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Abstract

This paper explores the question of how immigrant employees affect a firm's capacity to absorb foreign knowledge. Using matched employer-employee data from Denmark for the years 1996 to 2009, we are able to show that non-Danish employees from technologically advanced countries contribute significantly to a firm's total factor productivity (TFP) through their ability to access foreign knowledge. The empirical results suggest that the impact increases if the immigrants come from technologically advanced countries, are highly educated, and work in high-skilled positions.

Keywords: R&D Spillovers, Absorptive Capacity, Firm-Level Analysis, Foreign Workers, Immigrants

JEL Classification Numbers: D20, J82, L20, O30

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1 Introduction

Immigrant employees have a substantial impact on firm performance. Their different cultural backgrounds may be both, a boon or a bane to the firm. On the one hand, firms may incur high coordination costs from having an ethnically diverse labor force. On the other hand, they may benefit from the knowledge and social capital provided by foreign workers. Recent empirical findings have highlighted the substantial costs of ethnic diversity. According to Parotta et al. (2014a), although ethnic diversity may spur innovation, it is detrimental to firm productivity (Parrotta et al., 2014b). Yet as other research has shown, immigrant employees have the capacity to lower informational barriers and discover trading opportunities by exploiting ties to their ethnic networks (Rauch, 2001; Rauch and Trindade, 2002; Peri and Requena-Silvente, 2010), leading to a boost in firm trade with immigrants' home countries (Hatzigeorgiou and Lodefalk, 2015; Hiller, 2013; Bastos and Silva, 2012). Furthermore, immigrants may contribute not only to lowering barriers to trade in the firms where they work but also to increasing international knowledge acquisition by extending the firm's absorptive capacity (Cohen and Levinthal, 1990). Following Cohen and Levinthal (1994), the successful absorption of foreign knowledge makes it necessary to "evaluate the technological and commercial potential of knowledge in a particular domain, assimilate it, and apply it" (Cohen and Levinthal, 1994, p. 227). Arrow (1969) points out that the transfer of knowledge requires that the foreign knowledge first has to be decoded by the recipient. This decoding process requires not only prior technological knowledge but also linguistic and cultural knowledge as well as personal contacts.[1] Thus immigrant employees equipped with a particular language, a certain cultural background, or personal contacts can increase a firm's ability to absorb knowledge from its external environment.

The arguments in Arrow (1969) are supported by an empirical study of Kerr (2008), who argues that international ethnic scientific networks foster the diffusion of knowledge among nations around the world. He shows that foreign researchers outside the US cite researchers of their own ethnicity within the US more frequently than those from other ethnic groups, thus contributing significantly to technology diffusion between developed and emerging countries. The underlying argument is that ethnic scientific networks increase awareness of recent technological developments and foster trust in otherwise uncertain legal environments. The importance of social capital in co-ethnic networks that facilitate knowledge exchange between innovators through

[1] Arrow cites the development of jet engines during the Second World War as an example: When British authorities decided to share plans for the jet engine with US allies, it took US researchers as long as ten months to redraw the plans to make them suitable for American usage.

enhanced trustworthiness has been analyzed by Coleman (1988) and Kalnins and Chung (2006). Their functioning of reputation intermediaries in industries where tacit knowledge is important has been shown by Kapur (2001). Pertaining to the sources of technology transfers, Agrawal et al. (2008) have shown that social proximity (e.g., co-ethnic networks) among members of the US resident Indian diaspora substitutes for geographical proximity in its role for knowledge diffusion. Their result is particularly relevant for firms recruiting foreign workers to increase their innovation capacities through their access to foreign knowledge flows: Hiring immigrants may – to some extent – remove the need for "incurring the cost of moving teacher and student into the same geographical location" (Keller, 2004, p. 756) to pass on tacit knowledge. That firms' hiring decisions in general matter for inter-firm knowledge transmission is shown by Balsvik (2011), Parotta and Pozzoli (2012), and Poole (2013).

Thus, Arrow's (1969) considerations and the aforementioned empirical evidence on co-ethnic networks suggest that immigrant employees might extend a firm's absorptive capacity and enhance the absorption of international knowledge spillovers. However, this aspect of immigrant employment has not been analyzed in depth in the firm productivity literature. To the best knowledge of the authors, there are only three studies – Markusen and Trofimenko (2009), Malchow-Møller et al. (2011), and Mitaritonna et al. (2014) – that provide empirical evidence for the importance of immigrant workers for firms' productivity (approximated by wages). The study by Markusen and Trofimenko (2009) shows that in Colombian manufacturing plants, hiring foreign experts increases wages of the domestic workers with some time lag. Malchow-Møller et al. (2011) find that employment of foreign high-skilled workers raises productivity in a panel of Danish firms. In a more recent paper, Mitaritonna et al. (2014) report evidence for a positive effect of immigrants employed in French firms on total factor productivity (TFP). Yet, as these studies do not control for the knowledge in the home countries of the hired foreigners', they cannot distinguish between the influence of the personal skills of the employed foreigners' and the influence of the knowledge the foreigners absorbed abroad and passed on. However, this differentiation is crucial in identifying how immigrant workers affect firm productivity by extending the firm's absorptive capacity.

This is the starting point of our paper. We use highly detailed matched employer-employee data from Denmark covering the years from 1996 to 2009 to assess the impact of immigrant employment on firm TFP transmitted via an immigrant's access to home-country knowledge. To this end, we combine the matched employer-employee data set with information on international R&D capital stocks for OECD countries. Thus, we establish a direct link between available foreign knowledge and the foreign employees of a firm.

Due to our rich dataset, we are able to control for a broad range of firm-specific variables such as physical capital stock, intermediate goods, size of the labor stock, average firm tenure, and ethnic diversity. In addition, we also account for industry-year, region, and time fixed effects to control for unobserved heterogeneity.

The empirical results show that employing immigrants increases firms' TFP via improved transmission of foreign R&D capital stocks. We show that especially high-skilled immigrant workers and immigrant workers employed in skill-intense occupations transmit foreign knowledge, thereby raising firm productivity. Additionally, we confirm existing findings that workforce ethnic diversity is associated with a negative TFP elasticity (e.g., Parrotta et al., 2014a). However, in contrast to this "bane" of immigrant employment our findings provide also evidence for a "boon". That is, an ethnically diverse labor force is an important determinant of a firm's capacity to absorb foreign knowledge.

The remaining parts of the paper are organized as follows. In Section 2 we outline the empirical approach, which constitutes the basis of our empirical analysis. Section 3 describes the data and methods behind the construction of firm-specific international R&D knowledge stocks. Section 4 presents the empirical results, and Section 5 checks the robustness of the results to various sample sizes and among different specifications. Finally, Section 6 concludes by summarizing the main results.

2 Estimation Methodology

2.1 Firm-Level Production Function Estimates

In this section, we outline our empirical strategy for estimating the impact of foreign knowledge on firm TFP, which is based on Wooldridge (2009) and Petrin and Sivadasan (2013). As is standard in the literature, this involves two separate steps. In the first step, estimated productivity is derived from a production function estimation approach. The productivity measure obtained from the previous step can then be used to evaluate the association between firm's TFP and access to foreign knowledge stocks, conditional on other firm-specific controls.

Specifically, we rely on a Cobb-Douglas production function having the form:

$$y_{ijt} = \beta_0 + \beta_l l_{ijt} + \beta_k k_{ijt} + \beta_m m_{ijt} + \varepsilon_{ijt}, \tag{1}$$

where y_{ijt} is the log of gross production, l_{ijt} is the log of labor, k_{ijt} is the log of capital, and m_{ijt} is the log of materials utilized in firm i at year t in industry j, respectively. The error term,

ε_{ijt}, is assumed to have the form:

$$\varepsilon_{ijt} = \omega_{ijt} + \eta_{ijt}, \tag{2}$$

where ω_{ijt} is the transmitted productivity component and η_{ijt} is a purely random (unexpected) productivity shock. The difficulty in estimating equation (1) directly concerns the possible endogeneity problem between the firm's decision on their choice of inputs (l, k, m) given the contemporaneous firm-specific productivity shock, which is observed by the firm but *not* by the econometrician. To tackle this "transmission bias" on the traditional input coefficients, a wide variety of structural production function estimators have been developed (Olley and Pakes, 1996; Levinsohn and Petrin, 2003; Ackerberg et al., 2006; Wooldridge, 2009).[2] The solution to the transmission bias problem is to use information on observed investment i_{ijt} (Olley and Pakes, 1996) or materials m_{ijt} (Levinsohn and Petrin, 2003) to proxy for unobserved productivity shocks ω_{ijt}. Following the approach in Levinsohn and Petrin (2003), a key implication of the theory is that materials are strictly increasing in both capital and productivity. Therefore, it follows for some general function $m(\cdot, \cdot)$:

$$m_{ijt} = m(k_{ijt}, \omega_{ijt}). \tag{3}$$

The assumption of equation (3) is that firms with higher capital stocks (k_{ijt}) or productivity shocks (ω_{ijt}) have a higher demand for material inputs. Provided that materials are strictly positive, it is possible to express the inverse function for the unobservable productivity shock (ω_{ijt}) as follows:

$$\omega_{ijt} = m^{-1}(k_{ijt}, m_{ijt}) \equiv g(k_{ijt}, m_{ijt}). \tag{4}$$

Equation (4) now expresses the *unobservable* productivity shock as a function of *observable* state variables, which can be controlled for in the production function.

Finally, Levinsohn and Petrin (2003) use an assumption about the evolution in the productivity process to identify β_k in the second stage of their estimation approach. Specifically, the authors assume that productivity evolves according to a first-order Markov process, meaning that firm's expectations about its productivity level depends solely on the last period's expectation:

$$\mathbb{E}[\omega_{ijt}|\omega_{ij,t-1}, ..., \omega_{ij1}] = \mathbb{E}[\omega_{ijt}|\omega_{ij,t-1}], \tag{5}$$

[2] See also Eberhardt and Helmers (2010) for an excellent critical discussion on firm-level production function estimators.

along with the additional assumption that the forecast error

$$\xi_{ijt} = \omega_{ijt} - \mathbb{E}[\omega_{ijt}|\omega_{ij,t-1}] \tag{6}$$

is uncorrelated with k_{ijt}. The identification of β_k is achieved based on a timing assumption regarding the evolution of k_{ijt} that was determined by the firm's last-period investment decisions. Wooldridge (2009) strengthens this assumption, imposing that lagged state and proxy variables $(k_{ij,t-1}, m_{ij,t-1})$ are uncorrelated with the forecast error ξ_{ijt} to identify the production function coefficients:

$$\begin{aligned}&\mathbb{E}[\omega_{ijt}|k_{ij,t}, l_{ij,t-1}, k_{ij,t-1}, m_{ij,t-1}, ..., l_{ij1}, k_{ij1}, m_{ij1}]\\ &\qquad = \mathbb{E}[\omega_{ijt}|\omega_{ij,t-1}] \equiv f\left[g(k_{ij,t-1}, m_{ij,t-1})\right].\end{aligned} \tag{7}$$

Equation (7) allows current values of the variable inputs (labour l_{ijt} in this case) to be correlated with ξ_{ijt}, but k_{ijt} and past values of $(l_{ijt}, k_{ijt}, m_{ijt})$ to be uncorrelated with ξ_{ijt}. Inserting $\omega_{ijt} = f\left[g(k_{ij,t-1}, m_{ij,t-1})\right] + \xi_{ijt}$ into the production function yields the following specification, which corresponds to equation (2.11) in Wooldridge (2009):

$$y_{ijt} = \beta_0 + \beta_l l_{ijt} + \beta_k k_{ijt} + \beta_m m_{ijt} + f\left[g(k_{ij,t-1}, m_{ij,t-1})\right] + u_{ijt}, \tag{8}$$

where $u_{ijt} \equiv \xi_{ijt} + \varepsilon_{ijt}$. The orthogonality conditions to identify the production function parameters is expressed as:

$$\mathbb{E}[u_{ijt}|k_{ij,t}, l_{ij,t-1}, k_{ij,t-1}, m_{ij,t-1}, ..., l_{ij1}, k_{ij1}, m_{ij1}] = 0. \tag{9}$$

We follow Petrin and Sivadasan (2013) and approximate $f\left[g(k_{ij,t-1}, m_{ij,t-1})\right]$ using a second-order polynomial expansion in the variables $(k_{ij,t-1}, m_{ij,t-1})$. In addition to the contemporaneous state variable (k_{ijt}), we use first- and second-order lags of labor (l_{ijt}) and second-order lags of materials (m_{ijt}) as instrumental variables (IVs) to identify the production function parameters of the endogenous variables for labor (β_l) and materials (β_m), respectively.

The estimation approach proposed by Wooldridge (2009) offers a number of advantages compared to the standard semi-parametric approach, as outlined in Levinsohn and Petrin (2003). First, standard errors of the production function parameters can be obtained relying on the standard Generalized Methods of Moments (GMM) framework. In contrast, because of the complicated two-step estimation procedure, the semi-parametric approach requires bootstrapping methods to obtain standard errors for the input factors. Second, the *one-step* GMM estimator is more efficient than the *two-step* semi-parametric approach, because the latter procedure ignores the potential correlation across the two equations. Furthermore, specifying an optimal weighting matrix, the GMM framework is able to effectively account for serial correlation and heteroscedasticity. Third, under the Wooldridge (2009) estimation approach, there exist generally more IVs than endogenous variables, which allows for an overidentification restrictions test (testing the joint validity of the instruments).

The estimation is carried out for each two-digit NACE industry classification separately, because structural production function estimators (such as Olley and Pakes, 1996, Levinsohn and Petrin, 2003, Ackerberg et al., 2006) including the Wooldridge-Levinsohn-Petrin approach cannot control for time-invariant firm-level productivity effects, which leads to potential estimation bias in the coefficients for the traditional inputs labor, capital, and materials.[3] The coefficient estimates of the production function parameters are shown in Table 4.[4] The coefficients are of the expected signs and magnitude, with materials having the highest elasticity followed by labor and capital. The returns to scale of all input factors vary considerably across industries and are in the range of 0.53 to 1.01, where only one industry is slightly above constant returns to scale. The remaining industries show decreasing returns to scale. In addition, the overidentification restrictions test (Hansen's J-Statistic) demonstrates that in only four cases can the joint validity of the instrumental variables be rejected at the 1% significance level. In most cases, the joint validity of the included instruments is preserved at the 5% significance level. Only in industries 10, 16, 32, and 33 do we have to reject the null hypothesis of the joint validity of the instruments at the 1% significance level.

2.2 Estimating the Impact of Foreign Knowledge on TFP

Using the coefficient estimates of the production function parameters outlined in the previous section, the total factor productivity (TFP) for firm i in industry j at time t is constructed as follows:

$$\widehat{TFP}_{ijt} = y_{ijt} - \hat{\beta}_l l_{ijt} - \hat{\beta}_k k_{ijt} - \hat{\beta}_m m_{ijt} \equiv \hat{\beta}_0 + \hat{u}_{ijt}. \tag{10}$$

Following the derivation of firm-level TFP estimates, the relationship between this measure of a firm's economic performance and its access to foreign knowledge stocks along with additional

[3] For a critical discussion of this issue see Eberhardt and Helmers (2010).

[4] In some two-digit industries, the coefficient estimates of the production function parameters were of unexpected negative signs. Since negative elasticities seem implausible from an economics point of view, we set these production function estimates as missing values. Furthermore, we also neglect cases where the returns to scale of the variable inputs labor and materials is greater than 1.

firm-specific controls can be analyzed using the following regression equation:

$$\widehat{TFP}_{ijt} = \alpha + \beta_1 \mathcal{X}_{ijt} + \boldsymbol{X'_{ijt}\beta_2} + \alpha_r + \alpha_{jt} + e_{ijt}. \tag{11}$$

The variable of interest, $\mathcal{X}_{ijt}$, refers to our measure for the "accessible international R&D capital stock". A detailed discussion regarding the construction of this variable is provided in the next section. In addition, we also take into account a broad range of firm-specific control variables, summarized in the vector $\boldsymbol{X_{ijt}}$. This includes a measure of ethnic diversity, the log of average firm tenure in years, the share of male employees, the share of managers, the share of foreign workers, and a dummy variable indicating whether or not the firm is engaged in exporting. Furthermore, we also incorporate firm-specific controls indicating the share of employees belonging to each age distribution quartile, the share of employees with low-, medium-, and high-skilled occupations, and the share of employees with basic, secondary, and tertiary education. Thus, we are able to capture differences in firms' absorptive capacity on the employment level and thus control for Cohen and Levinthal's (1989) notion of prior knowledge.

Furthermore, the variables α_r and α_{jt} refer to regional fixed effects (by commuting area according to Andersen, 2002) and industry-year fixed effects, respectively, to control for unobserved heterogeneity across regions, industries, and years. These fixed effects specifications warrant careful discussion. First, we incorporate region fixed effects in the regression equation to control for differences in labor market policies, infrastructure quality, and assistance to industrial sectors across economic regions (Andersen, 2002). Second, the industry-year fixed effects remove all trends specific to the industry under consideration but are common to the firms belonging to that industry. These common trends include such factors as demand shifts and price changes, as well as differences in management skills, and industry-specific technology opportunity conditions. Moreover, they absorb shocks common to all firms within Denmark. It is important to point out that these time dummies also capture the impact of firms' own R&D knowledge stocks and the impact of the knowledge stocks of other firms located in Denmark, which is the Danish total R&D capital stock. Furthermore, these dummies also control for economy-wide effects such as demand and productivity shocks as well as measurement errors in deflators common to all firms. Finally, e_{ijt} refers to a firm-specific error term.[5]

To a large extent, endogeneity concerns are ameliorated by the inclusion of different sets of fixed effects. In particular, our results are not driven by unobserved price or demand shocks at the

[5]Summary statistics and pairwise correlations for the samples used in the empirical analysis are provided in Tables 1 and 2 in the Appendix.

industry level. Yet, even though the foreign R&D capital stock is likely to be exogenous to the individual Danish firm, it might be that some Danish Multinational Enterprisers (MNEs) conduct R&D activities abroad, thereby contributing to the foreign knowledge stock. Similar to Keller (2002), this concern is addressed by excluding MNEs from the base sample as shown in the robustness tests. A second important source of endogeneity is located at the firm level: Firms with substantial TFP are likely to be more successful in hiring qualified migrants, as they are likely to have a greater capacity to recruit workers (compare Malchow-Møller 2011). A third source of endogeneity may stem from a positive correlation between trade and migration. We tackle this problem from three sides: First, the quality of hires is likely to also depend on the composition of the management staff, which we control for in our specifications.[6] Secondly, we provide results where we include all foreign R&D capital stock measures in their first lag, as they were predetermined in a way that warrants the issue of exogeneity of the variables of interest. Third, we include a trade-weighted R&D capital stock. None of these modifications alter the main results significantly.

2.3 Approximation of Absorptive Capacity and Knowledge Spillovers

The common procedure to test for potential complementarities between the employed immigrants and the foreign R&D capital stock is to introduce an interaction term between the two. We therefore interact the share of employed migrants, as a proportion of total workers, with the sum of the foreign R&D capital stocks of OECD countries. The corresponding estimation is the first step in our analysis. However, the simple interaction of the two variables does not cover the Arrow (1969) argument precisely. The interaction terms test whether firms with a high share of immigrants and a high value of OECD R&D capital stock, which is equal among firms in a year, might perform better than other firms. Furthermore, it tests whether immigrants as such have better abilities to absorb foreign knowledge because they have, for example, better international networks or higher skills resulting from their experience working abroad. As the interaction term does not link the immigrants directly to the R&D capital stocks of their home countries, we do not control for the issue discussed above, that is, whether immigrants bring with them *country-specific* knowledge such as language, culture, personal contacts, or social-ethnic networks that enable them to access their home countries' R&D capital stocks more effectively. To address this important issue, in a second step we follow the argumentation of Griliches (1979)

[6] For instance, managers are more likely to hire employees of a similar nationality to their own (Åslund et al. 2014).

and construct a corresponding index number. Griliches (1979), and building on his work Coe and Helpman (1995), argue that knowledge spillovers occur primarily between technologically similar entities. They therefore use a weighted sum of foreign R&D capital stocks to proxy for this issue. The weighting function can be interpreted as that fraction of knowledge that can effectively spill over to receivers. In the study by Coe and Helpman (1995), bilateral import shares are used as weights. For example, if country A imports a fraction ω of its total imports from country B, country B's R&D capital stock is weighted by ω. Summing up across all trade partners yields the variable of interest.[7]

To establish a direct link between firms' absorptive capacity based on their immigrants and the international knowledge stock we follow this approach. However, we do not model the proximity to the foreign R&D capital stock in a technical sense. Instead, we use the shares of immigrants from different origins as a weighting function to account for Arrow's (1969) idea of proximity in the sense of language, culture, and personal contacts. Thus, the fraction of the R&D knowledge stock of a foreign country effectively available to spill over is determined by the fraction of immigrants from this specific country. For example, the more immigrants a firm hires from one country than from others, the more knowledge from this country can be explored and potentially absorbed. Here, we follow the procedure of Griliches (1979) and construct an ethnicity-weighted variable, where the weight is the share of immigrants from a certain country. Therefore, $\mathcal{X}_{ijt}$ becomes then:

$$\log s_{ijt}^{f,ew} = \log \left(\sum_{c \in S_{ijt}} \left(\frac{L_{ijct}^{For}}{L_{ijt}^{For}} s_{ct}^{f} \right) \right), \tag{12}$$

where s_{ct}^{f} is the R&D capital stock of country c at time t. S_{ijt} is the set of foreign workers in firm i in industry j for period t belonging to countries for which data on $R\&D$ capital stocks is available, L_{ijct}^{For} is the number of immigrants engaged in firm i from country c and L_{ijt}^{For} is the total number of immigrants in firm i. Thus, $\log s_{ijt}^{f,ew}$ is the log of the ethnicity-weighted (hereafter denoted as ew) $R\&D$ capital stock accessible to the firm via their foreign employees. Thus, the construction ensures that, ceteris paribus, firms with a higher share of immigrants from technologically advanced countries (here approximated by size of the R&D capital stock) have a larger $\log s_{ijt}^{f,ew}$ and vice versa. We furthermore differentiate the immigrant workforce by educational level by constructing three separate variables for immigrants with basic, secondary, and tertiary education. As an example, the foreign R&D variable $s_{ijt}^{f,ew,B}$ then includes only

[7] The trade-weighted R&D capital stock proposed by Coe and Helpman (1995) has indeed been shown to reflect trade-related spillovers as discussed in Coe and Hoffmaister (1999) after having been questioned by Keller (1998).

immigrants with basic education.[8]

Furthermore, particularly for immigrants, the occupational position might not correspond to the educational level, e.g., due to problems with the approval of foreign educational certificates (see Bosetti et al., 2015). Therefore, we construct an ethnicity-occupational position-weighted measure for each occupational level (low-skilled, medium-skilled, high-skilled, manager, other). It is again constructed according to the procedure of Griliches (1979), where the weight this time is the share of immigrants in a certain occupational position:

$$\log s_{ijt}^{f,ewoccu,\phi} = \log\left(\sum_{c\in S_{ijt}}\left(\frac{L_{ijct}^{For,\phi}}{L_{ijt}^{For}} s_{ct}^{f}\right)\right), \tag{13}$$

where s_{ct}^{f} is the R&D capital stock of country c at time t. $L_{ijct}^{For,\phi}$ is the number of persons engaged in firm i from country c with occupational level $\phi = (low, medium, high, manager, others)$.[9] Thus, $\log s_{ijt}^{f,ewoccu,\phi}$ represents the occupation-weighted $R\&D$ capital stock that is accessible to a firm via its foreign employees. According to this definition, ceteris paribus, firms with a higher share of immigrants from technologically advanced countries (again approximated by size of the R&D capital stock) and employed in a higher occupational position have a larger $\log s_{ijt}^{f,ewoccu,\phi}$ and vice versa.

3 Data Description

In evaluating the impact of immigrants on a firm's economic performance through their access to international R&D knowledge stocks, this study utilizes a longitudinal employer-employee data set compiled by Statistics Denmark from a variety of statistical registers. The starting point in data preparation is the Integrated Database for Labor Market Research (henceforth IDA). IDA integrates three databases on the personal, employee, and workplace level for any given year. It provides valuable information on a wide range of individual characteristics, containing, for instance, gender, age, country of origin, educational level, labor market experience, earnings, and current occupation on every individual employed by Danish firms during the entire period

[8] We further differentiate the educational aspect of the absorptive capacity by constructing an ethnicity-education-weighted measure of foreign $R\&D$ capital stocks for each firm and year. For this reason, we construct for each foreign worker the theoretical cumulative duration in years for a basic, secondary, and tertiary educational level based on the International Standard Classification of Education (ISCED), as reported by the United Nations Educational, Scientific and Cultural Organization (UNESCO). The results are qualitatively similar to those for the ethnicity-weighted foreign R&D variable and available from the authors upon request.

[9] Detailed information on the classification of occupational positions is provided in the Appendix.

1995 to 2009. The links between individuals and workplaces are uniquely identified each year at the end of November. The extracted information on each individual is then aggregated to obtain firm-specific variables, such as the number of full-time employees, average firm tenure, age distribution, shares of males, managers, highly-skilled workers, foreigners, and the shares of workers having basic, secondary, and tertiary education. Furthermore, a variable is created that reflects the ethnic composition of each firm based on the data providing each individual's country of origin. In addition, business accounts data is provided by the statistical register REGNSKAB, from which we extract such variables as gross production (total sales of goods and services), intermediate goods (purchase as goods, supplementary materials, and packaging), and the capital stock (total assets). REGNSKAB covers the construction and retail trade industries at the firm level since 1994, manufacturing industries since 1995, wholesale trade since 1998, and the remaining private industries since 1999. Finally, we establish a link to a firm's foreign trade statistics. This statistical register provides detailed information on bilateral import and export sales with information on destination markets and traded products based on an eight-digit classification scheme. We use this additional data source to construct an import- and export-weighted international R&D knowledge stock to test the robustness of our main results to trade-related knowledge spillovers. Table 1 and 2 provide descriptive statistics for the main variables utilized in the empirical analysis for firms employing at least ten workers. The last choice was set to ensure a certain degree of variability of foreign workers across firms when constructing firm-specific international R&D knowledge stocks. Finally, the data for the construction of R&D capital stocks in 27 countries is provided by the OECD's Analytical Business Enterprise Research and Development (ANBERD) database.[10]

4 Results

4.1 Foreigners and Foreign Knowledge: Specification Issues

Table 5 presents the first results on the relationship between the firm's TFP and the absorption of foreign knowledge if firms employ foreign workers. In column (1), we include a variable denoted *Foreigner* that refers to the share of foreign workers as a proportion of total workers employed. The positive sign associated with this measure suggests a beneficial effect of foreign workers on the firm's productivity that could originate from different sources such as an improved allo-

[10]See Table 3 for a list of countries included in the empirical analysis. Furthermore, we also provide a more formal discussion in the construction of R&D capital stocks for the number of sampled countries in the Appendix.

cation of resources, occupational upgrading triggered by foreign employment, as found in Peri and Foged (2015), or – and this is our focus – the improved access to foreign knowledge stocks. But in this specification, the source of the positive effect is unknown. Hence, in column (2), we include an interaction term between the share of foreign workers and the log value of the sum of international R&D knowledge stocks for the number of sampled countries (excluding Denmark). The estimated coefficient associated with the interaction term is not, however, statistically significant. One major drawback of the previous analysis is that the *Foreigner* share variable is unable to distinguish between immigrants from OECD and from non-OECD countries. Since a substantial portion of R&D activities worldwide are conducted by OECD countries, it would be of particular interest to know whether the employment of immigrants from these countries contributes significantly to firms' access to foreign knowledge. Therefore, the specification in column (3) includes the share of immigrants originating from OECD countries, which enters with a positive sign into the regression equation. In column (4), we include, again, an interaction term between the share of foreign workers from OECD countries and the log value of the sum of international R&D knowledge stocks for the number of sampled countries. Interestingly, the interaction term enters with a positive sign into the regression equation and is statistically significant at the 5% level, whereas the impact of the share of foreign workers from OECD countries now becomes negative. Yet, given the coefficient estimates from this specification, the impact of a rise in the *OECD* share evaluated at the mean value for Log $s_{t-1}^{f,total}$ remains positive: The marginal effect amounts to 0.1561, similar to the impact found in the previous column. This result states that firms employing immigrants from mainly OECD countries have higher access to foreign knowledge stocks, which contributes significantly to firm TFP. The results in columns (5) and (6) show that the impact of foreign workers from non-OECD countries on firm TFP is statistically insignificant. Finally, column (7) includes all variables for immigrants from OECD and non-OECD countries, identifying the most important variables contributing significantly to firm productivity through access to foreign knowledge stocks. The key implication from this specification is that only immigrants from OECD countries affect the economic performance of firms significantly.

One main shortcoming of the previous approach is that it neglects the direct relationships between the foreign employees and their capacity to absorb foreign knowledge from their country of origin. For example, one could imagine that the interaction term constructed between the share of foreign employees and the total foreign R&D capital stock generates cases where it indicates a high absorptive capacity for the particular firm, although the number of foreign

employees do not belong to highly developed OECD countries. In addition, this measure is unable to distinguish firms that employ exclusively foreign workers from one OECD country, although they might originate from countries with very different technological levels (e.g. 5% employees from Spain versus 5% employees from the US). To clarify this point, Figure 1 shows the relationship between our preferred ethnicity-weighted foreign R&D knowledge stock variable and the aforementioned interaction term, classified into five quantiles, in year 2005. For the sake of simplicity, this figure was restricted to firms employing foreign workers from only one OECD country alongside foreign workers from non-OECD countries. The figure indicates that there exists great variation in our ethnicity-weighted foreign R&D capital stock measure in each category. This observation provides positive evidence that the interaction term is unable to relate the absorptive capacity of foreign workers to their country of origin knowledge stock. As a specific example, consider two firms in the fourth quantile, each employing about 12.5% foreign workers. The only difference is that one firm employs only foreigners from Turkey whereas the other firm employs foreigners from Germany. According to our interaction term, both firms are considered to have access to the same knowledge stock (about 3.62 log points). However, we would expect that firms employing foreigners from more technologically advanced countries should also have access to a larger foreign knowledge stock. Our ethnicity-weighted foreign R&D knowledge stock measure captures this notion precisely as it indicates that the firm with German workers has access to a much larger foreign knowledge stock (about 26.39 log points) than the firm employing foreign workers from Turkey only (about 21.86 log points).
Therefore, to circumvent the aforementioned disadvantages related to the interaction term variable, the subsequent analysis utilizes our preferred firm-specific measure of foreign knowledge in the regression equation. Table 6 provides the results on the relationship between firms' economic performance and foreign knowledge absorbed by the employed immigrants.

4.2 Main Results: Immigrants and Absorptive Capacity

From the findings in Coe and Helpman (1995) and the subsequent literature, it is well known that technology sourced from technologically advanced countries has a particular stronger impact on the receiving countries TFP. Obviously, countries which are technologically advanced offer more knowledge to be absorbed than countries which are technologically laggards. We therefore account for an immigrant's country of origin and thereby test whether it matters for a firm's improvement in absorptive capacity. As described above, we follow the procedure of Griliches (1979) and construct an ethnicity-weighted measure of international R&D capital stocks (see

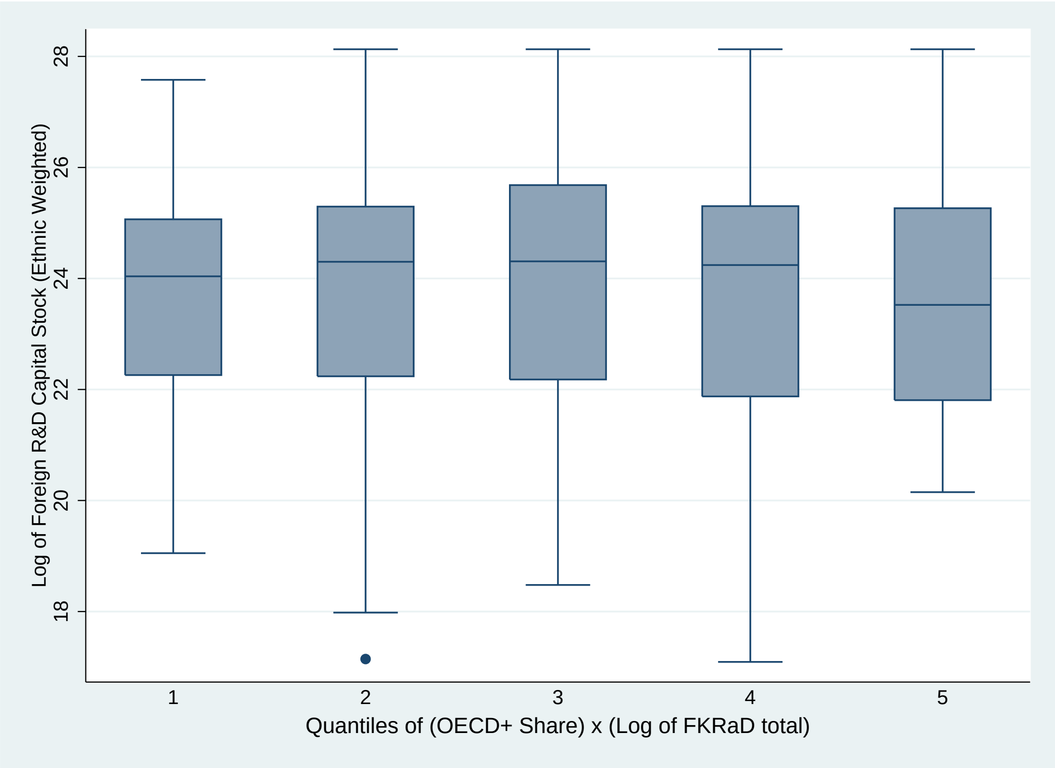

Figure 1: Boxplot of $Log\ s^{f,ew}$ and Foreigner$\times$$Log\ s^{f,total}$ in year 2005

equation (12) for additional details). In column (1) the ethnicity-weighted measure of international R&D capital stocks is introduced into the regression equation. The coefficient is highly statistically significant and confirms our assumptions that firms benefit from the employment of immigrants through the absorbed foreign knowledge. Our measure further suggests that employing immigrants from technologically advanced countries increases the potential benefits in terms of higher output with respect to foreign R&D knowledge stocks. In addition, we assess the impact of the immigrants' education for each educational level separately (as shown in columns 2 to 5). All immigrants from OECD countries, regardless of their educational level, offer a positive markup on the output elasticity of foreign knowledge vis-à-vis firms without immigrants as well as firms with non-OECD immigrants. As shown in column (4), OECD immigrants with tertiary education offer the highest benefits. Focusing on the specification in column (5) indicates that increasing the foreign R&D capital stock accessible through low-skilled workers (either due to a change in foreign employment or variation in foreign R&D capital) by 1% increases firm productivity by 0.0042%. The elasticity of TFP with respect to medium-skilled accessible foreign R&D capital stock is slightly lower (0.0034). The elasticity of TFP with respect to foreign R&D capital accessible through the high-skilled workforce ranges in the middle and amounts to 0.0036. It is surprising that the latter elasticity is smaller than that for basic-education-weighted R&D

capital stock, since we expect – in line with estimates from columns (2) - (4) and in line with Stoyanov and Zubanov (2012) – that immigrants with higher education might play a prominent role in the absorption of knowledge. It is likely that education does not measure migrants' skill levels properly (Bosetti et al., 2015). In particular, Bosetti et al. (2015) find that an education-based diversity measure underestimates the contribution of skilled immigrants to the creation of knowledge as compared to an occupation-based measure. We follow their approach and take into consideration both the educational and the occupational dimension of foreign workers' skill levels.

Thus, employees might not work in an occupational position in accordance with their educational level. In particular, immigrants might suffer from problems with the approval of their foreign educational certificates, resulting in a lower occupational position (Pohl Nielsen, 2011). Also, the opposite mismatch may be the case. Furthermore, the educational level approximates the human capital at the beginning of a business career, neglecting advances in human capital through training on the job. Additionally, the occupational position provides an accurate assessment of the actual employees' activities within the firm, which might be a closer approximation of our convention of absorptive capacity. More precisely, we construct an ethnicity-occupation-position weighted measure (see equation (13)) to further investigate on this issue. In each column (1) to (5) of Table 7 we introduce one of the separate measures for the different occupational levels indicating low-skilled, medium-skilled, high-skilled, managers, and other-skilled foreign workers. All immigrants add individually to the TFP elasticity with respect to the corresponding foreign knowledge stock. Column (6) checks the overall significance of the different ethnicity-occupation-position weighted measures of foreign knowledge when included simultaneously in the regression equation. It follows that the highest contribution is generated by immigrants with high-skilled occupations (0.0040), which is highly statistically significant at the 1% level. Furthermore, low-skilled and medium-skilled occupational positions make an equally high contribution to firms' TFP (0.0037), whereas foreigners with a manager position or unclassified occupational position contribute less. This finding is in accordance with a recent paper by Parrotta and Pozzoli (2012) showing that highly educated technicians are knowledge carriers, and also relates directly to Arrow's (1969) original idea that both prior technical knowledge and non-technical skills are ingredients in knowledge transmission. Quantitatively, doubling the available foreign R&D capital stock that can be accessed via high-skilled workers implies a productivity gain of 0.40%.

Another notable result throughout the empirical analysis is the predominant negative sign associated with the ethnic diversity measure, which is in line with previous studies. This measure corresponds to the average of workforce ethnic diversity in a particular firm and year, where higher values correspond to a more ethnically diverse labor force. Interestingly, firms employing more foreigners have on average higher TFP outcomes, while the impact of the ethnic diversity measure is negative and both are highly statistically significant in column (6).[11] In addition, the results show that it is not the percentage of foreigners that negatively affects firm TFP but rather the composition of the workforce of immigrants from different countries, as captured by the ethnic diversity measure. In contrast to the negative impact of workforce ethnic diversity on firms' economic performance, the results reported in this paper suggest that firms benefit from a diverse labor force by gaining an increased absorptive capacity to acquire foreign knowledge – which is fully in line with the positive impact of ethnic diversity on innovative activity found by Parrotta et al. (2014b).[12]

In sum, firms employing foreign workers have on average higher TFP, thanks to their increased absorptive capacity to acquire international R&D knowledge stocks. Furthermore, the higher the share of immigrants from technologically advanced countries and the higher the occupational position of the employed immigrants, the higher their contribution proves to be.

5 Robustness Analysis

This section establishes the robustness of the previous results to different sample sizes, specifications, and alternative production function estimators.

Column (1) of Table 8 shows the main results using the definition in equation (12) for the ethnicity-weighted foreign R&D capital stock variable. This specification corresponds to that in column (2), Table 6, and is shown for comparison purposes.

Non-exporters benefit less. The results reported in column (2) of Table 8 restrict the analysis to non-exporting firms. This specification leads in the exclusion of $33,989$ observations from the base sample. The exclusion of exporters from the base sample alleviates, to some extent,

[11] Prior research has shown the negative effect of ethnic diversity on firms' economic performance (Parrotta et al., 2014a). The main argument is that ethnic diversity is accompanied by both costs and benefits for firms' productivity. The negative effect is transmitted through higher communication costs and lower interpersonal trust, whereas the positive effect is transmitted through enhanced innovation activity (Alesina and La Ferrara, 2005).

[12] A more thorough analysis of the relationship between workforce ethnic diversity and firms' economic performance is, however, beyond the scope of the current paper and is left for future research.

knowledge spillovers triggered, for example, by export sales. Reassuringly, the estimates are not sensitive to the exclusion of exporters from the estimation sample. However, the estimated coefficient associated with the ethnicity-weighted foreign R&D capital stock variable falls to about 0.0033, but remains statistically significant at the 1% level. This result suggests that non-exporters benefit less from foreign workers than exporting firms. One possible reason for the importance of foreigners for exporters could be that they function as possible substitutes for international technology diffusion by export activity, for example, through co-ethnic networks.

Results are not driven by MNEs. Furthermore, column (3) maintains the robustness of the main results to the exclusion of multinational enterprises (MNEs), which might be particularly good at absorbing international knowledge spillovers due to their international structure and could, therefore, be driving the main results in our empirical analysis. The estimated coefficient associated with the ethnicity-weighted foreign R&D capital stock variable, however, retains its positive sign and still is highly statistically significant at the 1% level. This observation suggests that the previous results are not driven by R&D investments of Danish multinational companies abroad.

Not only high-tech firms benefit. Case studies have shown the importance of technology diffusion for the high-tech pharmaceutical and computer industries. For this reason, Keller (2004, p. 761) argues that endogeneity concerns are more pronounced in R&D-intense industries. Column (4), therefore, assesses the robustness of the results excluding the high-tech chemical industry (which includes the pharmaceutical industry) and the computer industry from the base sample. The estimated coefficient associated with Log $s^{f,ew}$ remains positive and is statistically significant at the 1% level. Thus, the main results in the empirical analysis are not driven by these industries.

Non-OECD foreigners do not confound the estimates. As a further robustness check, the results shown in column (5) exclude firms employing foreign workers from non-OECD countries. Therefore, the estimated coefficient on the ethnicity-weighted foreign R&D capital stock variable then indicates the impact on TFP for firms employing foreign workers from OECD countries in comparison to firms employing exclusively Danish workers. This criterion restricts the analysis to 37,258 observations. However, the estimated coefficient on the ethnicity-weighted foreign R&D capital stock variable is positive and increases slightly to about 0.0050, which is statistically significant at the 1% level.

Trade matters for knowledge diffusion – but migration does, too. Furthermore, to rule out the possibility that the ethnicity-based R&D capital stock measure captures knowledge spillovers triggered by trade relationships, column (6) includes an import- and export-weighted foreign R&D capital stock variable in the regression equation. Specifically, the two latter variables are constructed according to expression $\sum_{c \in T_{ijt}} \left(\omega_{ijct} s^f_{ct} \right)$, where ω_{ijct} refers to the bilateral import share of a firm's i trading partner countries in year t in one case (*Log import-weighted* s^f_{ct}) and the bilateral export share in the other (*Log export-weighted* s^f_{ct}). In addition, T_{ijt} is the set of firm i's trading partners in year t. This specification excludes $19,735$ observations from the base sample. However, the qualitative results remain unchanged following the inclusion of trade-weighted foreign R&D capital stocks. Interestingly, the positive coefficient associated with the import-weighted R&D capital stock confirms the findings in Coe and Helpman (1995), meaning that knowledge diffusion also takes place through imported goods from technologically advanced OECD countries.

Different productivity estimators lead to the same qualitative conclusions. In the following, the robustness of the main results is examined using alternative production function estimators in the construction of firm TFP. The results are shown in Table 9. Column (1) shows the main results of our preferred baseline Wooldridge (2009) estimation method, using an adjusted sample size to facilitate comparison across the various production function estimators. In column (2), firm TFP is obtained from a Cobb-Douglas production function where the coefficients are estimated by pooled OLS. The estimated coefficient of $s^{f,ew}$ drops considerably, but is still highly statistically significant at the 1% level. The main results are further confirmed when estimating a Cobb-Douglas production function with firm-fixed effects by OLS, as shown in column (3). Since production function estimators including firm-fixed effects rule out possibilities of time-varying productivity shocks, the estimator in column (4) includes firm-level fixed effects that vary across four time periods. As discussed in Petrin and Sivadasan (2013), this estimator remains consistent if the transmitted productivity shock behaves like $\omega_{ijt} = \omega_{ijp}$, where p refers to one of the four time periods (1995-1998, 1999-2002, 2003-2006, 2007-2010). However, the main results remain unaffected to this specification. In column (5), we obtain firm TFP using the Levinsohn and Petrin (2003) semi-parametric approach. In contrast to the baseline Wooldridge (2009) method, we find a much higher coefficient estimate for the variable $s^{f,ew}$. Some disadvantages of Cobb-Douglas production function specifications are that the estimated elasticities are restricted to be constant, that all firms have the same production function elasticities, and that the substitution elasticities are restricted to equal 1. To ensure a more flexible production function specification concerning the output and substitution elasticities with respect to the input factors, we estimate the following second-order Translog production function:

$$y_{ijt} = \beta_0 + \sum_{\psi} \beta_{\psi} \psi_{ijt} + \sum_{\psi} \beta_{\psi\psi} \psi_{ijt}^2 + \sum_{\psi \neq \tau} \sum_{\tau} \beta_{\psi\tau} \psi_{ijt} \tau_{ijt} + \omega_{ijp} + \varepsilon_{ijt}, \tag{14}$$

where $\psi, \tau = \{l, k, m\}$. We estimate the Translog production function by OLS including firm-level fixed effects that vary across the four time periods, as mentioned earlier. The results are presented in the last column of Table 9. Reassuringly, the main results are not sensitive to this production function specification. In contrast to the baseline result, the estimated coefficient associated with the foreign knowledge variable increases substantially in magnitude and remains statistically significant at the 1% level.

6 Conclusion

This paper investigates the question of whether immigrant employees increase firm TFP by extending firms' absorptive capacity for foreign knowledge. Based on Danish firm-level data and aggregated R&D capital stock data for OECD countries, the estimations show that immigrant employees facilitate the absorption of foreign knowledge. We find that foreign workers contribute significantly to firms' TFP elasticity with respect to foreign knowledge. The composition of the foreign workforce with respect to countries of origin, education, and occupational position has an important impact on the size of the effect on firm productivity. The higher the share of immigrants from technologically advanced countries and the higher their educational level, the greater the impact on a firm's TFP elasticity of foreign knowledge. Concerning occupational levels, we find that a firm's elasticity of foreign knowledge with respect to its TFP is the highest for immigrant employees with high-skilled occupations and the lowest for immigrant managers. The results are robust to controlling for trade-related spillovers and MNE status. Throughout all specifications, a measure of workforce ethnic diversity and a variable indicating the share of foreign workers (as a proportion of total workers employed) are included as control variables. While an ethnically diverse workforce reveals a negative direct impact on firms' TFP, the share of foreign workers shows a positive direct impact. Thus, it is not the percentage of foreigners in a firm that negatively affects the firm's TFP but rather the composition of the immigrant workforce originating from different countries, as captured by the ethnic diversity measure. However, whereas on one hand an ethnically diverse workforce reduce firms' economic performance, on the other hand it simultaneously improves their economic performance through the increased absorptive capacity to acquire foreign knowledge.

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A Data Description

Table 1: Summary Statistics and Data Description for the Main Variables

Variable	Description	Mean	S.D.	Min.	Max.
Log TFP (WLP)	The log of firm's Total Factor Productivity (TFP) estimated using the Wooldridge (2009) method of the Levinsohn and Petrin (2003) approach (WLP).	6.9326	1.4123	2.4021	14.7884
Log Gross Production	The log of firm's gross production as total sales of goods and services (in DKK).	17.2805	1.2930	10.0858	24.0804
Log Labour	The log of firm's fulltime equivalent workers.	3.4994	1.0666	0.0000	9.4122
Log Capital	The log of firm's total assets (in DKK).	15.7418	1.7013	6.9078	24.0446
Log Materials	The log of firm's intermediate goods (purchase of goods, supplementary materials, and packaging) used in the production process (in DKK).	16.3009	1.4855	6.9078	23.7692
Log $s_{t-1}^{f,total}$	The log of total foreign R&D capital stock.	28.8516	0.1402	28.6309	29.1023
Foreigner$_{t-1}$	Share of foreign workers, as a proportion of total workers employed.	0.0547	0.0842	0.0000	1.0000
$\left(\text{Foreigner} \times \text{Log } s^{f,total}\right)_{t-1}$	Interaction term between the Foreigner share and the log of total foreign R&D capital stock.	1.5799	2.4327	0.0000	29.1023
OECD$_{t-1}$	Share of foreign workers from OECD countries, as a proportion of total workers employed.	0.0249	0.0509	0.0000	1.0000
$\left(\text{OECD} \times \text{Log } s^{f,total}\right)_{t-1}$	Interaction term between the OECD share and the log of total foreign R&D capital stock.	0.7188	1.4695	0.0000	29.1023
Non-OECD$_{t-1}$	Share of foreign workers from Non-OECD countries, as a proportion of total workers employed.	0.0298	0.0593	0.0000	1.0000
$\left(\text{Non-OECD} \times \text{Log } s^{f,total}\right)_{t-1}$	Interaction term between the Non-OECD share share and the log of total foreign R&D capital stock.	0.8611	1.7132	0.0000	28.9032
Log $s_{t-1}^{f,ew}$	Ethnicity-weighted firm's foreign R&D capital stock based on foreign workers from OECD member countries.	11.0389	11.9574	0.0000	28.2279
Log $s_{t-1}^{f,ew,B}$	Ethnicity-weighted firm's foreign R&D capital stock based on foreign workers with basic education from OECD member countries.	9.2419	11.5413	0.0000	28.2279
Log $s_{t-1}^{f,ew,S}$	Ethnicity-weighted firm's foreign R&D capital stock based on foreign workers with secondary education from OECD member countries.	3.7532	8.5582	0.0000	28.2279
Log $s_{t-1}^{f,ew,T}$	Ethnicity-weighted firm's foreign R&D capital stock based on foreign workers with tertiary education from OECD member countries.	1.8347	6.1569	0.0000	28.2279
Log $s_{t-1}^{f,ewoccu,low}$	Ethnicity-occupation-weighted firm's foreign R&D capital stock based on foreign workers with low-skilled occupational position.	3.2043	7.8625	0.0000	28.2279
Log $s_{t-1}^{f,ewoccu,mid}$	Ethnicity-occupation-weighted firm's foreign R&D capital stock based on foreign workers with medium-skilled occupational position.	7.9856	11.1432	0.0000	28.2279
Log $s_{t-1}^{f,ewoccu,high}$	Ethnicity-occupation-weighted firm's foreign R&D capital stock based on foreign workers with high-skilled occupational position.	2.9626	7.7726	0.0000	28.2279
Log $s_{t-1}^{f,ewoccu,managers}$	Ethnicity-occupation-weighted firm's foreign R&D capital stock based on foreign workers with manager position.	1.0348	4.7827	0.0000	27.9527
Log $s_{t-1}^{f,ewoccu,other}$	Ethnicity-occupation-weighted firm's foreign R&D capital stock based on foreign workers with other-skilled occupational position.	0.8951	4.4246	0.0000	28.1584
Ethnic Diversity	Ethnic worker diversity index, averaged across work places.	0.0966	0.1228	0.0000	0.8471
Log Tenure	The log of average firm tenure (in years).	1.3881	0.4831	0.0000	2.7081
Males	Men, as a proportion of total workers employed.	0.7481	0.2033	0.0000	1.0000
Age15_28	Workers aged between 15 and 28, as a proportion of total workers employed.	0.2072	0.1510	0.0000	1.0000
Age29_38	Workers aged between 29 and 38, as a proportion of total workers employed.	0.2596	0.1182	0.0000	1.0000
Age39_48	Workers aged between 39 and 48, as a proportion of total workers employed.	0.2515	0.1161	0.0000	1.0000
Age49_65	Workers aged between 49 and 65, as a proportion of total workers employed.	0.2616	0.1417	0.0000	1.0000
Low-Skilled	Workers with low-skilled occupation according to the definition of ISCO, as a proportion of total workers employed.	0.1567	0.1800	0.0000	1.0000
Medium-skilled	Workers with medium-skilled occupation according to the definition of ISCO, as a proportion of total workers employed.	0.6100	0.2158	0.0000	1.0000
High-Skilled	Workers with high-skilled occupation according to the definition of ISCO, as a proportion of total workers employed.	0.1245	0.1343	0.0000	1.0000
Managers	Managers, according to Statistics Denmark's definitions based on ISCO, as a proportion of total workers employed.	0.0563	0.0693	0.0000	1.0000
Other-Skilled	Workers with other-skilled occupation according to the definition of ISCO, as a proportion of total workers employed.	0.0526	0.1423	0.0000	1.0000
Basic Education	Workers with basic education, as a proportion of total workers employed.	0.3648	0.1766	0.0000	1.0000
Secondary Education	Workers with secondary education, as a proportion of total workers employed.	0.5399	0.1736	0.0000	1.0000
Tertiary Education	Workers with tertiary education, as a proportion of total workers employed.	0.0953	0.1033	0.0000	1.0000
Exporter	Takes value 1, if the firm exports and zero otherwise.	0.7633	0.4251	0.0000	1.0000
Foreigner	Foreign workers, as a proportion of total workers employed.	0.0567	0.0863	0.0000	1.0000
Observations			44528		

Notes: Summary statistics are constructed for all manufacturing firms between 1996 and 2009. The industrial sectors utilized in the empirical analysis are as follows: beverages (261); chemicals and chemical products (1161); computer, electronic and optical products (272); fabricated metal products, except machinery and equipment (6403); food products (4466); furniture (3606); leather and related products (142); machinery and equipment n.e.c (4813); motor vehicles, trailers and semi-trailers (305); other non-metallic mineral products (1987); paper and paper products (1135); rubber and plastic products (3196); textiles (1279); tobacco products (74); wood and of products of wood and cork, except furniture (2357); other manufacturing (1585); repair and installation of machinery and equipment (11486). The number of firm-year observations in each industry are shown in parenthesis.

Table 2: Correlation Matrix for the Main Variables.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	(31)	(32)	(33)	(34)	(35)	(36)	(37)	(38)
(1) Log TFP (WOP)	1.0000																																					
(2) Log Gross Production	0.0111	1.0000																																				
(3) Log Labour	0.0099	0.8876	1.0000																																			
(4) Log Capital	-0.0001	0.7896	0.7437	1.0000																																		
(5) Log Materials	-0.0870	0.9323	0.7999	0.7071	1.0000																																	
(6) Log $s_{t-1}^{f,total}$	0.0805	0.1268	-0.0317	0.0874	0.0801	1.0000																																
(7) Foreigner$_{t-1}$	0.0015	0.0336	0.0172	0.0416	0.0277	0.1088	1.0000																															
(8) $\left(\text{Foreigner} \times \text{Log } s^{f,total}\right)_{t-1}$	0.0017	0.0340	0.0171	0.0419	0.0280	0.1118	1.0000	1.0000																														
(9) OECD$_{t-1}$	0.0036	0.0275	0.0081	0.0263	0.0189	0.0583	0.7192	0.7191	1.0000																													
(10) $\left(\text{OECD} \times \text{Log } s^{f,total}\right)_{t-1}$	0.0037	0.0278	0.0080	0.0265	0.0191	0.0607	0.7194	0.7193	1.0000	1.0000																												
(11) Non-OECD$_{t-1}$	-0.0009	0.0241	0.0175	0.0366	0.0230	0.1045	0.8029	0.8030	0.1633	0.1635	1.0000																											
(12) $\left(\text{Non-OECD} \times \text{Log } s^{f,total}\right)_{t-1}$	-0.0008	0.0245	0.0175	0.0368	0.0233	0.1068	0.8029	0.8030	0.1634	0.1636	1.0000	1.0000																										
(13) Log $s_{t-1}^{f,ew}$	0.0086	0.4681	0.4812	0.3879	0.4204	0.0602	0.3753	0.3753	0.5157	0.5156	0.0905	0.0906	1.0000																									
(14) Log $s_{t-1}^{f,ew,B}$	0.0110	0.4603	0.4754	0.3987	0.4125	0.0657	0.3649	0.3650	0.4789	0.4789	0.1073	0.1074	0.8655	1.0000																								
(15) Log $s_{t-1}^{f,ew,S}$	0.0050	0.4006	0.4222	0.3229	0.3552	0.0132	0.1291	0.1291	0.2050	0.2050	0.0074	0.0074	0.4917	0.2406	1.0000																							
(16) Log $s_{t-1}^{f,ew,T}$	-0.0020	0.3773	0.3759	0.3136	0.3320	0.0705	0.1030	0.1033	0.1375	0.1378	0.0282	0.0284	0.3307	0.2118	0.2225	1.0000																						
(17) Log $s_{t-1}^{f,ewoccu,low}$	-0.0285	0.3061	0.3251	0.2764	0.2711	0.0285	0.2936	0.2935	0.3486	0.3486	0.1177	0.1178	0.4361	0.4663	0.2466	0.2063	1.0000																					
(18) Log $s_{t-1}^{f,ewoccu,mid}$	0.0301	0.4373	0.4715	0.3679	0.3928	0.0160	0.2980	0.2978	0.4106	0.4104	0.0709	0.0709	0.7781	0.7135	0.4699	0.2440	0.2057	1.0000																				
(19) Log $s_{t-1}^{f,ewoccu,high}$	0.0072	0.4477	0.4405	0.3716	0.3937	0.0623	0.0920	0.0922	0.1483	0.1484	0.0034	0.0036	0.4294	0.3601	0.3900	0.4987	0.1943	0.2269	1.0000																			
(20) Log $s_{t-1}^{f,ewoccu,managers}$	0.0043	0.2363	0.2459	0.2085	0.2052	-0.0036	0.0748	0.0747	0.1103	0.1102	0.0115	0.0115	0.2463	0.2120	0.2140	0.2561	0.1068	0.1292	0.1781	1.0000																		
(21) Log $s_{t-1}^{f,ewoccu,other}$	0.0080	0.1376	0.1214	0.1192	0.1139	0.1423	0.1539	0.1546	0.1800	0.1807	0.0641	0.0645	0.2182	0.2264	0.1094	0.1154	0.0305	0.0565	0.0778	0.0278	1.0000																	
(22) Ethnic Diversity	0.0009	0.0738	0.0752	0.0701	0.0669	0.0992	0.8417	0.8417	0.5677	0.5677	0.7082	0.7082	0.3838	0.3744	0.1438	0.1129	0.2837	0.3111	0.1123	0.0812	0.1503	1.0000																
(23) Log Tenure	0.1033	0.1306	-0.0068	0.1063	0.0844	0.6863	0.0335	0.0354	0.0121	0.0137	0.0372	0.0386	0.0633	0.0634	0.0343	0.0543	-0.0022	0.0431	0.0776	0.0179	0.0839	0.0130	1.0000															
(24) Males	0.1245	-0.0739	-0.1127	-0.0888	-0.0694	-0.0104	-0.1409	-0.1410	-0.0979	-0.0980	-0.1160	-0.1161	-0.1299	-0.1522	-0.0316	-0.1008	-0.1558	-0.0916	-0.0776	-0.0657	-0.0532	-0.1621	0.0514	1.0000														
(25) Age15_28	-0.0900	-0.2745	-0.0912	-0.2172	-0.2433	-0.3208	-0.0110	-0.0120	-0.0246	-0.0253	0.0054	0.0047	-0.1374	-0.1304	-0.0887	-0.1048	-0.0267	-0.1057	-0.1580	-0.0681	-0.0580	-0.0066	-0.4477	-0.0434	1.0000													
(26) Age29_38	0.0352	0.1432	0.1295	0.1119	0.1388	-0.2132	-0.0008	-0.0015	-0.0009	-0.0015	-0.0003	-0.0009	0.0542	0.0502	0.0433	0.0472	0.0304	0.0539	0.0599	0.0290	-0.0174	0.0140	-0.1929	0.0586	-0.1471	1.0000												
(27) Age39_48	0.0490	0.2282	0.1210	0.1803	0.2013	0.2940	0.0197	0.0207	0.0140	0.0147	0.0159	0.0168	0.1075	0.1119	0.0629	0.0740	0.0362	0.0853	0.1156	0.0366	0.0666	0.0269	0.2723	-0.0026	-0.5020	-0.2248	1.0000											
(28) Age49_65	0.0334	0.0413	-0.0594	0.0298	0.0305	0.2572	-0.0073	-0.0065	0.0131	0.0138	-0.0216	-0.0211	0.0363	0.0268	0.0286	0.0290	-0.0181	0.0215	0.0466	0.0320	0.0223	-0.0249	0.3993	0.0188	-0.5289	-0.4376	-0.0684	1.0000										
(29) Low-Skilled	-0.0781	-0.1007	-0.0829	-0.0611	-0.0901	-0.0002	0.1255	0.1256	0.0844	0.0845	0.1057	0.1058	-0.0090	0.0143	-0.0611	-0.0333	0.2174	-0.1042	-0.0660	-0.0307	0.0015	0.1256	-0.1071	-0.2050	0.1753	-0.0979	-0.0762	-0.0846	1.0000									
(30) Medium-skilled	0.0788	-0.0199	0.0698	-0.0105	-0.0108	-0.1794	-0.1261	-0.1267	-0.1042	-0.1047	-0.0897	-0.0901	-0.0540	-0.0548	-0.0063	-0.0871	-0.1720	0.1128	-0.1191	-0.0315	-0.1489	-0.1209	-0.0604	0.2073	0.0847	0.0348	-0.0758	-0.0184	-0.5438	1.0000								
(31) High-Skilled	-0.0310	0.2939	0.1917	0.1824	0.2623	0.0965	-0.0323	-0.0320	0.0139	0.0141	-0.0577	-0.0575	0.1604	0.1210	0.1630	0.2319	0.0583	0.0719	0.3473	0.1036	0.0273	-0.0230	0.0833	-0.0274	-0.2637	0.1421	0.1760	0.0453	-0.1725	-0.4236	1.0000							
(32) Managers	0.0360	-0.0722	-0.1512	-0.0621	-0.0689	0.0309	0.0025	0.0026	0.0095	0.0096	-0.0046	-0.0046	-0.0403	-0.0514	-0.0362	-0.0281	-0.0505	-0.0577	-0.0266	0.0666	-0.0564	-0.0175	0.1017	0.0201	-0.1600	-0.0281	0.0431	0.1464	-0.1287	-0.1195	0.0191	1.0000						
(33) Other-Skilled	-0.0089	-0.0848	-0.1084	-0.0489	-0.0838	0.1662	0.0618	0.0622	0.0335	0.0339	0.0590	0.0593	-0.0386	-0.0243	-0.0495	-0.0311	-0.0446	-0.0792	-0.0509	-0.0436	0.2256	0.0548	0.0989	-0.0389	-0.0233	-0.0495	0.0241	0.0209	-0.2147	-0.3705	-0.0929	-0.1613	1.0000					
(34) Basic Education	-0.0801	-0.0421	0.0292	0.0426	-0.0142	-0.1319	0.3231	0.3226	0.2099	0.2095	0.2788	0.2784	0.0927	0.1564	-0.0663	-0.0588	0.1434	0.0853	-0.0798	0.0003	0.0489	0.3397	-0.1576	-0.3938	0.1837	-0.1782	-0.0808	-0.0192	0.3080	-0.0649	-0.3564	-0.0682	0.0785	1.0000				
(35) Secondary Education	0.0983	-0.0956	-0.1090	-0.1285	-0.1069	0.0674	-0.3279	-0.3276	-0.2235	-0.2234	-0.2738	-0.2736	-0.1728	-0.2171	0.0002	-0.0820	-0.1847	-0.1205	-0.0713	-0.0494	-0.0790	-0.3523	0.1229	0.4661	-0.0701	0.0989	0.0053	0.0173	-0.2690	0.2791	-0.0251	0.0187	-0.0683	-0.8260	1.0000			
(36) Tertiary Education	-0.0282	0.2325	0.1331	0.1431	0.2039	0.1122	-0.0014	-0.0010	0.0169	0.0173	-0.0165	-0.0162	0.1319	0.0974	0.1130	0.2383	0.0652	0.0567	0.2563	0.0824	0.0491	0.0114	0.0629	-0.1101	-0.1962	0.1384	0.1292	0.0036	-0.0744	-0.3581	0.6514	0.0851	-0.0193	-0.3213	-0.2684	1.0000		
(37) Exporter	0.0307	0.3252	0.2684	0.2583	0.3216	0.0179	0.0557	0.0558	0.0504	0.0505	0.0359	0.0360	0.2013	0.1812	0.1263	0.1180	0.0995	0.1633	0.1618	0.0803	0.0313	0.0766	0.0833	-0.0795	-0.2083	0.0685	0.1335	0.0672	-0.0636	-0.0758	0.2288	0.0735	-0.0564	-0.0600	-0.0583	0.2005	1.0000	
(38) Foreigner	-0.0070	0.0359	0.0267	0.0427	0.0325	0.0852	0.8935	0.8934	0.6388	0.6389	0.7207	0.7206	0.3216	0.3201	0.1034	0.0920	0.2654	0.2594	0.0785	0.0666	0.1389	0.9409	0.0049	-0.1490	0.0069	0.0144	0.0120	-0.0304	0.1333	-0.1222	-0.0414	-0.0108	0.0611	0.3537	-0.3541	-0.0095	0.0550	1.0000

B Construction of the Foreign R&D Capital Stock

Data for the construction of R&D capital stocks in 39 countries[13] is provided by the OECD's Analytical Business Enterprise Research and Development (ANBERD) database. In order to increase the number of observations per country, we combine the newly available ANBERD data in ISIC Rev. 4 with those from ANBERD ISIC Rev. 3 (update 2011). Differences in industry classifications were of minor interest, since we focus on R&D expenditures at the country rather than the industry level. Data on R&D expenditures were first deflated by a country-specific GDP price deflator provided by the World Bank *World Development Indicators* and then converted into constant 2000 US dollars.

The construction of the R&D capital stock for each country was then carried out following the Perpetual Inventory Method (PIM).[14] Specifically, the R&D capital stock evolves according to the following equation:

$$KR\&D_{ct} = (1-\delta)KR\&D_{ct-1} + R\&D_{ct}, \tag{15}$$

where $KR\&D_{ct}$ is the $R\&D$ capital stock of country c in period t and $R\&D_{ct}$ is the flow of real $R\&D$ expenditures of country c in period t. To apply this equation to data on real $R\&D$ expenditures, two crucial decisions with respect to the depreciation rate δ and the initial capital stock must be made. The depreciation rate is assumed to be 10%, the same across countries, and constant over time. Furthermore, assuming a constant country-specific growth rate of g_c for the $R\&D$ capital stock before period $t = 1$, the value for the initial $R\&D$ capital stock is computed according to the following expression:

$$\begin{aligned} KR\&D_{c1} &= R\&D_{c0} + (1-\delta)R\&D_{c-1} + (1-\delta)^2 R\&D_{c-2} + \cdots \\ &= \sum_{s=0}^{\infty}(1-\delta)^s R\&D_{c-s} = R\&D_{c0}\sum_{s=0}^{\infty}\left[\frac{1-\delta}{1+g_c}\right]^s = \frac{R\&D_{c0}}{\delta+g_c}. \end{aligned} \tag{16}$$

In contrast to other studies, which assume a constant growth rate (e.g., Hall and Mairesse, 1995) for g_c, in this study g_c is computed using an average geometric growth rate in years for which data on R&D expenditures is available. Summary statistics on the R&D capital stocks of the different countries is given in Table 3.

In addition to the construction of the $R\&D$ capital stocks, countries follow different approaches in reporting their R&D expenditures. The large majority of countries report R&D expenditures

[13] See Table 3 for the countries employed in the empirical analysis.

[14] Hulten (1991) provides an extensive discussion of the PIM for the measurement and construction of physical and human capital stocks.

using the main activity approach, whereas for some countries (e.g., Belgium, France, and United Kingdom) longer time series are only available using the product field approach. Hence, we employ the approach generating the largest number of observations per country when constructing the R&D capital stocks by the PIM method.

Table 3: Descriptive Statistics for the Sampled *R&D* Countries

Country Code	Country	OECD	Obs.	Coverage	Mean	Median	S.D.	Min.	Max.
AUS	Australia	1	25	1987-2011	21447.30	17869.37	12221.12	6990.07	47102.19
AUT	Austria	1	14	1998-2011	20961.02	20375.22	5892.34	12525.88	30461.34
BEL	Belgium	1	25	1987-2011	22272.73	21999.78	5554.00	14174.61	31573.60
CAN	Canada	1	27	1987-2013	54696.91	52919.27	17691.55	30888.02	78738.05
CHE	Switzerland	1	24	1989-2012	43743.95	41500.10	6437.02	36415.39	56715.71
CHL	Chile	1	2	2007-2008	282.36	282.36	103.67	209.06	355.66
CHN	China	0	23	1991-2013	71454.45	33640.80	81331.00	4776.48	279864.31
CZE	Czech Republic	1	22	1991-2012	4838.31	4752.01	400.67	4386.81	5723.72
DEU	Germany	1	26	1987-2012	264564.91	254921.36	41056.50	204713.88	344850.66
DNK	Denmark	1	4	2009-2012	43552.90	43493.96	1161.24	42260.60	44963.07
ESP	Spain	1	26	1987-2012	20431.08	17378.49	9623.34	8066.97	38835.14
EST	Estonia	1	15	1998-2012	149.79	105.99	133.23	15.72	446.11
FIN	Finland	1	26	1987-2012	15702.18	13819.57	8315.11	5613.47	30109.10
FRA	France	1	26	1987-2012	145906.58	145926.64	26417.49	100721.52	189066.70
GBR	United Kingdom	1	26	1987-2012	157421.84	153893.98	12461.22	139532.91	180336.31
GRC	Greece	1	20	1988-2007	1011.95	878.93	505.13	385.07	1938.83
HUN	Hungary	1	19	1994-2012	1358.69	1180.05	610.34	658.11	2657.60
IRL	Ireland	1	25	1987-2011	4293.39	4034.85	2666.27	924.16	9402.28
ISL	Iceland	1	23	1987-2009	421.13	248.29	385.33	30.18	1165.89
ISR	Israel	1	22	1991-2012	21237.99	19767.87	13316.39	4897.70	45089.25
ITA	Italy	1	22	1991-2012	58047.57	56484.00	3643.37	54815.97	66892.58
JPN	Japan	1	27	1987-2013	824137.19	800920.94	211738.27	487687.78	1169614.38
KOR	South Korea	1	19	1995-2013	86455.90	75917.24	40735.84	37428.04	171099.16
LUX	Luxembourg	1	10	2000-2009	2990.84	2984.49	152.38	2767.85	3204.62
MEX	Mexico	1	17	1995-2011	4944.75	4277.21	2873.89	1312.81	9648.09
NLD	Netherlands	1	26	1987-2012	32565.99	32251.00	4358.45	26535.37	40579.00
NOR	Norway	1	26	1987-2012	12402.50	12315.50	1928.59	9809.51	15466.97
NZL	New Zealand	1	23	1989-2011	1403.64	1161.69	660.38	645.42	2704.39
POL	Poland	1	19	1994-2012	2996.76	2974.05	546.20	2043.81	4291.53
PRT	Portugal	1	26	1987-2012	1729.33	1059.30	1515.35	324.76	5280.69
ROU	Romania	0	20	1993-2012	2643.75	2426.74	872.21	1576.55	4211.61
RUS	Russia	0	15	1995-2009	13919.47	13585.43	4037.29	8365.06	20473.29
SGP	Singapore	0	18	1994-2011	7586.72	6791.18	4291.89	2093.70	15134.92
SVK	Slovakia	1	20	1994-2013	981.18	1007.26	113.31	692.28	1157.92
SVN	Slovenia	1	18	1995-2012	1108.86	1018.39	491.85	501.45	2179.61
SWE	Sweden	1	7	2007-2013	75232.12	75177.50	454.81	74741.01	75983.91
TUR	Turkey	1	24	1990-2013	3286.92	2522.21	2647.69	478.47	9762.18
USA	United States	1	25	1987-2011	1416122.38	1379397.75	302660.47	993008.88	1947659.13
ZAF	South Africa	0	23	1987-2009	3607.30	3229.44	1325.40	1933.49	6381.76

Notes: The construction of the R&D capital stocks is based on the Perpetual Inventory Method (PIM) applied to data for R&D expenditures from the OECD's Analytical Business Enterprise Research and Development (ANBERD) database, as outlined in the main text. R&D expenditures by country are first deflated with a country-specific GDP price deflator from the World Bank *World Development Indicators* and then converted into constant 2000 US-Dollars. The values in this table are expressed in millions of US-Dollars.

C Regression Tables

Table 4: Baseline Production Function Estimates based on Wooldridge (2009) method

NACE Rev. 2 Industry Classification	Industry Description	Labour	Capital	Materials	Obs.	Hansen J-Statistic p-value	Returns to Scale (all inputs)	Returns to Scale (excl. capital)
10	Food products	0.2109	0.0584	0.6240	3984	0.0033	0.8932	0.8349
11	Beverages	0.2521	0.0415	0.5005	231	0.0562	0.7941	0.7526
12	Tobacco products	0.5622	0.2862	0.0840	65	——	0.9324	0.6462
13	Textiles	0.3307	0.0900	0.2180	1141	0.1104	0.6387	0.5487
15	Leather and related products	0.2332	0.1989	0.0986	122	0.7095	0.5307	0.3318
16	Wood products	0.3299	0.0317	0.4804	2112	0.0002	0.8421	0.8103
17	Paper and paper products	0.2621	0.0069	0.6263	1022	0.0790	0.8952	0.8883
20	Chemicals and chemical products	0.2522	0.0396	0.6874	1048	0.0627	0.9793	0.9397
22	Rubber and plastic products	0.3056	0.0405	0.5904	2867	0.5354	0.9366	0.8960
23	Other non-metallic mineral products	0.3326	0.0464	0.6216	1783	0.3160	1.0007	0.9543
25	Fabricated metal products	0.4191	0.0293	0.4220	5747	0.0107	0.8704	0.8411
26	Computer, electronic and optical products	0.5837	0.0698	0.3133	241	0.9275	0.9667	0.8970
28	Machinery and equipment n.e.c.	0.3850	0.0264	0.5041	4341	0.2711	0.9155	0.8891
29	Motor vehicles, trailers and semi-trailers	0.4986	0.0266	0.1570	273	0.0723	0.6823	0.6557
31	Furniture	0.2863	0.0375	0.5411	3202	0.3937	0.8648	0.8273
32	Other manufacturing	0.3264	0.0527	0.5792	1395	0.0042	0.9582	0.9055
33	Repair and installation of machinery and equipment	0.3700	0.0073	0.5629	10315	0.0046	0.9402	0.9329

Notes: The coefficient estimates of the production function parameters are obtained from the Wooldridge (2009) method which is in turn based on the Levinsohn and Petrin (2003) approach. The Hansen J-Statistic is an overidentification restrictions test. The null hypothesis is that the instruments are valid, implying that they are uncorrelated with the error term. For NACE industry 12 the Hansen J-Statistic could not be calculated due to insufficient observations.

Table 5: Firm's Economic Performance and Access to Foreign Knowledge

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dependent Variable: Log of Firm TFP						
Foreigner_{t-1}	0.1027*	-5.4068					
	(0.0568)	(5.9976)					
$\left(\text{Foreigner} \times \text{Log } s^{f,total}\right)_{t-1}$		0.1908					
		(0.2084)					
OECD_{t-1}			0.1670**	-20.5132**			-21.5417**
			(0.0756)	(10.1651)			(10.1513)
$\left(\text{OECD} \times \text{Log } s^{f,total}\right)_{t-1}$				0.7164**			0.7524**
				(0.3534)			(0.3530)
Non-OECD_{t-1}					-0.0465	4.4783	7.0383
					(0.0567)	(7.4800)	(7.4638)
$\left(\text{Non-OECD} \times \text{Log } s^{f,total}\right)_{t-1}$						-0.1567	-0.2429
						(0.2591)	(0.2585)
Ethnic Diversity	-0.0589	-0.0584	-0.0389	-0.0378	0.0135	0.0134	-0.0488
	(0.0378)	(0.0372)	(0.0300)	(0.0294)	(0.0341)	(0.0342)	(0.0342)
Log Tenure	0.0604***	0.0604***	0.0607***	0.0608***	0.0608***	0.0608***	0.0607***
	(0.0101)	(0.0101)	(0.0100)	(0.0100)	(0.0101)	(0.0101)	(0.0101)
Males	0.0525**	0.0527**	0.0527**	0.0528**	0.0534**	0.0533**	0.0525**
	(0.0259)	(0.0259)	(0.0259)	(0.0259)	(0.0259)	(0.0259)	(0.0259)
Managers	-0.0009	-0.0004	-0.0006	0.0001	0.0005	0.0002	-0.0006
	(0.0606)	(0.0606)	(0.0605)	(0.0605)	(0.0606)	(0.0606)	(0.0606)
Exporter	0.0684***	0.0684***	0.0683***	0.0683***	0.0683***	0.0683***	0.0683***
	(0.0073)	(0.0073)	(0.0073)	(0.0073)	(0.0073)	(0.0073)	(0.0073)
Constant	6.0017***	6.0025***	6.0019***	6.0031***	6.0046***	6.0042***	6.0021***
	(0.0808)	(0.0809)	(0.0808)	(0.0809)	(0.0808)	(0.0808)	(0.0809)
Observations	44,528	44,528	44,528	44,528	44,528	44,528	44,528
R-squared	0.951	0.951	0.951	0.951	0.951	0.951	0.951
Industry-Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Regional Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm's Age Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm's Occupation Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm's Education Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The dependent variable is the log of a firm's total factor productivity (TFP). TFP for each two-digit NACE Rev. 2 industry is constructed from Cobb-Douglas production function estimated by Wooldridge (2009) method.

Independent variables: *Foreigner* is the share of foreign workers, as a proportion of total workers employed. Foreigner × Log $s^{f,total}$ refers to an interaction term between the *Foreigner* share and the total foreign R&D capital stock. *OECD* is the share of foreign workers from OECD countries, as a proportion of total workers employed. OECD × Log $s^{f,total}$ refers to an interaction term between the *OECD* share and the total foreign R&D capital stock. *Non-OECD* is the share of foreign workers from non-OECD countries, as a proportion of total workers employed. Non-OECD × Log $s^{f,total}$ refers to an interaction term between the *Non-OECD* share and the total foreign R&D capital stock. *Ethnic Diversity* refers to the workforce ethnic diversity measure, averaged across work places. *Log Tenure* is the log of average firm tenure (in years). *Males* is the fraction of men employees engaged in production. *Managers* refers to the fraction of managers employed, according to Statistics Denmark's definitions of occupations for employment based on ISCO. *Exporter* takes value 1 if the firm exports and zero otherwise. *Firm's Age Characteristics* refers to a full set of shares of employees belonging to each age distribution quartile. *Firm's Occupation Characteristics* refers to a full set of shares of employees belonging to low-skilled, medium-skilled, and high-skilled occupations. *Firm's Education Characteristics* refers to a full set of shares of employees with basic, secondary, and tertiary education.

Standard errors, clustered at the firm-level, are reported in parenthesis.

*: Significant at the 10% level. **: Significant at the 5% level. ***: Significant at the 1% level.

Table 6: Firm's Economic Performance and Access to Foreign Knowledge (Assessing Immigrants Structure)

	(1)	(2)	(3)	(4)	(5)
	Dependent Variable: Log of Firm TFP				
Log $s_{t-1}^{f,ew}$	0.0047***				
	(0.0003)				
Log $s_{t-1}^{f,ew,B}$		0.0049***			0.0042***
		(0.0003)			(0.0003)
Log $s_{t-1}^{f,ew,S}$			0.0047***		0.0034***
			(0.0004)		(0.0004)
Log $s_{t-1}^{f,ew,T}$				0.0053***	0.0036***
				(0.0006)	(0.0006)
Ethnic Diversity	-0.4111***	-0.3776***	-0.2382**	-0.1643*	-0.4492***
	(0.0962)	(0.0957)	(0.0933)	(0.0921)	(0.0954)
Foreigner	0.3761***	0.3496**	0.2859**	0.2094	0.4093***
	(0.1384)	(0.1377)	(0.1348)	(0.1328)	(0.1373)
Log Tenure	0.0541***	0.0536***	0.0577***	0.0591***	0.0517***
	(0.0098)	(0.0098)	(0.0099)	(0.0099)	(0.0096)
Males	0.0670***	0.0660***	0.0587**	0.0643**	0.0775***
	(0.0254)	(0.0254)	(0.0256)	(0.0258)	(0.0251)
Managers	0.0338	0.0396	0.0189	0.0166	0.0603
	(0.0599)	(0.0599)	(0.0601)	(0.0602)	(0.0593)
Exporter	0.0531***	0.0546***	0.0620***	0.0654***	0.0494***
	(0.0071)	(0.0071)	(0.0073)	(0.0073)	(0.0071)
Constant	6.0547***	6.0527***	6.0542***	6.0302***	6.1023***
	(0.0786)	(0.0784)	(0.0791)	(0.0795)	(0.0770)
Observations	44,528	44,528	44,528	44,528	44,528
R-squared	0.952	0.952	0.951	0.951	0.952
Industry-Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Regional Fixed effects	Yes	Yes	Yes	Yes	Yes
Firm's Age Characteristics	Yes	Yes	Yes	Yes	Yes
Firm's Occupation Characteristics	Yes	Yes	Yes	Yes	Yes
Firm's Education Characteristics	Yes	Yes	Yes	Yes	Yes

Notes: The dependent variable is the log of a firm's total factor productivity (TFP). TFP for each two-digit NACE Rev. 2 industry is constructed from Cobb-Douglas production function estimated by Wooldridge (2009) method.
Independent variables: Log $s^{f,ew}$ is the log of a firm's ethnicity-weighted sum of foreign R&D capital stocks of non-Danish employees. Log $s^{f,ew,B}$ is the log of a firm's ethnicity-weighted sum of foreign R&D capital stocks of non-Danish employees with basic education. Log $s^{f,ew,S}$ is the log of a firm's ethnicity-weighted sum of foreign R&D capital stocks of non-Danish employees with secondary education. Log $s^{f,ew,T}$ is the log of a firm's ethnicity-weighted sum of foreign R&D capital stocks of non-Danish employees with tertiary education. *Ethnic Diversity* refers to the workforce ethnic diversity measure, averaged across work places. *Log Tenure* is the log of average firm tenure (in years). *Males* is the fraction of men employees engaged in production. *Managers* refers to the fraction of managers employed, according to Statistics Denmark's definitions of occupations for employment based on ISCO. *Exporter* takes value 1 if the firm exports and zero otherwise. *Foreigner* is the share of foreign workers, as a proportion of total workers employed. *Firm's Age Characteristics* refers to a full set of shares of employees belonging to each age distribution quartile. *Firm's Occupation Characteristics* refers to a full set of shares of employees belonging to low-skilled, medium-skilled, and high-skilled occupations. *Firm's Education Characteristics* refers to a full set of shares of employees with basic, secondary, and tertiary education.
Standard errors, clustered at the firm-level, are reported in parenthesis.
*: Significant at the 10% level. **: Significant at the 5% level. ***: Significant at the 1% level.

Table 7: Firm's Economic Performance and Access to Foreign Knowledge (Assessing Occupation Structure)

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent Variable: Log of Firm TFP					
Log $s_{t-1}^{f,ewoccu,low}$	0.0051***					0.0037***
	(0.0004)					(0.0003)
Log $s_{t-1}^{f,ewoccu,mid}$		0.0046***				0.0037***
		(0.0003)				(0.0003)
Log $s_{t-1}^{f,ewoccu,high}$			0.0057***			0.0040***
			(0.0005)			(0.0004)
Log $s_{t-1}^{f,ewoccu,managers}$				0.0045***		0.0025***
				(0.0007)		(0.0006)
Log $s_{t-1}^{f,ewoccu,other}$					0.0035***	0.0027***
					(0.0006)	(0.0006)
Ethnic Diversity	-0.2058**	-0.3374***	-0.2127**	-0.1477	-0.1410	-0.4389***
	(0.0947)	(0.0954)	(0.0937)	(0.0983)	(0.0963)	(0.0973)
Foreigner	0.1998	0.3243**	0.2679**	0.2038	0.1932	0.3692***
	(0.1375)	(0.1374)	(0.1353)	(0.1431)	(0.1387)	(0.1406)
Log Tenure	0.0580***	0.0548***	0.0552***	0.0593***	0.0604***	0.0499***
	(0.0099)	(0.0098)	(0.0098)	(0.0100)	(0.0100)	(0.0095)
Males	0.0639**	0.0642**	0.0650**	0.0561**	0.0525**	0.0830***
	(0.0256)	(0.0254)	(0.0257)	(0.0260)	(0.0259)	(0.0252)
Managers	0.0166	0.0318	0.0224	-0.0209	0.0227	0.0622
	(0.0600)	(0.0598)	(0.0600)	(0.0612)	(0.0604)	(0.0594)
Exporter	0.0626***	0.0563***	0.0625***	0.0670***	0.0681***	0.0483***
	(0.0072)	(0.0072)	(0.0072)	(0.0073)	(0.0073)	(0.0071)
Constant	6.0461***	6.0567***	6.0487***	6.0191***	5.9897***	6.1105***
	(0.0791)	(0.0782)	(0.0789)	(0.0802)	(0.0810)	(0.0767)
Observations	44,528	44,528	44,528	44,528	44,528	44,528
R-squared	0.951	0.952	0.951	0.951	0.951	0.953
Industry-Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Regional Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Firm's Age Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Firm's Occupation Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Firm's Education Characteristics	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The dependent variable is the log of a firm's total factor productivity (TFP). TFP for each two-digit NACE Rev. 2 industry is constructed from Cobb-Douglas production function estimated by Wooldridge (2009) method.

Independent variables: Log $s^{f,ewoccu,low}$ is the log of a firm's sum of foreign R&D capital stocks of non-Danish employees with low-skilled occupation. Log $s^{f,ewoccu,mid}$ is the log of a firm's sum of foreign R&D capital stocks of non-Danish employees with medium-skilled occupation. Log $s^{f,ewoccu,high}$ is the log of a firm's sum of foreign R&D capital stocks of non-Danish employees with high-skilled occupation. Log $s^{f,ewoccu,managers}$ is the log of a firm's sum of foreign R&D capital stocks of non-Danish employees with a managers position. Log $s^{f,ewoccu,other}$ is the log of a firm's sum of foreign R&D capital stocks of non-Danish employees with other-skilled occupation. *Ethnic Diversity* refers to the workforce ethnic diversity measure, averaged across work places. *Log Tenure* is the log of average firm tenure (in years). *Males* is the fraction of men employees engaged in production. *Managers* refers to the fraction of managers employed, according to Statistics Denmark's definitions of occupations for employment based on ISCO. *Exporter* takes value 1 if the firm exports and zero otherwise. *Foreigner* is the share of foreign workers, as a proportion of total workers employed. *Firm's Age Characteristics* refers to a full set of shares of employees belonging to each age distribution quartile. *Firm's Occupation Characteristics* refers to a full set of shares of employees belonging to low-skilled, medium-skilled, and high-skilled occupations. *Firm's Education Characteristics* refers to a full set of shares of employees with basic, secondary, and tertiary education. Standard errors, clustered at the firm-level, are reported in parenthesis.

*: Significant at the 10% level. **: Significant at the 5% level. ***: Significant at the 1% level.

Table 8: Firm's Economic Performance and Access to Foreign Knowledge (Robustness Analysis)

	(1) Full Sample	(2) Excl. Exporters	(3) Excl. Multi-nationals	(4) Excl. Chemicals and Computers	(5) Control Group: Firms w/o For.	(6) Export/Import Spillovers
	Dependent Variable: Log of Firm TFP					
Log $s_{t-1}^{f,ew}$	0.0047***	0.0033***	0.0049***	0.0047***	0.0050***	0.0045***
	(0.0003)	(0.0005)	(0.0003)	(0.0003)	(0.0003)	(0.0003)
Ethnic Diversity	-0.4111***	-0.1326*	-0.4401***	-0.3391***	-0.3964***	-0.5683***
	(0.0962)	(0.0676)	(0.0988)	(0.0761)	(0.1189)	(0.0680)
Foreigner	0.3761***	0.0027	0.4085***	0.2773**	0.3329*	0.5549***
	(0.1384)	(0.0943)	(0.1415)	(0.1106)	(0.1708)	(0.0891)
Log Tenure	0.0541***	0.0408**	0.0488***	0.0527***	0.0528***	0.0608***
	(0.0098)	(0.0161)	(0.0101)	(0.0099)	(0.0108)	(0.0137)
Males	0.0670***	0.1588***	0.0585**	0.0594**	0.0671**	0.0688**
	(0.0254)	(0.0437)	(0.0283)	(0.0261)	(0.0270)	(0.0346)
Managers	0.0338	0.0358	0.0410	0.0274	0.0183	-0.0168
	(0.0599)	(0.0852)	(0.0661)	(0.0629)	(0.0664)	(0.0885)
Exporter	0.0531***		0.0572***	0.0533***	0.0523***	0.0207
	(0.0071)		(0.0081)	(0.0071)	(0.0075)	(0.0207)
Log import-weighted s^f						0.0033***
						(0.0006)
Log export-weighted s^f						-0.0001
						(0.0023)
Constant	6.0547***	6.1271***	6.1160***	6.1001***	5.9722***	5.8291***
	(0.0786)	(0.1297)	(0.0848)	(0.0798)	(0.0853)	(0.1266)
Observations	44,528	10,539	35,262	43,095	37,258	24,793
R-squared	0.952	0.950	0.947	0.950	0.949	0.958
Industry-Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Regional Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Firm's Age Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Firm's Occupation Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Firm's Education Characteristics	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The dependent variable is the log of a firm's total factor productivity (TFP). TFP for each two-digit NACE Rev. 2 industry is constructed from Cobb-Douglas production function estimated by Wooldridge (2009) method.
Independent variables: Log $s^{f,ew}$ is the log of a firm's ethnicity-weighted sum of foreign R&D capital stocks of non-Danish employees. *Ethnic Diversity* refers to the workforce ethnic diversity measure, averaged across work places. *Log Tenure* is the log of average firm tenure (in years). *Males* is the fraction of men employees engaged in production. *Managers* refers to the fraction of managers employed, according to Statistics Denmark's definitions of occupations for employment based on ISCO. *Exporter* takes value 1 if the firm exports and zero otherwise. *Foreigner* is the share of foreign workers, as a proportion of total workers employed. *Log import-weighted* s^f is the log of the bilateral import-share weighted R&D capital stocks of a firm's trading partner countries. *Log export-weighted* s^f is the log of the bilateral export-share weighted R&D capital stocks of a firm's trading partner countries. *Firm's Age Characteristics* refers to a full set of shares of employees belonging to each age distribution quartile. *Firm's Occupation Characteristics* refers to a full set of shares of employees belonging to low-skilled, medium-skilled, and high-skilled occupations. *Firm's Education Characteristics* refers to a full set of shares of employees with basic, secondary, and tertiary education.
Standard errors, clustered at the firm-level, are reported in parenthesis.
*: Significant at the 10% level. **: Significant at the 5% level. ***: Significant at the 1% level.

Table 9: Firm's Economic Performance and Access to Foreign Knowledge (Assessing Alternative TFP Estimates)

	(1)	(2)	(3)	(4)	(5)	(6)
	WLP	OLS	OLS	OLS	Levinsohn-	Translog
	Baseline	Pooled	FE	Time FE	Petrin	Time FE
	Dependent Variable: Log of Firm TFP					
Log $s^{f,ew}_{t-1}$	0.0043***	0.0007***	0.0071***	0.0111***	0.0076***	0.1466***
	(0.0003)	(0.0002)	(0.0003)	(0.0004)	(0.0004)	(0.0044)
Ethnic Diversity	-0.3909***	-0.3293***	-0.3150***	-0.3913***	-0.3937***	-1.1895
	(0.0999)	(0.0740)	(0.0820)	(0.0992)	(0.0997)	(0.9239)
Foreigner	0.3653**	0.4289***	0.1559	0.0856	0.1233	-5.1491***
	(0.1427)	(0.1063)	(0.1178)	(0.1454)	(0.1432)	(1.3387)
Log Tenure	0.0525***	0.0336***	0.0356***	0.0405***	0.0289*	0.2682*
	(0.0102)	(0.0094)	(0.0111)	(0.0133)	(0.0152)	(0.1387)
Males	0.0725***	0.0462**	0.1251***	0.1338***	-0.0642*	0.9827***
	(0.0267)	(0.0231)	(0.0288)	(0.0331)	(0.0387)	(0.3390)
Managers	0.0448	0.1625**	-0.0157	-0.1089	-0.0387	-3.5002***
	(0.0627)	(0.0653)	(0.0621)	(0.0687)	(0.0778)	(0.5369)
Exporter	0.0508***	-0.0022	0.0909***	0.1554***	0.1028***	2.0380***
	(0.0074)	(0.0067)	(0.0080)	(0.0094)	(0.0118)	(0.0981)
Constant	6.0253***	5.6888***	6.4157***	7.5968***	7.0298***	11.4209***
	(0.0838)	(0.0814)	(0.0889)	(0.0954)	(0.1156)	(0.8096)
Observations	40,328	40,328	40,328	40,328	40,328	40,328
R-squared	0.946	0.927	0.898	0.896	0.984	0.761
Industry-Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Regional Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Firm's Age Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Firm's Occupation Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Firm's Education Characteristics	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The dependent variable is the log of a firm's total factor productivity (TFP). In column (1), productivity for each two-digit NACE Rev. 2 industry is constructed from Cobb-Douglas production function using the Wooldridge (2009) method of the Levinsohn and Petrin (2003) production function approach. In column (2) productivity for each two-digit NACE Rev. 2 industry is constructed from Cobb-Douglas production function estimated by pooled OLS. In column (3), productivity for each two-digit NACE Rev. 2 industry is constructed from Cobb-Douglas production function estimated by OLS with firm-fixed effects. In column (4), productivity for each two-digit NACE Rev. 2 industry is constructed from Cobb-Douglas production function estimated by OLS with time-varying firm-fixed effects. In column (5), productivity for each two-digit NACE Rev. 2 industry is constructed from Cobb-Douglas production function estimated by the semi-parametric approach of Levinsohn and Petrin (2003). In column (6), productivity for each two-digit NACE Rev. 2 industry is constructed from a second-order Translog production function specification estimated by OLS with time-varying firm-fixed effects.

Independent variables: Log $s^{f,ew}$ is the log of a firm's ethnicity-weighted sum of foreign R&D capital stocks of non-Danish employees. *Ethnic Diversity* refers to the workforce ethnic diversity measure, averaged across work places. *Log Tenure* is the log of average firm tenure (in years). *Males* is the fraction of men employees engaged in production. *Managers* refers to the fraction of managers employed, according to Statistics Denmark's definitions of occupations for employment based on ISCO. *Exporter* takes value 1 if the firm exports and zero otherwise. *Foreigner* is the share of foreign workers, as a proportion of total workers employed. *Firm's Age Characteristics* refers to a full set of shares of employees belonging to each age distribution quartile. *Firm's Occupation Characteristics* refers to a full set of shares of employees belonging to low-skilled, medium-skilled, and high-skilled occupations. *Firm's Education Characteristics* refers to a full set of shares of employees with basic, secondary, and tertiary education.

Standard errors, clustered at the firm-level, are reported in parenthesis.

*: Significant at the 10% level. **: Significant at the 5% level. ***: Significant at the 1% level.

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