i>RE 1</i>	<i>RE 2</i>	<i>RE IV - 2SLS</i>
% of foreign workers	-0.037*** (0.004)	0.036*** (0.004)	-0.073*** (-0.006)	-0.012*** (0.004)	0.002 (0.004)	-0.078*** (0.008)
% of high-skilled workers	0.169*** (0.003)	0.121*** (0.003)	0.170*** (-0.003)	0.072*** (0.003)	0.033*** (0.003)	0.150*** (0.003)
% of female workers	0.111*** (0.003)	0.067*** (0.003)	0.120*** (-0.003)	0.056*** (0.003)	0.020*** (0.003)	0.116*** (0.003)
% of part-time workers	0.030*** (0.003)	0.031*** (0.003)	0.007*** (-0.003)	-0.017*** (0.002)	0.013*** (0.002)	0.008*** (0.003)
% of young (< 25) workers	-0.148*** (0.004)	-0.141*** (0.003)	-0.138*** (-0.004)	0.011*** (0.003)	-0.022*** (0.003)	-0.087*** (0.004)
Industry average revenue distance	0.000*** (0.000)	0.000*** (0.000)	0.000*** (-0.000)	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)
Constant	7.600*** (0.002)	7.796*** (0.012)	7.576*** (-0.002)	7.667*** (0.002)		7.588*** (0.002)
NACE sectors*years		Yes			Yes	
provinces*years		Yes			Yes	
Number of observations	185,224	185,224	149,212	185,224	185,224	149,212
Number of groups				39,888	39,888	33,445
	F(5, 185217) = 1,433.11 Prob > F = 0.0000	F(193, 185029) = 115.48 Prob > F = 0.0000	Wald chi ² (6) = 6,747.67 Prob > chi ² = 0.0000	Wald chi ² (5) = 823.25 Prob > chi ² = 0.0000	Wald chi ² (193) = 17,310.17 Prob > chi ² = 0.0000	Wald chi ² (6) = 4,815.65 Prob > chi ² = 0.0000
	R ² = 0.085 Root MSE = 0.390	R ² = 0.149 Root MSE = 0.376	R ² = 0.094 Root MSE = 0.382	R ² = 0.071	R ² = 0.125	R ² = 0.094

Note: *** $p < .01$; ** $p < .05$; * $p < .1$; OLS estimates: robust standard errors in parentheses

Results suggest that the presence of foreign workers in the workforce has a negative impact on estimated firm-level TFP. The coefficient is negative and statistically significant in four of six models; it turns positive when the sector and province controls are included, but it is significant in only one case (pooled OLS2). The share of high-skilled workers always has a positive sign and is always significant; this also aligns with the previous analyses, in that an improvement in the workers' education and training profiles sum up to the total increase in TFP. The share of female and part-time

workers is also always positive and significant (not for part-time workers in RE 1), whereas the presence of young workers has a statistically significant and negative sign in five of six cases. This may be related to the training and organizational costs that firms have to face when hiring young employees – training that is likely to improve firms’ performance, albeit not in the short term. Finally, the industry distance variable captures firms’ heterogeneity with respect to the industry average; it is always positive and statistically significant (although the coefficient is negligible), thus controlling for the deviation of an individual firm’s sales from the industry average. Our analysis reveals a distinct pattern regarding interaction terms across models. The interaction term *sectors*year* demonstrates minimal to no statistical significance in both OLS and RE estimates, suggesting limited evidence for sector-specific trends over time. By contrast, the interaction term *province*year* exhibits statistically significant results with both positive and negative values in several instances, implying the presence of territorial-level business cycles that influence firm productivity. However, it is important to emphasize that the observed negative impact of the share of foreign workers remains quantitatively small. Additionally, although we explored model specifications using levels instead of shares for all variables, this approach was ultimately deemed unsuitable due to potential identification issues arising from the inclusion of dependent worker levels in the first stage.

To further investigate the interaction between the foreign workforce and high-skilled workers at the firm level, we conducted regressions on the four quartiles of firms based on their average growth rate of high-skilled workers between 2008 and 2015. Firms in the fourth quartile – signifying a negative growth rate – experienced losses in high-skilled positions during this period. The key findings from these regressions are presented in Table 6.

Table 6. Impact over TFP by quartiles of average high-skilled workers' growth in 2008–2015

Dependent variable: TFP	1st quartile	2nd quartile	3rd quartile	4th quartile
<i>Avg. growth rate of HS jobs</i>	< -0.071	$\geq -0.071; < 0$	$\geq 0; < 0.083$	≥ 0.083
Key Regressors				
% of foreign workers	-0.297*** (0.064)	-0.433*** (-0.104)	-0.374*** (0.107)	-0.019*** (0.009)
% of high-skilled workers	0.071*** (0.008)	0.112*** (0.015)	0.006 (0.014)	0.204*** (0.005)
Number of observations	26,705	17,413	20,646	66,001
Number of groups	5,901	3,264	3,887	16,033
R ²	0.0601	0.0871	0.1086	0.103
Wald chi ² (6)	287.54	184.45	106.42	2905.7
Prob > chi ²	0.000	0.000	0.000	0.000

Note: RE IV - 2SLS estimates. *** $p < .01$; ** $p < .05$; * $p < .1$

Analysis of the data reveals that the majority of firms experienced an average increase in high-skilled workers, aligning with the fourth quartile. Interestingly, the impact of foreign workers consistently demonstrates a negative association that is especially concentrated around the median group exhibiting no average increase. Conversely, the impact of high-skilled workers consistently exhibits a positive association, with the strongest effect observed within the fourth quartile. This observation suggests potential increasing returns associated with investments in training and education. Significantly, the negative impact of foreign workers appears to be mitigated in the fourth-quartile firms. This phenomenon may be attributable to superior performance arising from organizational or industry-specific factors, or to fewer foreign-worker hires within these firms. On average, the fourth quartile employed 2.14 foreign workers during the 2008–2015 period, compared to 5.77 and 4.52 in the third and second quartiles, respectively. Furthermore, although firms positioned below the median exhibited an average reduction in high-skilled workers, the impact of the remaining skilled workers surpassed that observed in the third quartile. Also, the third quartile experienced an increase in their share of high-skilled workers, albeit not to the same extent as the fourth quartile. However, it is important to note that the coefficient for high-skilled jobs in the third quartile is not statistically significant.

7. Discussion and conclusions

This study exploits an observational administrative database from the Emilia-Romagna region of northern Italy (SIL-ER), which details both firm characteristics and their employee intakes disaggregated by nationality, gender, and skill level. Additionally, matching with the AIDA database provides financial data for these firms. The Emilia-Romagna region offers a relevant research context due to its consistent rise in migrant inflows and, consequently, the increasing share of foreign workers within local firms from 2008 to 2015. Amidst ongoing discussions regarding the impact of foreign immigration on economic growth, this study employs a rigorous two-step approach to assess the magnitude and direction of foreign worker contributions to firm productivity. First, we estimated TFP across the eight-year observation period; the second step quantified the impact of foreign workers on firm TFP. To address potential endogeneity concerns, the first step incorporated a shift-share instrument rooted in the Markov process to estimate productivity, drawing inspiration from the enclave theory of migrant worker relocation based on familial networks. Notably, the initial step reveals a negative association between TFP and foreign labour, with only two sectors demonstrating higher TFP for firms employing foreign workers. Furthermore, across the entire investigated timeframe, TFP exhibits a general decline. When taking into consideration high-skilled workers'

share of the administrative data, we find a negative correlation with the foreign workers' presence, which supports the hypothesis of a labour market adjusting to allow low- to medium-skilled foreign workers to shift into those roles once occupied by national workers, perhaps tapping into higher wages while moving towards more highly skilled working positions. Those firms hiring more high-skilled workers are also the firms employing a lower average number of foreign workers. In certain respects, this mechanism resembles the current process related to artificial intelligence (AI) diffusion, where unskilled or low-skilled workers will be easily replaced by cost-effective new technologies, whereas skilled professionals who are able to use and manage the new tool may be able to develop new competences and achieve more highly paid positions, with a certain increasing polarization in the labour market and increasing disparities. For a very small proportion of the firms), we have information about the international stance. Firms with an international dimension through foreign direct investment – both inward and outward – exhibit higher estimated TFP than solely domestic firms, and those employing foreign workers always have higher TFP than those employing only national workers; however, the relatively small number of firms for which internationality information was available did not permit the inclusion of these variables in the estimates. It would appear that a further polarization of competencies across firms is at work, with respect to foreign labour. Less knowledge-intensive firms may be turning to low-skilled foreign labour in a bid to survive and adapt to the changing context. From a policy perspective, for distressed firms experiencing demand shortages and cyclical downturns, facilitating the influx of lower-cost, low-skilled labour (often composed of foreign workers) may offer a temporary buffer against economic fluctuations. However, such a strategy entails the potential downside of exacerbating labour market segmentation, creating distinct strata between low-skilled foreign workers and their domestic counterparts. It is important to acknowledge that our analysis excludes an important issue: the potential impact on low-skilled domestic workers who lack the capacity to reallocate or retrain themselves. This transformation could have undesirable consequences, potentially leading to an increase in the gig economy workforce or, more concerningly, a decline in overall labour force participation. Such outcomes may arise from the inability of certain individuals to adapt to changing economic demands, potentially necessitating increased reliance on public support structures. To ensure sustainable output growth and enhanced competitiveness in the long run, policymakers should prioritize investments in high-level education and training for both domestic and foreign workforces. Additionally, a focus on aligning wages with demonstrably improved and elevated productivity could incentivize investment in human capital and contribute to a more dynamic and resilient economy.

Statements and Declarations

The authors have no relevant financial or non-financial interests to disclose.

The authors have no conflicts of interest to declare that are relevant to the content of this article.

All authors certify that they have no affiliations with, or involvement in, any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

The authors have no financial or proprietary interests in any material discussed in this article.

No funds, grants, or other support was received.

8. References

Acemoglu D (2002) Directed technical change. *Rev Econ Stud* 69:781–809

Akerberg D, Caves K, Frazer G (2015). Identification properties of recent production function estimators. *Econometrica* 83: 2411–2451.

Altonji J, Card D (1991) The effects of immigration on the labor market outcomes of less-skilled natives, in immigration, trade, and the labor market. NBER Inc. pp 201–234

Andrews M, Schank T, Upward R (2017) Do foreign workers reduce trade barriers? Microeconomic evidence. *World Econ* 40:1750–1774.
<https://doi.org/10.1111/twec.12486>

Baldwin Edwards M (1998) Where free markets reign: Aliens in the twilight zone. *South Eur Soc Politics* 3:1–15. <https://doi.org/10.1080/13608740308539545>

Ban C (2012) Economic transnationalism and its ambiguities: The case of Romanian migration to Italy. *Int Migr* 50:129–149. <https://doi.org/10.1111/j.1468-2435.2009.00556.x>

Bettin G, Lo Turco A, Maggioni D (2014) A firm-level perspective on migration: The role of extra-EU workers in Italian manufacturing. *J Prod Anal* 42:305–325. <https://doi.org/10.1007/s11123-014-0390-2>

Bianchi M, Buonanno P, Pinotti P (2012) Do immigrants cause crime? *J Eur Econ Assoc* 10:1318–1347. <https://doi.org/10.1111/j.1542-4774.2012.01085.x>

Bianchi P, Giardino R, Labory S, Rinaldi A, Solinas G (2021) Regional resilience: Lessons from a historical analysis of the Emilia-Romagna region in Italy. *Bus Hist*.
[doi:10.1080/00076791.2021.1945034](https://doi.org/10.1080/00076791.2021.1945034)

- Bonizzoni P (2018) Looking for the best and brightest? Deservingness regimes in Italian labour migration management. *Int Migr* 56:47–62. <https://doi.org/10.1111/imig.12447>
- Bosco MG, Valeriani E (2023) Energy retrofitting of firms after a natural disaster: A ‘build back better’ strategy. *Energy Policy*. <https://doi.org/10.1016/j.enpol.2023.113634>
- Boubtane E, Dumont J-C, Rault C (2016) Immigration and economic growth in the OECD countries 1986–2006. *Oxford Economic Papers*, Volume 68, Issue 2:340–360, <https://doi.org/10.1093/oenp/gpw001>
- Boucher AK, Gest J (2018) *Crossroads: Comparative immigration regimes in a world of demographic change*. Cambridge University Press.
- Bratti M, Conti C (2018) The effect of immigration on innovation in Italy. *Reg Stud* 52:934–947. <https://doi.org/10.1080/00343404.2017.1360483>
- Brunello G, Lodigiani E, Rocco L (2020) Does low-skilled immigration increase profits? Evidence from Italian local labour markets. *Reg Sci Urban Econ* 85:103582. <https://doi.org/10.1016/j.regsciurbe.co.2020.103582>
- Card D (2001) Immigrant inflows, native outflows, and the local labor market impacts of higher immigration. *J Labor Econ* 19:22–64
- Card D, Dustmann C, Preston I (2012) Immigration, wages, and compositional amenities. *J Eur Econ Assoc* 10:78–119. <https://doi.org/10.1111/j.1542-4774.2011.01051.x>
- Casacchia O, Polli C (2021) The contribution of foreign workers on productivity and wages: Company-level evidence from Italy. *Riv Ital Econ Demogr Stat* 75:July–September 2021. <http://www.sieds.it/index.php/2022/01/19/rieds-vol-lxxv-3-july-september-2021/>
- Castles S (2006) Guestworkers in Europe: A resurrection? *Int Migr* 40:741–766. <https://doi.org/10.1111/j.1747-7379.2006.00042.x>
- Centro Studi Luca d’Agliano and Collegio Carlo Alberto, 7th Migration Observatory Report, 2023, https://dagliano.unimi.it/wp-content/uploads/2023/03/Obs_Mig_7_Annual_Report.pdf
- Coad A, Holm JR, Krafft J, Quatraro F (2018) Firm age and performance. *J Evol Econ* 28:1–11. <https://doi.org/10.1007/s00191-017-0532-6>
- Colombo AD, Dalla-Zuanna G (2019) Immigration Italian style, 1977–2018. *Popul Dev Rev* 45:585–615. <https://doi.org/10.1111/padr.12275>
- De Arcangelis G, Di Porto E, Santoni G (2015) Migration, labour tasks and production structure. *J Econ Issues* 53:156–169. <https://doi.org/10.1016/j.regsciurbeco.2015.06.001>
- De Benedictis L (2005) Three decades of Italian comparative advantages. *World Econ* 28:1679–1709. <https://doi.org/10.1111/j.1467-9701.2005.00752>
- Del Boca D, Venturini A (2005) Italian migration. In: Zimmermann KF (ed), *European migration - What do we know?* Oxford University Press, pp 303–336.

- Demireva N, Zwysen W (2021) Ethnic enclaves, economic and political threat: An investigation with the European Social Survey. *Front Sociol.* <https://doi.org/10.3389/fsoc.2021.660378>
- Devadas S (2017) Threat or help?: The effects of unskilled immigrant workers on national productivity growth (March 1, 2017). World Bank Research and Policy Briefs No. 113185, available at SSRN: <https://ssrn.com/abstract=3249557>
- Devicienti F, Grinza E, Vannoni D, (2018) The impact of part-time work on firm productivity: Evidence from Italy. *Ind Corp Change* 27:321–347. <https://doi.org/10.1093/icc/dtx037>
- Devitt C (2023) The admission of foreign workers to Italy: Closing the ‘gap’ with Northern Europe. In: Finotelli C, Ponzo, I. (eds) *Migration control logics and strategies in Europe*. IMISCOE Research Series. Springer, Cham. https://doi.org/10.1007/978-3-031-26002-5_10
- Doran K, Gelber AM, Gelber A, Isen A (2014) The effects of high-skilled immigration policy on firms: Evidence from H-1B visa lotteries. NBER working paper No. w20668. Available at <https://ssrn.com/abstract=2521426>
- Dustmann C, Glitz A, Frattini T (2008) The labour market impact of immigration. *Oxf Rev Econ Policy* 24:477–494. <https://doi.org/10.1093/oxrep/grn024>
- Finotelli C, Sciortino G (2009) The importance of being Southern: The making of policies of immigration control in Italy. *Eur J Mgr Law* 11:119–138. <https://doi.org/10.1163/157181609X439998>
- Gandal N, Hanson GH, Slaughter MJ (2004) Technology, trade, and adjustment to immigration in Israel. *Eur Econ Rev* 48:403–428. [https://doi.org/10.1016/S0014-2921\(02\)00265-9](https://doi.org/10.1016/S0014-2921(02)00265-9)
- Geddes A, Pettrachin A (2020) Italian migration policy and politics: Exacerbating paradoxes. *Contemp Ital Politics* 12:227–242. <https://doi.org/10.1080/23248823.2020.1744918>
- Gidehag A, Lodefalk M (2016) Recruiting for small business growth: Micro-level evidence. Örebro University working paper in economics 2016:6.
- Gill F (2019) Do enclaves help or hinder the American dream? *J Econ Issues* 53:39–56. DOI: [10.1080/00213624.2019.1557000](https://doi.org/10.1080/00213624.2019.1557000)
- Gosh A, Mayda AM, Ortega F (2016) The impact of skilled foreign workers on firms: An investigation of publicly traded U.S. firms. IZA discussion paper No. 8684.
- Hannan MT, Freeman J (1984) Structural inertia and organizational change. *Am Sociol Rev* 49:149–164. <https://doi.org/10.2307/2095567>
- Hatzigeorgiou A, Lodefalk M (2016) Migrants’ influence on firm-level exports. *J Ind Compet Trade* 16:477–497. <https://doi.org/10.1007/s10842-015-0215-7>
- Ismail R (2015) Impact of foreign workers on labour productivity: Analysis of firm-level data. *Int J Product Qual Manag* 16:36–53. <https://doi.org/10.1504/IJPQM.2015.070191>
- ISTAT (2013), *La classificazione delle professioni*. https://www.istat.it/it/files/2013/07/la_classificazione_delle_professioni.pdf

- Kangasniemi M, Mas M, Robinson C, Serrano L (2012) The economic impact of migration: Productivity analysis for Spain and the U.K. *J Prod Anal* 38:333–343. <https://doi.org/10.1007/s11123-012-0280-4>
- Konings J, Vanormelingen S (2015) The impact of training on productivity and wages: Firm-level evidence. *Rev Econ Stat* 97:485–497. <https://www.jstor.org/stable/43556188>
- Larch M (2005) Stuck in a rut? Italy's weak export performance and unfavourable product specialization. *ECFIN Country Focus* 2:1–6
- Levinsohn J, Petrin A (2003) Estimating production functions using inputs to control for unobservables. *Rev Econ Stud* 70:317–341
- Lewis E (2011) Immigration, skill mix, and capital skill complementarity. *Q J Econ* 126:1029–1069. <https://doi.org/10.1093/qje/qjr011>
- Lucas RE (1988) On the mechanics of economic development. *J Monet Econ* 22:3–42
- McGowan MA, Andrews D (2015) Skill mismatch and public policy in OECD countries. OECD Economics Department working papers no. 1210. Paris, OECD. <https://doi.org/10.1787/18151973>
- Mariotti S, Nicolini M, Piscitello L (2015) Vertical linkages between foreign MNEs in service sectors and local manufacturing firms. *Struct Change Econ Dyn* 25:133–145. <https://doi.org/10.1016/j.strueco.2012.07.001>.
- Martins PS, Piracha M, Varejão J (2018) Do immigrants displace native workers? Evidence from matched panel data. *Econ Model* 72:216–222. <https://doi.org/10.1016/j.econmod.2018.01.019>
- Mayda AM (2006) Who is against immigration? A cross-country investigation of individual attitudes toward immigrants. *Rev Econ Stat* 88:510–530. <http://dx.doi.org/10.1162/rest.88.3.510>
- Mayda AM, Ortega F, Peri G, Shih K, Sparber C (2023) Coping with H-1B shortages: Firm performance and mitigation strategies. *ILR Review* 76:919–943. <https://doi.org/10.1177/00197939231165770>
- McGowan MA, Andrews D (2015) Labour market mismatch and labour productivity: Evidence from PIAAC data. OECD Economics Department Working Papers, No. 1209, OECD Publishing, Paris, <https://doi.org/10.1787/5js1pzx1r2kb-en>
- Mehra M, Shen H (2022) Skilled immigration, firms, and policy. *J Int Econ* 139:103662. <https://doi.org/10.1016/j.jinteco.2022.103662>
- Milken Institute (2017), Best-performing cities, Europe 2017, available at: <https://milkeninstitute.org/report/best-performing-cities-europe>
- Mitaritonna C, Orefice G, Peri G (2017) Immigrants and firms' outcomes: Evidence from France. *Eur Econ Rev* 96:62–82. <https://doi.org/10.1016/j.eurocorev.2017.05.00>
- Moehling C, Piehl AM (2009) Immigration, crime, and incarceration in early twentieth-century America. *Demography* 46:739–763. <https://doi.org/10.1353/dem.0.0076>

- Nicodemo C (2013) Immigration and labor productivity. New empirical evidence for Spain. IZA Discussion Paper no. 7297, Bonn, IZA
- OECD (2012) Renewing the skills of ageing workforces: The role of migration, international migration outlook. OECD Publishing
- OECD (2018) International migration outlook 2018. OECD Publishing
- OECD Statistics (2019) <https://data.oecd.org/price/price-level-indices.htm#indicator-chart>
- Olley SG, Pakes A (1996) The dynamics of productivity in the telecommunications equipment industry. *Econometrica* 64:1263–1297
- Ortega F, Peri G (2009) The causes and effects of international migrations: Evidence from OECD countries 1980–2005. NBER working papers No. 14833, National Bureau of Economic Research, Inc. https://www.nber.org/system/files/working_papers/w14833/w14833.pdf
- Ortega F Peri G (2014) The aggregate effects of trade and migration: Evidence from OECD countries. In: Artal-Tur A, Peri G, Requena-Silvente F (eds) The socio-economic impact of migration flows. Population economics. Springer.
- Ottaviano G, Peri G (2006) The economic value of cultural diversity. Evidence from U.S. cities. *J Econ Geog* 6:9–44. <https://doi.org/10.1093/jeg/lbi002>
- Ottaviano G, Peri G, Wright GC (2018) Immigration, trade and productivity in services. Evidence from U.K. firms. *J Int Econ* 112:88–108. <https://doi.org/10.1016/j.jinteco.2018.02.007>
- Paserman MD (2013) Do high-skill immigrants raise productivity? Evidence from Israeli manufacturing firms, 1990–1999. *IZA J Migr* 2:1–31. <https://doi.org/10.1186/2193-9039-2-6>
- Pastore F (2010) Managing migration through the crisis. Evolving patterns in European policies on labour migration and mobility. LabMigGov Papers, FIERI. <http://briguglio.asgi.it/immigrazione-e-asilo/2011/gennaio/art-pastore-migr-crisi.pdf>
- Peri G (2012) The effect of immigration on productivity. Evidence from U.S. states. *Rev Econ Stat* 94:348–358. https://doi.org/10.1162/REST_a_00137
- Peri G (2016) Immigrants, productivity, and labor markets. *J Econ Perspect* 30:3–30. <http://dx.doi.org/10.1257/jep.30.4.3>
- Peri G, Sparber C (2009) Task specialization, immigration, and wages. *Am Econ J Appl Econ* 1:135–69. DOI: [10.1257/app.1.3.135](https://doi.org/10.1257/app.1.3.135)
- Petrin A, Poi BP, Levinsohn J (2004) Production function estimation in Stata using inputs to control for unobservables. *Stata J* 4:113–123. <https://doi.org/10.1177/1536867X0400400202>
- Piracha M, Vadean F (2013) Migrant educational mismatch and the labor market. In: Constant AF, Zimmermann KF (eds) International handbook on the economics of migration, Edward Elgar, Cheltenham, U.K., and Northampton, U.S.A, Chapter 9, pp 176–192. <https://doi.org/10.4337/9781782546078.00017>

- Quispe-Agnoli M, Zavodny M (2002) The effect of immigration on output mix, capital and productivity. *Econ Rev* 87:1–11. <https://core.ac.U.K./download/pdf/6648589.pdf>
- Regione Emilia-Romagna (2022) L'immigrazione straniera in Emilia-Romagna. Edizione 2022. https://sociale.regione.emilia-romagna.it/documentazione/pubblicazioni/prodotti-editoriali/2022/12019immigrazione-straniera-in-emilia-romagna-anno-2022/@@download/publicationFile/Immigrazione2022_web.pdf
- Rybczynski TN (1955) Factor endowments and relative commodity prices. *Economica* 22:336–341. <https://doi.org/10.2307/2551188>
- Romer P (1990) Endogenous technological change. *J Pol Econ* 98:S71–102
- Rovigatti V, Mollisi G (2018) Theory and practice of total-factor productivity estimation: The control function approach using Stata. *Stata J* 18:618–662. <https://doi.org/10.1177/1536867X1801800307>
- Salis E (2012) Labour migration governance in contemporary Europe: The case of Italy. FIERI. DOI:10.13140/RG.2.1.4296.0088
- Sciortino G (2009) Fortunes and miseries of Italian labour migration policy. CeSPI. https://www.cespi.it/sites/default/files/documenti/country_mig-italia-sciortino.pdf
- Shapiro C, Stiglitz JE (1984) Equilibrium unemployment as a worker discipline device. *Am Econ Rev* 74:433–444. <http://www.jstor.org/stable/1804018>
- Smarzynska Javorcik B (2004) Does foreign direct investment increase the productivity of domestic firms? In search of spillovers through backward linkages. *Am Econ Rev* 94:605–627. DOI: 10.1257/0002828041464605
- Smith J (2018) Migration, productivity and firm performance: A report for the migration advisory committee. https://assets.publishing.service.gov.U.K./government/uploads/system/uploads/attachment_data/file/740988/Smith_2018_.pdf
- Solow R (1957) Technical change and the aggregate production function. *Rev Econ Stat* 39:312–320
- Trax M, Brunow S, Suedekum J (2015) Cultural diversity and plant-level productivity. *Reg Sci Urban Econ* 53:85–96. <https://doi.org/10.1016/j.regsciurbeco.2015.05.004>
- Vittori C, Ricci A, Ferri F (2023) Extra-EU immigrants and labour productivity: New evidence from Italian firms. *World Econ*. <https://doi.org/10.1111/twec.13430>
- Wooldridge JM (2009) On estimating firm-level production functions using proxy variables to control for unobservables. *Econ Lett* 104:112–114. <https://doi.org/10.1016/j.econlet.2009.04.026>

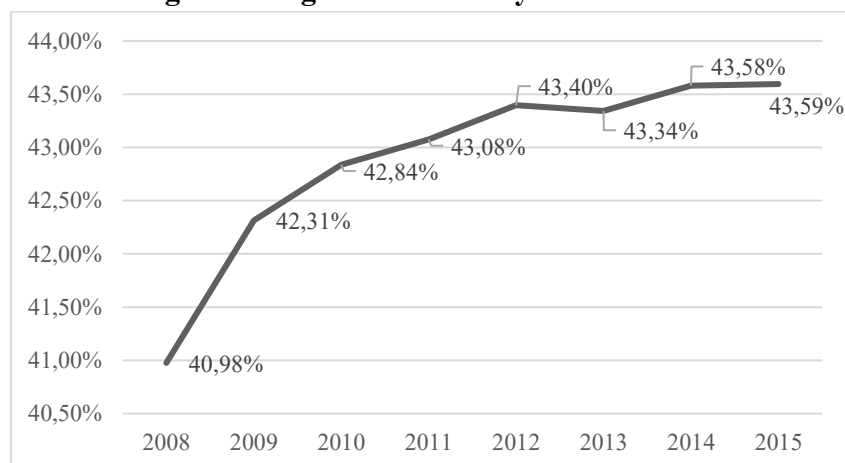
Appendix

Table 7. KIA sectors

<i>NACE Rev. 2 codes</i>	<i>Description</i>
9	Mining support service activities
19	Manufacture of coke and refined petroleum products
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
26	Manufacture of computer, electronic and optical products
51	Air transport
58	Publishing activities
59	Motion picture, video and television programme production and pharmaceutical preparations
60	Programming and broadcasting activities
61	Telecommunications
62	Computer programming, consultancy and related activities
63	Information service activities
64	Financial service activities, except insurance and pension funding
65	Insurance, reinsurance and pension funding, except compulsory social security
66	Activities auxiliary to financial services and insurance activities
69	Legal and accounting activities
70	Activities of head offices; management consultancy activities
71	Architectural and engineering activities; technical testing and analysis
72	Scientific research and development
73	Advertising and market research
74	Other professional, scientific and technical activities
75	Veterinary activities
78	Employment activities
79	Travel agency, tour operator reservation service and related activities
84	Public administration and defence; compulsory social security
85	Education
86	Human health activities
90	Creative, arts and entertainment activities
91	Libraries, archives, museums and other cultural activities
94	Activities of membership organisations
99	Activities of extraterritorial organisations and bodies

Source: https://ec.europa.eu/eurostat/cache/metadata/Annexes/htec_esms_an8.pdf

Figure 8. High-skill workdays in 2008–2015



Source: SIL-ER database

Table 8. Levinsohn–Petrin estimates for TFP

<i>LP productivity estimator</i>		Plain				
<i>Dependent variable: ln(sales)</i>	<i>Coefficient</i>	<i>Std. err.</i>	<i>z</i>	<i>P > z </i>	<i>[95% conf. interval]</i>	
ln(employees)	0.451	0.003	133.97	0.000	0.4451737	0.4583922
ln(capital)	0.077	2.56e-08	3.0e+06	0.000	0.0777995	0.0777996
Shift-share instrument	4.42e-06	2.97e-07	14.88	0.000	3.83e-06	5.00e-06
Firm age	-0.005	6.07e-08	9.5e+04	0.000	-0.005769	-0.0057688
Province unemployment	-0.041	1.80e-08	2.3e+06	0.000	-0.0418389	-0.0418388
Intermediate inputs	0.290	2.17e-07	1.3e+06	0.000	0.2904881	0.290489
Wald test on constant returns to scale: $\chi^2 = 4,552.77$				$p = (0.00)$		
Number of observations = 221,243		Number of groups = 44,164				

<i>LP productivity estimator</i>		With endogeneity correction				
ln(employees)	0.459	0.0030873	148.96	0.000	0.4538262	0.4659282
ln(capital)	0.101	9.91e-08	1.0e+06	0.000	0.1015206	0.101521
Shift-share instrument	5.74e-07	3.55e-07	1.61	0.106	-1.23e-07	1.27e-06
Firm age	0.017	1.63e-08	1.1e+06	0.000	0.0174146	0.0174147
Province unemployment	-0.011	1.19e-07	-9.8e+04	0.000	-0.0116386	-0.0116381
Intermediate inputs	0.319	8.43e-08	3.8e+06	0.000	0.3197347	0.319735
Wald test on constant returns to scale: $\chi^2 = 1,341.83$				$p = (0.00)$		
Number of observations = 201,321		Number of groups = 43,811				