DOES LABOUR DIVERSITY AFFECT FIRM PRODUCTIVITY?

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Abstract

Using a comprehensive linked employer-employee dataset, we analyze how diversity in cultural background, skills and demographic characteristics affects total factor productivity (TFP) of firms in Denmark. Implementing structural estimation of the production function, we find evidence that all three dimensions of labour diversity significantly enhance firm performance as measured by firm TFP. Moreover, we find that larger shares of younger workers facilitate the exploitation of labour force heterogeneity in terms of productivity.

JEL Classification: C23, J33, J38, J51
Keywords: Labour diversity, Total factor productivity, Denmark

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1 Motivation

Diverse labour force is increasingly a reality in many developed countries. This results among others from the following major factors: policy measures to counteract population aging, anti-discrimination measures and the experienced growth in immigration during the latest decades in many developed countries (Pedersen et al. (2008)). Moreover, as a consequence of the worldwide globalisation process and skill biased technological change governments took a number of steps to increase skill level of the workforce, by e.g. increasing supply of university educated people. All that leads to an increasing diversity of labour force in terms of age, gender, skills and ethnicity.

From the demand side, we observe increasing diversity across many workplaces and we hear often about importance of further internationalization and demographic diversification. In many countries firms' hiring decisions are affected by governmental affirmative action policies. Countries that do not pursue affirmative actions have at least some kind anti-discrimination law and often an agenda to promote equality on labour market.[1] Besides firms are often under pressure to be more diverse, because this is how they should socially look like[2], possibly since not being diverse may be an evidence of discrimination. Businesses viewed as discriminatory can be harmed by customer preferences or by preferences of their business partners, whether more diverse firms signalling non-discriminatory behaviour may on contrary benefit from customers support. At the same time, firms are challenged by constantly changing demand for goods and services, new customers and markets in today's globalized world. The di-

[1] For instance, Denmark, does not have any binding affirmative programs to address discrimination in personnel policies so far. Denmark has an anti-discrimination legislation (the law on prohibition against difference of treatment on the labour market adopted from 1996) without any obligation to initiate an active requirement. Besides some other institutions and NGOs work to promote greater equality especially in the gender area. In particular, a new general complaints board called Equality Board was established as from 2009 to consider individual complaints regarding discrimination based on gender, race, colour of the skin, religion or faith, age, disability or national, social or ethnic origin, political views or sexual orientation. This board replaced The Gender Equality Board, which, as it comes from the title, was only for gender-related complaints (www.ligenaevn.dk).

[2] As mentioned by human resource managers of key Danish firms at the recent CCP meeting.

verse workforce may be a key factor in helping firms to understand and to meet the new needs. Popular press usually emphasizes demographic diversity to be beneficial for firms, but is it really true? Do firms benefit from the workforce diversity, so that it is translated into their competitive advantage? What is the relationship between workplace labour diversity and firm performance? Although the issue is very important and relevant for policy-makers, there is considerable ambiguity surrounding the research-based knowledge.

So far the theory suggests that workforce diversity may affect firm performance through various channels The Becker's economic model of discrimination (Becker,1957) predicts that if a firm is discriminating in the sense that workers are hired on the basis of their demographic characteristics (age, gender, having children) or ethnicity instead of ability, then the firm has higher wage costs, but it is not more productive than a non-discriminating firm. Thus, higher diversity of workforce would then be positively associated with firm total factor productivity. Further, ethnic diversity can be beneficial to the firm performance through better decision making and improved problem solving (Hong and Page (1998), (2001)) and through more innovation and creativity (Alesina and La Ferrara, 2005). In addition, workforce diversity may provide useful information to the firm about the product's market enhancing firm's ability to compete in global markets (Osborne (2000)). According to study by Lazear (1999), diversity in skills, education and tenure may generate knowledge spillovers and skill complementarities among the employees in a firm and thus it has a positive effect on firm performance. Ethnic-cultural diversity may affect firm performance negatively as it may (i) hinder potential knowledge transfers among workers, (ii) reduce peer pressure by weakening social ties and trust among them, and (iii) create non-pecuniary disutility of joining or remaining in a demographically diverse firm (Lazear (1999)).

Until now, the empirical evidence concerning diversity and economic performance has been fairly scarce, and most of the previous studies were based on case studies within

one firm (e.g. Hamilton et al. (2003), (2004) and Kurtulus, (2009)), or on aggregate regional data (e.g. Ottaviano and Peri, (2005)), whether evidence using more comprehensive data is almost non-existent. Moreover, majority of the previous studies has focused on only one dimension of diversity on firm performance, with the study by Kurtulus (2009) being the only exception. Summarising briefly key findings of the studies: (i) the former group of case studies find that diversity with respect to skills and knowledge has a positive effect on worker performance, whether diversity in age and race lowers firm performance (Hamilton et al. 2003, 2004 and Kurtulus, 2009), (ii) studies using aggregated regional data find a positive effect of citizenship diversity on performance (e.g. Ottaviano and Peri, (2005), Alesina and La Ferrara, (2005) and Suedekum et al.(2009)) (iii) studies using the micro linked employer-employee data find a positive effect of skill diversity on firm performance (Navon, (2009)), positive or no significant effect of ethnicity diversity on firm performance (Barrington and Troske, (2001)) and inverse U-shaped relationship between age diversity and firm productivity (Grund and Westergaard-Nielsen (2008a, 2008b)). So there seems to be some consensus with respect to skill diversity being positively related to firm performance, whether the evidence of diversity along ethnic and demographic lines on performance is rather mixed.

In this paper, we add to the empirical evidence by analysing the relationship of diversity in nationality, skills and demographics on firm performance using register-based linked employer-employee dataset (LEED) from Denmark, which covers the entire population of workers and firms in Denmark. The LEED was then merged with firm-level financial accounting and patent application datasets. The richness and comprehensiveness of the data allows us to overcome many of the limitations of previous studies and shed some light on yet unexplored research areas. From the methodology point of view we follow the Levinsohn and Petrin (LP) approach to deal with measurement errors, simultaneity and endogeneity problems in the computation of firm TFP. In our patent production

function analyses we introduce pre-sample estimators to proxy unobserved time invariant firm characteristics and reduce the bias caused by zero inflation and trend in the count of patent applications. Besides exploiting the longitudinal and geographical dimensions of our data, we employ an instrumental variable (IV) approach to cope with potential simultaneity and endogeneity related to firm-level diversity indexes.

Our results are encouraging for both policy-makers and business leaders: they show that there is a positive effect of diversity in all three dimensions – skills, demographics and ethnicity – on firm TFP. Results from TFP analysis indicate that firm workforce diversity is either positively associated with firm performance or there is no significant relationship between diversity and firm performance. Most importantly, we do not find any significant negative relationship between firm diversity and firm performance in any of the model specifications. These findings have important implications for the policy debate about anti-discrimination measures as they suggest that governmental policies actively promoting greater equality will not bring any detrimental effects on businesses in terms of firm performance, on contrary firms may benefit from more diverse workforce.

The structure of the paper is as follows: section 2 reviews related literature and derives hypothesis, section 3 briefly describes the data, section 4 provides details on the empirical strategy, section 5 contains and discusses results of our empirical analyses and Section 6 offers some concluding remarks.

2 Background Discussion, Previous Literature and Hypotheses Development

Over the past couple of decades, Denmark experienced, similarly as other developed (and not only) countries, many changes in the composition of the workforce, which con-

tributed to an increased diversity of labour force. Among the most significant changes has been an increase in the female labour participation, increased immigration and skill upgrading of the Danish workforce. This is partly a result of policies adopted to counteract the problem of population aging, anti-discrimination measures, immigration and the worldwide globalization process.

Demographic projections by the United Nations suggest that during the next four decades populations in Europe ceteris paribus might decline by 12 per cent, respectively, (United Nations (2003)). The main factor responsible for the population ageing is a large decline in the total fertility rate over the last half century. Although projections for Denmark are less extreme than for other European countries, it will still suffer from the population aging. According to the DREAM projections (DREAM (2002)), it is expected that by 2040 the ageing effects will reduce the labour force by around 7 per cent (DREAM (2002)). As a consequence the government have adopted a number of measures to counteract the problem of population aging such as policies encouraging people to work longer e.g. by increasing the regular and early-retirement age to 67 and 62 years, respectively, and by restricting access to early retirement by changing economic incentives, and age antidiscrimination measures (Danish Ministry of Finance). Female labour participation in Denmark has grown significantly in the last century, ranking among highest in OECD countries (OECD, 2002). This is partly due to policies encouraging women to work e.g. better childcare and parental leave provisions and gender anti-discrimination measures. Subsequently diversity of workforce with respect to gender, age and employees with children has increased. Furthermore, Denmark has experienced large inflows of immigration during the latest decades and became net immigration country as from 1970s. Last not least, as a consequence of the worldwide globalisation process and skill biased technological change the government took a number of steps to increase skill level of the workforce, by e.g increasing supply of university educated people and by enhancing availability of lifelong learning. All

that leads to an increasing diversity of Danish labour force.

From the demand side, we observe increasing diversity across many workplaces and we hear often about importance of further internationalization and demographic diversification. In many countries governments introduce affirmative action policies.in addition to the general ban on discrimination in order to promote equality and in this way affect firms' hiring decisions. On the other hand some countries hesitate with introduction of any affirmative policies arguing that affirmative action could be counterproductive.for both the discriminated groups and for businesses. Denmark, does not have any binding affirmative programs to address discrimination in personnel policies. So far, Denmark's anti-discimination policy is based on an anti-discrimination legislation (the law on prohibition against difference of treatment on the labour market adopted from 1996) without any obligation to initiate an active requirement. Besides some other institutions and NGOs work in order to promote greater equality especially in the gender area. In particular, a new general complaints board called Equality Board was established as from 2009 to consider individual complaints regarding discrimination based on gender, race, colour of the skin, religion or faith, age, disability or national, social or ethnic origin, political views or sexual orientation. This board replaced The Gender Equality Board, which, as the title says, was only for gender-related individuals'complaints (www.ligenaevn.dk).

Even though Denmark does not have any legally binding affirmative programs for private sector, firms can be often under pressure to be more diverse, because this is how they should socially look like, possibly since not being diverse may be an evidence of discrimination. Businesses viewed as discriminatory can be harmed by customer preferences or by preferences of their business partners, whether more diverse firms signalling non-discriminatory behaviour may on contrary benefit from customers support or brand loyalty. At the same time, firms are challenged by constantly changing demand for goods and services, new customers and markets in today's globalized world.

The diverse workforce may be a key factor in helping firms to understand and to meet the new needs. Do firms benefit from the workforce diversity, so that it is translated into their competitive advantage? What is the relationship between workplace labour diversity and firm performance? Although the issue is very important and relevant for policy-makers, there is considerable ambiguity surrounding the research-based knowledge.

Economic theory suggests that workforce diversity may affect firm performance differently and through various channels. The Becker's economic model of discrimination (Becker,1957) predicts that if a firm is discriminating in the sense that workers are hired on the basis of their demographic characteristics (age, gender, having children) or ethnicity instead of ability, then the firm has higher wage costs, but it is not more productive than a non-discriminating firm. Thus, higher diversity of workforce would then be positively associated with firm TFP. According to study by Lazear (1999), diversity in skills, education and tenure may generate knowledge spillovers and skill complementarities among the employees within a firm (as long as workers' information are relevant) and thus it has a positive effect on firm performance. Similarly, diversity in age can be beneficial to firms because there are complementarities between the human capital of younger and older workers. Younger employees have knowledge of new technologies and IT and older employees have a better understanding and experience with the intra-firm structures and the operating process (Lazear (1998)).At the same time Becker's (1957) model of co-worker discrimination suggests that demographic heterogeneity among workers may create communication frictions if workers are prejudiced, and thus bring some cost connected to the frictions.

The theoretical contribution on the effect of ethnic and cultural diversity on firm performance in non-discriminatory framework brings mixed conclusions. Ethnic-cultural diversity may affect firm performance negatively as it may (i) hinder potential knowledge transfers among workers due to linguistic and cultural barriers, (ii) reduce peer

pressure by weakening social ties and trust among them, and (iii) create non-pecuniary disutility of joining or remaining in a demographically diverse firm (Lazear (1999)). Similar point on trust is made by Glaseser et. al. (2000), and Alesina and La Ferrara (2002) showing that people often distrust members of other ethnic groups and tend to prefer interacting in culturally relatively homogeneous communities. On the other hand, ethnic diversity can be beneficial to the firm performance through better decision making and improved problem solving (Hong and Page (1998), (2001)). Page and Hong (1998 and 2001) in their model show that diverse groups of problem solvers consistently outperformed the homogeneous groups of the best individuals at solving problems. The reason is that the diverse groups get stuck less often than homogenous groups of high-ability solvers, who tend to think similarly. The authors argue that it is because more diverse groups have broader spectrum of perspectives improving their decision-making. Berliant and Fujita (2004) also refer to the significance of cultural diversity for knowledge creation and transfer. The heterogeneity of people is important for the creation of new ideas. Further, Alesina and La Ferrara, (2005) propose a simple theoretical framework, in which skills of ethnically heterogeneous groups of individuals are complementary in the production process for a private good, bringing more innovation and creativity, which is translating diversity into increased productivity. However as individual utility also depends on the consumption of a shared public good and as heterogenous ethnic groups may have different public goods preferences, increased diversity lowers the utility from public good consumption. In addition, workforce diversity may provide useful information to the firm about the product's market, enhancing firm's ability to compete in global markets (Osborne (2000)).

Until now, the empirical evidence concerning diversity and economic performance has been fairly scarce, and most of the previous studies were based on case studies within one firm (e.g. Hamilton et al. (2003), (2004) and Kurtulus, (2009)), or on aggregate regional data (e.g. Ottaviano and Peri, (2005) and Suedekum et al. (2009)),

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Hypotheses development Based on the different theoretical approaches and their

[3]There is quite large literature on the role of skill distribution on firm performance and how it changed over time, mostly due to skill biased technological change (SBTCH). Some argue that it is important to have few talented workers ala "superstar", which leads to more dispersed skill distribution of the workforce (Rosen (1981)), other claim that tasks are performed at a certain level of competence leading to team of workers with similar skills and more seggregation (Kremer (1993)). Some recent matching and sorting models argue that production has shifted from mode of hiring more diverse workers towards modes, where some firms hire only high-skilled (e.g.Microsoft) and other firms hire only low-skilled (e.g.McDonalds), resulting in seggregation (Kremer and Maskin (1996)). Some argue that SBTCH reduce communication costs and increase an optimal degree of skill dispersion (Garicano, Rossi-Hansberg, (2006)). For some discussion and evidence of educational sorting see Eriksson et al. (2009). In our paper we do not refer to skill diversity as overall educational distribution. By skill diversity we mean diversity in skill complementarity, i.e. we focus on different skill specializations, e.g. we distinguish between different sciences, workforce exprience, see the skill diversity index described in the next section of the paper.

predictions, we try to derive hypotheses for the effect of diversity on firm performance as measured by firm total factor productivity and firm innovation activity.

Effect of diversity on firm total factor productivity

Diversity can have a *positive effect on firm TFP* in the market with *discrimination*, where some firms conduct discriminatory behaviour in their hiring behaviour and some not (Becker, 1957). If the discrimination is present on the Danish labour market, then we would expect diversity of firm workforce in demographics and ethnicity to influence the firm TFP positively. We would expect that such discriminatory behaviour is most likely practised towards women, workers with small children, old (but maybe also young) workers and towards immigrants and their descedants. Thus we would expect that there might be some discimination against some *demographic and ethnic* groups, but not so much against different educational specialisations.

If discrimination is not present on the market the *effect of diversity along ethnic-cultural and demographic lines on firm TFP* can still be positive as theoretical predictions are somewhat *ambiguous*. From the existing theoretical contributions it is clear that there are two forces driving the effect in the opposite directions. On one hand the demographic and ethnic diversity can benefit the firm with more diverse spectrum of p*roblem solving abilities, creativity and knowledge spillovers*, which in turn *foster TFP* (Lazear (1998), Hong and Page (1998 and 2001), Berliant and Fujita (2004), Alesina and La Ferrara (2005)). We would expect the inter-cultural learning and knowledge spillovers to materialize more easily in firms with younger and more educated workforce. On the other hand, the demographic and ethnic *diversity may also lower TFP* because of higher *costs connected to communication barriers and higher distrust levels*, which arise if people of different cultural backgrounds, gender and ages have to interact and to work together on projects (Lazear (1999), Glaseser et. al. (2000), and Alesina and La Ferrara (2002)). Some firm-level policies however can counteract the costs associated with the diversity, e.g. by introduction of the same "professional" language

and implementation of diversity management and film-level integration practises. We would expect that these firm-level policies are more likely to materialize in larger firms, where the organizational and management structures and practises are well established. There is a consensus across the existing theoretical contributions that because of the knowledge spillovers *skill-related diversity shall bring a positive effect on firm TFP.*

3 Data

3.1 Data description

For our empirical analysis we have built a dataset by merging information from two different data sources: the "Integrated Database for Labour Market Research" (IDA henceforth) and a register of firms' business accounts" (Regnskab henceforth). A shorter time span characterizes the accounting data. It covers the construction industry from 1994, manufacturing from 1995, wholesale trade from 1998, and the remaining part of the service industry from 1999 onwards. We need information collected in Regnskab in order to estimate the firm production function. It reports among others the most used aggregations of financial items: sales, intermediate goods or materials, fixed assets and profits. We drop from the analysis, firms with less than 10 employees and firms whose accountings have been imputed. Both Regnskab and IDA are provided by Denmark Statistics. IDA is a longitudinal employer-employee register containing valuable information on individuals employed in the recorded population of Danish firms during the period 1980-2005. Excluding death and permanent migration, there is no attrition in IDA. The labour market status of each individual is recorder every 30th of November. The retrieved information has been aggregated at firm level and consequentially merged to variables like enterprises' location (County), size and related

industry. [4]

All in all, the three datasets give us the possibility to analyze firm total factor productivity during 11 years period, 1995 to 2005 which gives us 64,324 firm observations, respectively. Table 1 provides some basic descriptive statistics on all variables used in our analysis.

[Insert Table 1 around here]

3.2 Firm labour diversity

This section focuses on the measurement of employees' diversity at firm level. Employees diversity will be quantified using information regarding their gender, age, whether the employee has any children, work experience, highest fulfilled education and nationality.

As the main literature in this field (Jost, 2006; Stirling, 2007) has defined the Shannon entropy as the most profound and useful of all diversity indexes, we use the exponential of Shannon-Weaver entropy index to measure the degree of diversity at the firm level. This method is commonly used to measure ecological diversity. Contrary to the traditional indexes, like the percentage of employees belonging to a specific group or the Herfindahl index, the Shannon entropy index combines two quantifiable measures: the "species" richness (number of categories represented within the firm or the workplace) and "species" equitability or evenness (how even are the numbers of the individual categories).

Specifically, we calculate three separate entropy indexes to measure diversity along the

[4] We do not include the following industries: i) agriculture, fishing and quarrying, ii) electricity, gas and water supply, and iii) public services.

cultural, skill and demographic dimensions[5]. Cultural diversity is represented by the employees' nationality and is based on the following categories: Danish, North America and Oceania, Central and South America, Africa, West and South Europe, Formerly Communist Countries, Asia, East Asia and Muslim Countries (see Appendix A for list of countries). As we also distinguish between first and second generation immigrants among non-Danish employees, our cultural index is based on 17 categories.

The skill-related diversity is based instead on 24 categories as it is constructed on the combination of the highest educational level (tertiary education, secondary and vocational education and below secondary education) and the quartiles of the work experience. We divide tertiary education into 4 categories making a distinction between Bachelor, Master and PhD degrees in social science, humanities, engineering and natural sciences.

Finally the demographic index is build on the intersection of gender, age quartiles and whether the employee has any child (16 categories, in total). To measure diversity at firm level for each dimension, we sum up the entropy indexes calculated for each workplace belonging to the same firm, weighted by the number of employees employed in each workplace, as follows:

$$index\_h_{it} = exp(\sum_{w=1}^{W} \frac{N_w}{N_i} \sum_{s=1}^{H} p_{swt}(lnp_{swt})), \tag{1}$$

where $index\_h_{ijt}$ is the diversity index of firm i at time t calculated along the h dimension (cultural, skill-related and demographic), W is the total number of workplaces

[5]We also run all our empirical analyses using the Herfindahl index as an alternative diversity measure for Shannon-Weaver entropy index. The results are shown in the section devoted to robustness analyses.

belonging to firm i, N_w and N_i are respectively the total number of employees of the workplace w and of firm i. The proportion of the workplace workforce that falls into each category s of the hth dimension at time t is represented by the term p_{swjt}. The diversity index has a minimum value equal to 1 if one category dominates all the others or there is only one category represented within the workplace, and a maximum value equal to the number of categories if all categories are equally represented.

As seen from the Table 1 there is not much firm diversity with respect to ethnicity in firms in Denmark as the mean value of the index is 1.1. In Table 2 we show descriptive statistics for the within firm (between workplaces), within industry and within county (between firms) diversity indexes. We observe that there is not much variation in indexes between workplaces within a firm and that the most variation in diversity takes place between firms within industries for all three dimensions of diversity. In addition we show in Table 3 how diversity of workforce differs by counties in order to show the composition of the local supply. Not surprisingly the most diverse county in terms of cultural background is Copenhagen. The opposite is true for North Jutland and Aarhus. The highest diversity in skills and demographics is in Frederiksborg county. It should be noted that the differences across counties with respect to the heterogeneity in demographics are relatively small.

[Insert Table 2 around here]

[Insert Table 3 around here]

4 Empirical Strategy

In the next section we describe our empirical modelling strategy.with respect to estimation the effect on diversity on firm performance. The first subsection discusses

different approaches to estimating firm production functions and describes our preferred total factor productivity model specification. In the second subsection we scetch the empirical modelling strategy we chose for analyses of diversity and firm innovation as measured by firm patenting activity. The third subsection discusses identification concerns with respect to the effect of diversity on firm outcomes and tools addressing these concerns.

4.1 Productivity estimation

As pointed out by the literature on the identification of the firm production functions, the major issue in the estimation of parameters is the possibility that there are factors influencing production, unobserved by the econometrician but observed by the firm. In such case, asymmetrically observed shocks may be taken into account by firms to maximize their profits or minimize their costs. Specifically, it is expected that firms respond to positive (negative) productivity shocks by expanding (reducing) output, which requires higher quantity/quality of inputs for the production. Thus, OLS estimates of coefficients on the inputs observed by the econometrician are biased: there is a clear endogeneity problem.

Potential and earlier proposed solutions have been the instrumental variables (IV) and fixed-effects (FE) estimation techniques (Mundlak, 1961). Whereas, the former need the use of variables correlated with observed input choices but uncorrelated with unobserved ones (partially and totally), the latter are based on the assumption that the unobservables are time invariant. However, these methodologies do not seem to be successful in practice for two main reasons. First, it is really difficult to find variables fulfilling the IV requirements or having asymmetrically observed shocks fixed over time. Second, fixed-effect estimators exploit only the across time variation, leaving unused a

substantial part of information, which is incorporated into the cross-sectional dimension. In the last case, the coefficients could be weakly identified.

More recent techniques follow the GMM or the structural approach mainly advocated by Olley and Pakes (1996) (OP henceforth) and Levinsohn and Petrin (2003) (LP henceforth), (see Ackerberg et al, 2008, for a survey). The GMM system estimator (Blundell and Bond, 2000) is a suitable estimation method in case of endogenous variables. It requires a long time span, since lagged values and differences are used as instruments. In practice, efficiency is a problem for dynamic panel data model estimations: the presence of weak instruments is quite frequent. The poor performances of these estimators have roots in their underlying statistical assumptions. Furthermore, the eventual absence of a number of lagged values may turn into a non-random selection of the dataset, introducing therefore some sample bias. Trying to get a balanced sub-sample is not a convenient solution here since it is likely to bias the estimates of factor coefficients. OP propose a correction for the presence of attrition bias in the sample. In particular, it might be that firms are recorded for few years because they drop out of the market. It implies that firms characterized by higher capital stock are less likely to exit the market in case of negative (production) shock realizations, inducing a downward bias in the estimates of capital coefficients. Thus, OP assume that incumbent firms decide at the beginning of each period whether to continue to participate in the market on the basis of their expected profitability. More generally, they introduce survival probabilities to deal with such sample selection problem. Moreover, OP suggest a novel approach to address the endogeneity problem related to the estimation of production function parameters. They design a semi-parametric estimation method that uses investment levels to proxy for time-varying productivity shocks observed only by the firm. It is based on the assumption that future productivity is strictly increasing with respect to such term, so firms that observe a positive

productivity shock in period t will invest more in that period, for any value of capital and labour. However, OP's method presents a relevant drawback too. This disadvantage comes from the nature of the investment variable, which is very lumpy due to the related considerable adjustment costs. LP argue that the investment proxy may not smoothly respond to the productivity shock and then estimates parameters may be inconsistent. Thus, LP propose to proxy the asymmetrically observed time-varying productivity shock by using intermediate inputs. This approach may not be associated with additional computational costs if the intermediate inputs are also used to get value added values. There are three main benefits deriving from the use of the LP's estimation method (Petrin, Poi and Levinsohn, 2004). Firstly, it allows to take into account firms reporting zero investment level in a given period. In fact, the OP's approach determines a severe truncation in the data, excluding de facto firms that cannot easily adjust their equipment or machinery (likely) because of budget constraints. This truncation might also affect the efficiency of estimated parameters. Secondly, intermediate inputs are less costly to adjust and usually respond better to productivity shocks than investments. Lastly, intermediate inputs provide a simple link between estimation strategy and economic theory because they do not typically represent state variables. Moreover, LP suggest three specification tests for evaluating the proxy's performance. It is worth underlying that, differently from OP, LP does not deal with any selection problem associated with the firm exiting out of the market.

Although, OP and LP are broadly used methods for the structural identification of production function, they could suffer from collinearity problems as pointed out by Ackerberg, Caves and Frazen (2006) (ACF henceforth). Referring to the timing and dynamic implications of input choices, they cast doubts especially on the LP estimation techniques. Thus, ACF propose their estimation method built upon OP and LP approaches but not suffering from potential collinearity problems. Further improve-

ments for the structural identification of the production function have been made. Among them, De Loecker (2007) takes imperfect competition in output markets as well as multi-product firms into account. However, extensions emerging from the literature are still work in progress, making it particularly difficult to pick one of the alternatives.

4.1.1 *Our TFP model specification*

Referring to the literature on the identification of the production functions, we implement the structural techniques suggested by LP to obtain estimates of firm TFP Specifically, the productivity is obtained from a Cobb-Douglas production function containing the real value added (Y), labour (L), capital (K) and a number of other controls affecting productivity, such as firm specific characteristics of employees, foreign ownership, year, size and regional dummies. Since input characteristics differ across industries, production function parameters are estimated for each 2-digit sector j separately. Therefore, our reported results use the following specification:

$$y_{ijt} = \beta_0 + \beta_l l_{ijt} + \beta_k k_{ijt} + u_{ijt}, \tag{2}$$

where y_{ijt}, l_{ijt} and k_{ijt} are the logarithm of the firm value added, labour and capital stock of firm i at time t in industry j. Specifically, it is assumed that the error term, u_{ijt}, is the sum of two shocks:

$$u_{ijt} = \omega_{ijt} + \eta_{ijt}, \tag{3}$$

where ω_{ijt} is the productivity shock observed by the firm but not by the econometrician, and η_{ijt} is an unexpected productivity shock, which is unobserved by both. Using the

estimates of production function parameters, the firm i's TFP, at time t in industry j, is defined as

$$tfp_{ijt} = y_{ijt} - \hat{\beta}_l l_{ijt} - \hat{\beta}_k k_{ijt} \tag{4}$$

Next to the computation of TFP values, the relationship between these and alternative measures of diversity can be estimated in the following equation:

$$\begin{aligned} tfp_{ijt} &= \gamma_0 + \gamma_1(index - fore_{it}) + \gamma_2(index - skill_{it}) + \gamma_3(index - demo_{it}) \\ &\quad + \gamma_z(Z_i t) + \gamma_t + \gamma_r + \gamma_j + \xi_i t, \end{aligned} \tag{5}$$

where γ_1, γ_2 and γ_3 are respectively the labour diversity effects associated with employees' diversity in terms of nationality, skill and demographic characteristics; $Z_i t$ are firm specific characteristics of employees; γ_t, γ_r and γ_j are time, regional, and industry controls.

Additionally, we add all possible interaction couples between our three diversity indexes into the model in order to test whether the effects of a particular dimension of diversity can be influenced by other dimension of diversity. For instance, more diverse firm workforce with respect to demographics might be more tolerant and accepting in the case of more ethnically diverse workforce, and thus translate the diversity into greater firm total factor productivity. Further, there might be complementarities among different skills and demographic groups: e.g. young workers have new technology knowledge and skills whether older workers have firm-specific human capital and knowledge about relevant markets and networks (Lazear, 1999), which might be reinforced by skill diversity The model with interaction effects between the diversity indexes has the following

form:

$$\begin{aligned} tfp_{ijt} &= \gamma_0 + \gamma_1(index - fore_{it}) + \gamma_2(index - skill_{it}) + \gamma_3(index - demo_{it}) \\ & \gamma_{12}(index - fore_{it} * index - skill_{it}) + \gamma_{23}(index - skill_{it} * index - demo_{it}) + \\ & \gamma_{31}(index - demo_{it} * index - fore_{it}) + \gamma_z(Z_i t) + \gamma_t + \gamma_r + \gamma_j + \xi_i t, \end{aligned} \tag{6}$$

where γ_{12}, γ_{23} and γ_{31} are the interaction effects of our diversity indexes. In the interaction model, we calculate the marginal effect of one index, for example $index - fore_{it}$ and its variance as follows:

$$\frac{\partial tfp_{ijt}}{\partial index - fore_{it}} = \gamma_1 + \gamma_{12} index - skill_{it} + \gamma_{13} index - demo_{it}, \tag{7}$$

and

$$\begin{aligned} \hat{\sigma}^2_{(\partial tfp_{ijt}/\partial index - fore_{it})} &= var(\hat{\gamma_1}) + (index - skill_{it})^2 var(\hat{\gamma_{12}}) \\ & +(index - demo_{it})^2 var(\hat{\gamma_{13}}) + 2index - skill_{it} cov(\hat{\gamma_1}, \hat{\gamma_{12}}) + \\ & +2index - demo_{it} cov(\hat{\gamma_1}, \hat{\gamma_{13}}) \\ & +2index - skill_{it} * index - demo_{it} cov(\hat{\gamma_{12}}, \hat{\gamma_{13}}). \end{aligned} \tag{8}$$

Finally, one would expect that inter-cultural learning and knowledge spillovers, which influence firms economic performance positively, would materialize more easily in firms with younger and more educated workforce. Therefore we augment the basic model

specification to allow for interaction effects between the diversity indexes and share of young and share of highly educated workers.

4.2 Identification

One may argue that the relationship between firm performance and diversity could be affected by simultaneity or even endogeneity. The latter issue might arise because there could be unobserved firm specific factors influencing both TFP and labour diversity. For instance, successful firms might be aware of the beneficial effects associated with a diversified workforce and thus implement recruitment strategies aimed at this purpose. For example it is generally known that MNE and exporting firms tend to be doing well in terms of TFP. Those firms especially may look for more diverse workforce in order to cope with needs for information on different customers and product requirements, and different markets[6]. Also certain workers may self-select into certain well-performing firms, and so the firm diversity level may be driven by firm productivity rather than the other way around[7].

To address these concerns we follow an instrumental variable (IV henceforth) approach. A good instrument for our labour diversity indexes should be correlated with the indexes, but be uncorrelated with the firm outcome variable, i.e. TFP. We consider two instrumental variable strategies: (1) the first one uses an index of labour diversity measured at the commuting area level, in which a given workplace operates, as an instrument for workplace diversity index in the TFP equation [8]; (2) the second one

[6]In line with Osborne (2000) labour diversity can provide useful information to the firm about products and shipping markets.

[7]However, regarding the latter, it is less likely in our case that endogeneity would be determined by selection of highly skilled or more productive workers. If this would be a case, we could in fact observe more segregation rather than heterogeneity in a firm labour force composition. Moreover, the data show that the diversity indexes do not vary much over time, so it seems that there is no systematic selection mechanism. The tables with variation in indexes over the time are available from the authors upon a request.

[8]Since firm diversity is computed as weighted average of the workplace diversity measures, the

employs the second and third lag of labour diversity indexes of the same firm as an instrument for current firm workforce diversity index. [9]

Whereas the latter instrument in the form of lags is widely adopted and appears quite straightforward (they are well suited to proxy the actual firm diversity), we spend some words to motivate the use of the first type of instrument. We think that diversity at the commuting area level presents a suitable supply driven instrument for workplace level diversity because (except for Copenhagen) counties in Denmark are typically rather thin in terms of population. That may imply that firms usually recruit workers from a given local supply of labour, which is characterized by a certain degree of heterogeneity. This argument is further reinforced by the role of networks in employment process (Montgomery, 1991, Munshi 2003). Thus firms placed in regions with a high labour diversity are also more likely to employ more diverse workforce. In the context of Denmark, where residential mobility rates are low, our assumption that the labour supply at the county level is given is rather appropriate (Deding and Filges, 2009)[10].

5 Results

In the following section, we provide results from our analyses, which exploit the cross-sectional and longitudinal dimensions of our data to investigate how diversity in nationality, skills and demographic characteristics is associated with the variation in TFP and patenting activity at firm level.

instrument here is a weighted average of diversity measures related to the counties, where workplaces are located.

[9]The first lag is not included because it could be still considered as endogenous, given the high persistence of the diversity indexes.

[10]Further one may point towards potentially endogenous location behaviour of immigrants. Validity of our instrument may be reinforced by the spatial dispersion policy implemented for immigrants between 1986 and 1998 by the Danish authorities. The dispersal policy implied that new refugees were randomly distributed across locations in Denmark, see e.g. Damm A.P. (2009).

5.1 Effect of diversity on firm total factor productivity

As mentioned in the section above, measures of TFP are computed as residuals from the first step estimation, in which the firm value added is regressed on capital and labour stocks (all taken in logs), and a number of control variables. Table 4 reports coefficients to the OLS and LP estimates of the main elasticities for each 2-digit industry.[11] Looking across columns and different industries it is clear that coefficients estimated by LP approach are generally lower than those estimated by the OLS. This is in line with the concern discussed in the previous section on the biasness of the OLS approach in the production function estimation: parameters appear generally upward biased especially for the capital stock. That induces us to retain (for the second step) solely the TFP measures obtained from the LP approach.

[Insert Table 4 around here]

We now turn to the results from the second step of LP procedure, which are shown in Table 5. To make sure that the coefficients to the diversity indexes do not reflect effects coming from firm workforce composition or nature of ownership, we add controls for firm ownerhisp, firm age and share of middle managers and managers, share of foreigners, shares of high and medium educated workers, share of males and four age categories into our model. In addition, all specifications include industry, year, firm size and regional dummies to capture macroeconomic, industrial or geographical fluctuations[12].

[Insert Table 5 around here]

[11] The level of industrial (dis)aggregation may affect both size and standard deviation of the residuals. Whereas a narrower aggregation may better group similar production technologies, a lower number of observations per industry could hurt the asymptotic properties of the estimators.

[12] As the firms' workforce diversity does not vary over time within a given firm (development of firm' labour diversity indexes over time are available from authors upon request), we prefer to not use the FE estimator in the second step LP approach as adding firm specific fixed effects tends to "eat" the effect of the firms' workforce diversity.

The first two columns of Table 5 show results from our model without and with our three diversity indexes, respectively. Adding the diversity indexes into the model increases the explanatory power (R2) from 62 per cent to 64 per cent, so it does not add much in terms of explanatory power, but the contribution is not unimportant. Focusing on our variables of interest, the results show that all of the diversity indexes attach significantly positive coefficients. What's more, their parameters are relatively large, significant and robust across the different model specifications in Table 5. Thus we find a positive effect of all three firm workforce diversity dimensions on firms' TFP. This is consistent both with the notion on discrimination (Becker 1957) and with the theory on knowledge spillovers, creativity and problem solving abilities (Hong and Page (1998 and 2001), Berliant and Fujita (2004), Alesina and La Ferrara (2005)). Our results show that negative effects (if any) coming from communication and integration costs connected to more diverse workforce are outweighed by the positive effect of diversity on firm TFP coming from creativity and knowledge spillovers and lower wage costs in firms with higher workforce diversity due to possible existence of discrimination on the Danish labour market.

In column (3) Table 5 all possible interaction couples between the diversity indexes are included, whilst in columns (4) and (5) the diversity indexes are multiplied with the share of highly skilled and younger workers, respectively. As described in the previous section we might expect that there might be greater knowledge spillovers and creativity coming from an interaction of young workers and more diverse workforce in other dimensions. In particular young workers possess more up-to-date IT, software and other technology knowledge. Together with more diverse workforce can stimulate innovation and creativity through technology knowledge transfers and cause spillover effects. Young workers can also better deal with cultural and linguistic differences; they have higher willingness to learn and are more flexible compared to older workers. We would also expect that the more educated is a firm workforce, the more flexible

are workers in sharing their knowledge and in coping with more diverse workforce in the firm. It turns out that indeed a higher share of younger workers may considerably strengthen the positive impact of diversity on firm productivity (column 5, Table 5). Instead, an increase in demographic diversity, and ethnic diversity, given a certain level of skill heterogeneity (or vice versa) slightly reduces the total benefit from such sources of labour diversity (column 4). Details concerning the decreasing or increasing behaviour of the cited interactions are depicted in Figure 1, 2 and 3.

[Insert Figure 1, 2 and 3 around here]

As described above, we pursue an IV approach in order to address potential simultaneity and endogeneity of diversity indexes in our analyses. We consider two instrumental variable strategies, which are explained in detail in the subsection above devoted to identification issues. The first IV strategy uses a supply-driven instrument for firm diversity index in the form of county level diversity index. The second IV strategy takes into account the second and third lag of the firm labour diversity indexes. The results from both IV analyses are presented in Table 5, column 6 and 7, respectively. Besides the economic motivation for the instruments presented in the section above, their statistical validity is largely confirmed by both F and Hansen tests, see the notes under the Table 5. As seen from the columns 6 and 7 in Table 5 estimations adopting both types of IV strategies yield very similar results and thus support the economic implications associated with previous findings suspected to be affected by simultaneity or endogeneity.

To sum up, these findings of positive effects of heterogeneity in ethnicity, skills and education and demographic characteristics on firm TFP are somewhat consistent with the notion of discriminatory behaviour in hiring of firms (Becker,(1957)) and that the positive effect knowledge spillovers prevail over costs of having a diverse workforce. It might be that modern management techniques, e.g. related to diversity management,

and firm integration policies that emerged in recent years helped firms to counteract some initial costs of diversity and turn the diversity into the overall competitive advantage. As seen from the interactions of diversity indexes with share of young workers (Table 5, column 6) the presence of junior workers may stimulate seniors to implement innovative approaches and new technology that young workers bring along to firms.

Robustness tests of the production function results

Next as a part of robustness analyses we examine whether the labour diversity indexes differ between different categories of firms. First, we look at whether there are any differences in the effect of diversity on TFP across different industries. This is motivated by expectation that the positive labour diversity effects on firm' TFP may have different magnitude (or even negative effects) for less "creative" industries. The results are shown in Table 6. We observe that there is indeed some heterogeneity among the coefficients to our diversity indexes across different industries - although for most of industries the coefficients are relatively robust and close to the aggregate results. However one industry, the wholesale and retail trade, stands out above all. Explicitly, the coefficient to the ethnic diversity index is much higher than in other industries, whether the coefficient to the skill diversity turned its sign and it is significantly negative in comparison to other industries that follow the general pattern found in aggregated analyses[13].

Then we divide firms by size and run the TFP functions to see whether there are any differences in coefficients to diversity for smaller firms with less than 50 employees and medium and large firms with more than 50 employees. We would expect that the positive effect of diversity could be larger in bigger firms as their organizational and management structures and practises are well established, and thus are more likely to introduce policies that help to counteract the potential costs associated with the

[13]This industry is the typical industry, where immigrants tend to work , in Denmark approximately 20 % of all immigrants works in wholesale and retail; it is also industry with very high of small one-man businesses (which is also visible from the high number of observations).

diversity, e.g. introduction of the same "professional" language, diversity management and film-level integration practises. Nevertheless as the results in Table 6 show, we do not find support to our hypothesis, there is no difference with respect to coefficients to ethnic diversity index between smaller and larger firms and small differences with respect to skill and demographic diversity, with coefficients slightly larger for smaller firms, which is the opposite of what we would expect.

Further, we look at differences with respect to type of ownership and we distinguish between domestic and foreign firms in Denmark. There are no significant differences between the coefficients to demographic and ethnic diversity, whether the coefficient to skill diversity loses its significance, see Table 6.

After that we wanted to test whether our results are not influenced by Shannon entropy index as our choice for diversity measure. Thus as a part of robustness checks we used an alternative measure of diversity, Herfindhal index, which is often used in previous studies on labour diversity or segregation The results (Table 6) show that all three labour diversity dimensions as represented by the Herfindahl index attach similarly to the Shannon entropy index statistically significant positive coefficients.

Finally we run robustness checks by TFP quintiles, which show that the most successful firms in terms of TFP benefit most from the demographic and ethnic diversity, whether the coefficient to skill diversity seems to be largest for firms belonging to the lowest TFP quartile.

[Insert Table 6 around here]

6 Conclusions and Policy Implications

Using a comprehensive linked employer-employee dataset, this paper investigates the effect of firm labour diversity in ethnic-cultural, skill and demographic characteristics

on productivity and patenting activity of firms in Denmark. Contrary to majority of previous empirical works, which focused on single aspects of labour diversity, we provide a number of findings that may concretely address as a whole the consequences of firm workforce heterogeneity on firm performance.

For our analyses we use an index of diversity borrowed from biology, based on the Shannon's entropy index, to measure extensively the three above mentioned diversity dimensions. Regarding methodology we follow the LP approach to deal with measurement errors, simultaneity and endogeneity problems in the computation of firm TFP. In our patent production function analyses we introduce pre-sample estimators to proxy unobserved time invariant firm characteristics and reduce the bias caused by zero inflation and trend in the count of patent applications. In addition, exploiting respectively longitudinal and geographical dimensions of our data, we employ two different types of IV strategies to cope with potential simultaneity and endogeneity concerning the diversity indexes.

Controlling for a wide set of firm specific characteristics and applying different estimation techniques, we find that diversity in ethnicity, skills and demographics enhances significantly firm TFP. The result is very robust across all the different model specifications and estimation strategies. This is consistent both with the notion on discrimination (Becker, (1957) and with the theory on knowledge spillovers, creativity and problem solving abilities (Hong and Page (1998 and 2001), Berliant and Fujita (2004), Alesina and La Ferrara (2005)). Our results show that negative effects (if any) coming from communication and integration costs connected to more diverse workforce are outweighed by the positive effect of diversity on firm TFP coming from creativity and knowledge spillovers and lower wage costs in firms with higher workforce diversity due to possible existence of discrimination on the Danish labour market. It also emerges that the presence of a higher number of younger employees increases the gains from

diversity in terms of firm productivity. Young workers are more likely to possess new technology knowledge and be better in interacting with cultural and linguistic differences (Lazear (1998 and 1999). Together with more diverse workforce young workers can stimulate innovation, creativity and knowledge spillovers.

To conclude, our main finding is that there is a positive effect of diversity in all three dimensions, in nationality, skills and demographics, on firm TFP. In the TFP analysis adding the diversity indexes does not add much in terms of explanatory power of models, but the contribution is not unimportant. What's more, the coefficients to the diversity indexes show that firm workforce diversity is either positively associated with firm performance or there is no significant relationship between diversity and firm performance. Thus, we do not find any significant negative relationship between firm diversity and firm performance in any of the model specifications. This allows us to draw a conclusion that governmental policies actively promoting greater equality will not bring any detrimental effects on businesses in terms of firm performance, on the contrary, they may be beneficial to firms and their performance.

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Measurement of Ethnic Diversity

The citizens in the different nationality groups are: **Danish**, Danish native excluding second generation immigrants; **North America and Oceania**, United States, Canada, Australia, New Zealand; **Central and South America**, Guatemala, Belize, Costa Rica, Honduras, Panama, El Salvador, Nicaragua, Venezuela, Ecuador, Peru, Bolivia, Chile, Argentina, Brazil; **Formerly Communist Countries**, Armenia, Belarus, Estonia, Georgia, Latvia, Lithuania, Moldova, Russia, Tajikistan, Ukraine, Bulgaria, Czech Republic, Hungary, Poland, Romania, Slovakia, Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Rep. of Macedonia, Montenegro, Serbia, and Slovenia; **Muslim Countries**, Afghanistan, Algeria, Arab Emirates, Azerbaijan, Bahrain, Bangladesh, Brunei Darussalem, Burkina Faso, Camoros, Chad, Djibouti, Egypt, Eritrea, Gambia, Guinea, Indonesia, Iran, Iraq, Jordan, Kazakstan, Kirgizstan, Kuwait, Lebanon, Libyan Arab Jamahiriya, Malaysia, Maldives, Mali, Mauritania, Morocco, Nigeria, Oman, Pakistan, Palestine, Qatar, Saudi Arabia, Senegal, Sierra Leone, Somalia, Sudan, Syria, Tadzhikstan, Tunisia, Turkey, Turkmenistan, Uzbekistan, Yemen; **East Asia**, China, Hong Kong, Japan, Korea, Korea Dem. People's Rep. Of, Macao, Mongolia, Taiwan; **Asia** all the other Asian countries non included in both East Asia and Muslim Countries categories and **Africa** all the other African countries not included in the Muslim Country; **West and South Europe**, all the other European countries not included in the Formerly Communist Countries. category.

Table 1: Descriptive statistics

Variables	Definition	Mean	Median	Sd	N
IDA Variables:					
males	men as a proportion of all employees	0.709	0.783	0.237	88478
foreigners	non-danish emloyees as a proportion of all emloyees	0.048	0.022	0.091	88478
age1	employees aged 15-28 as a proportion of all employees	0.232	0.105	0.250	88478
age2	employees aged 29-36 as a proportion of all employees	0.263	0.262	0.129	88478
age3	employees aged 37-47 as a proportion of all employees	0.253	0.250	0.126	88478
age4	employees aged 47-65 as a proportion of all employees	0.252	0.178	0.150	88478
skill1	employees with compulsory education as a proportion of all employees	0.272	0.164	0.128	88478
skill2	employees with a secondary/ post-secondary vocational education as a proportion of all employees	0.685	0.750	0.326	88478
skill3	employees with a tertiary education as a proportion of all employees	0.043	0.000	0.100	88478
tenure	average tenure	4.531	4.403	1.831	88478
manager	managers as a proportion of all employees	0.022	0.000	0.043	88478
middle manager	middle managers as a proportion of all employees	0.411	0.319	0.416	88478
bluecoll	blue collars as a proportion of all employees	0.567	1.000	0.348	88478
size1	total number of employees (less than 50)	0.733	1.000	0.442	88478
size2	total number of employees (50-100)	0.136	0.000	0.343	88478
size3	total number of employees (more than 100)	0.131	0.000	0.338	88478
Index-fore	Diversity index based on employees' nationality	1.192	1.042	0.360	88478
Index-skill	Diversity index based on employees' skills	1.750	1.772	0.453	88478
Index-demo	Diversity index based on employees' demographic characteristics	3.746	3.794	1.361	88478
Accounting Variables:					
value added	(1000 kr.)	34891.84	10792.59	197860.4	88478
materials	(1000 kr.)	90729.84	18894.45	662175	88478
capital	(1000 kr.)	107911.9	16889.7	1301386	88478
foreign-ownership	1, if the firm is foreign owned	0.004	0	0.0602	88478
multi	1, if the firm is multi-establishment	0.262	0	0.4397	88478

Notes: All IDA and Accounting variables are expressed as time averages from 1995 to 2005. The industrial sectors included in the empirical analysis are the following: food, beverages and tobacco (4.05 %); textiles (2 %), wood products (6.19 %), chemicals (3.95 %), other non-metallic mineral products (1.94 %), basic metals (18.95 %), furniture (3.46 %), construction (15.07 %), sale and repair of motor vehicles (3.64 %), wholesale trade (14.67 %), retail trade (6.06 %), hotels and restaurants (2.08 %), transport (6.12 %), post and telecommunications (0.40 %), financial intermediation (1.17 %) and business activities (10.25 %).

Table 2: Within firm, industry and county descriptive statistics of diversity indexes.

Index	**Mean**	**Median**	**Min**	**Max**	**Sd**
	within firms, between workplaces				
Index-fore	1.087	1.087	1	7.543	0.278
Index-skill	1.435	1.435	1	5.742	0.520
Index-demo	2.191	2.191	1	8.000	1.314
	within industries, between firms				
Index-fore	1.211	1.094	1	7.223	0.330
Index-skill	1.782	1.813	1	5.131	0.404
Index-demo	3.815	3.938	1	7.637	1.356

Table 3: Descriptive statistics of diversity indexes by industry, size and year.

	Manufacturing	**Wholesale and retail trade**	**Construction**	**Transport**	**Financial and business services**	**Others**
Index_fore	1.233	1.123	1.219	1.081	1.294	1.406
Index_skill	1.819	1.614	1.823	1.575	2.082	1.766
Index_demo	4.143	3.508	3.387	3.443	3.748	3.403
N	32870	23337	5287	14316	8932	3736
	Small size	**Middle size**	**Big size**	**1995**	**1999**	**2005**
Index_fore	1.183	1.233	1.200	1.135	1.184	1.238
Index_skill	1.753	1.797	1.689	1.735	1.752	1.782
Index_demo	3.821	3.798	3.270	4.087	3.752	3.723
N	64841	12033	11604	5421	8811	11420

Table 4: Coefficients of the production function, Levinsohn and Petrin approach.

Industry	**Labour**	**Capital**
Food and beverage (15009)	0.515	0.177
Textile and leather (17009)	0.626	0.437
Wood (20000)	0.583	0.487
Paper and printing (21009)	0.617	0.311
Chemicals (24000)	0.523	0.659
Rubber and plastics (25000)	0.571	0.056
Stone, clay and glass (26000)	0.421	0.336
Manufacture of basic metals (27009)	0.661	0.291
Machinery and equipment (29000)	0.636	0.345
Electronics (30009)	0.574	0.294
Transport (35009)	0.641	0.231
Furniture (36000)	0.608	0.306
Construction (45000)	0.676	0.211
Trade in cars, service stations (50000)	0.647	0.361
Wholesale and commission trade (51000)	0.611	0.196
Retail sale (52109)	0.401	0.265
Re. sale of phar. goods, cosmetic art. (52300)	0.421	0.265
Re. sale of clothing, footwear (52419)	0.343	0.141
Retail, repair services (52449)	0.626	0.483
Hotels and restaurants (55000)	0.6	0.105
Land and air transport (60000)	0.567	0.2
Shipping (61000)	0.326	0.591
Supporting transport activities (63000)	0.621	0.376
Post and telecommunications (64000)	0.72	0.08
Finance (65000)	0.55	0.255
Real estate activities (70000)	0.494	0.378
Business activities (72000)	0.711	0.276
Research and development (73000)	0.889	0.021
Consultancy activities (74000)	0.671	0.142

Table 5: The effects of labour diversity on firm productivity, main results.

	1	2	3	4	5	6	7	8
Diversity Indexes:								
Index_fore	0.010	0.010	0.014	0.019		0.007	0.032	0.079
	(0.012)	(0.022)	(0.022)	(0.018)		(0.023)	(0.041)	(0.050)
Index_skill	0.027**	0.027**	0.028**	0.014*		0.027**	0.086**	0.050*
	(0.012)	(0.013)	(0.013)	(0.010)		(0.012)	(0.041)	(0.027)
Index_demo	0.002	0.005*	0.007*	0.008**		0.012**	0.001	0.002
	(0.003)	(0.003)	(0.004)	(0.002)		(0.006)	(0.044)	(0.005)
Low (Index_fore)					0.006			
					(0.011)			
Average (Index_fore)					0.002			
					(0.005)			
High (Index_fore)					–0.005			
					(0.007)			
Low (Index_skill)					0.009*			
					(0.005)			
Average (Index_skill)					0.011*			
					(0.007)			
High (Index_skill)					0.016*			
					(0.008)			
Low (Index_demo)					0.012**			
					(0.004)			
Average (Index_demo)					0.021**			
					(0.005)			
High (Index_demo)					0.021**			
					(0.007)			
Index_fore(t-1)						0.026**		
						(0.011)		
Index_skill(t-1)						–0.007		
						(0.010)		
Index_demo(t-1)						–0.005*		
						(0.003)		
Firm specific characteristics:								
middle manager		0.041**	0.043**	0.008	0.009	0.012	0.009	0.021
		(0.015)	(0.015)	(0.011)	(0.011)	(0.013)	(0.013)	(0.026)
manager		0.175***	0.175***	0.118***	0.118***	0.108**	0.128***	0.112**
		(0.043)	(0.043)	(0.030)	(0.030)	(0.036)	(0.032)	(0.055)
tenure		0.016***	0.015***	0.012***	0.012***	0.009***	0.010***	0.008***
		(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
skill1		0.198***	0.185***	0.087***	0.087***	0.110***	0.085***	0.147***
		(0.030)	(0.029)	(0.021)	(0.021)	(0.024)	(0.024)	(0.036)
skill2		0.383***	0.345***	0.262***	0.279***	0.340***	0.192**	0.372**
		(0.099)	(0.099)	(0.073)	(0.071)	(0.089)	(0.088)	(0.152)
age1		–0.093**	–0.084**	–0.161***	–0.160***	–0.209***	–0.144***	–0.184***
		(0.030)	(0.030)	(0.022)	(0.022)	(0.025)	(0.023)	(0.034)
age2		0.051*	0.056*	0.007	0.007	–0.024	–0.004	–0.004
		(0.028)	(0.028)	(0.020)	(0.020)	(0.022)	(0.021)	(0.031)
age3		0.080**	0.082***	0.027*	0.027*	0.011	0.028*	0.002
		(0.024)	(0.024)	(0.018)	(0.018)	(0.020)	(0.018)	(0.028)
males		0.123***	0.118***	0.118***	0.121***	0.147***	0.082**	0.235***
		(0.036)	(0.036)	(0.025)	(0.025)	(0.030)	(0.025)	(0.040)
foreigners		–0.039	–0.042	-0.032	-0.128*	–0.005	–0.052	–0.377*
		(0.121)	(0.121)	(0.096)	(0.067)	(0.122)	(0.106)	(0.204)
foreign_ownership			0.377**	0.380**	0.375**	dropped	0.350**	0.350**
			(0.189)	(0.185)	(0.187)		(0.185)	(0.185)
multi			0.026**	0.004	0.003	0.008	0.004	0.004
			(0.012)	(0.008)	(0.008)	(0.009)	(0.008)	(0.008)
R2	0.01	0.02	0.02	0.51	0.51	0.51	0.52	0.52
N	88691	88691	88691	88691	88691	67374	67454	38123

Notes: The dependent variable in all estimations is the productivity estimated from the LP approach. All regressions include year, size and three-digit industry dummies. Significance levels: ***1%, **5%, *10%. Columns (1)-(6) show results from the FE method. Column (7): Diversity indexes at firm level instrumented with the indexes calculated at commuting area level. The sample includes only firms which have not changed their location over the period 1990-2005. Standard errors clustered at the commuting areas level. F-stats on excluded instruments: i) Index_fore at county level: ; ii) Index_skill at county level: ; iii) Index_demo at county level: F-stats on excluded instruments: i) Index_fore at communting area level: 5505; ii) Index_skill at commuting area level: 2905; iii) Index_demo at commuting area level: 1805. Column (8): Diversity indexes at firm level instrumented with the second and the third lag of the indexes. F-stats on excluded instruments: i) Lags of Index_fore: 11735.95; ii) Lags of Index_skill: 14140.62 ; iii) Lags of Index_demo: 1663.64.

Table 6: Robustness checks on the effects of diversity on productivity: estimates by industry.

	Estimates by industry					
	Manufacturing	**Other**	**Construction**	**Wholesale and retail trade**	**Transport**	**Financial and business services**
Diversity Indexes:						
Index_fore	–0.024	0.004	–0.052	–0.022	–0.046	0.082**
	(0.028)	(0.030)	(0.073)	(0.040)	(0.041)	(0.025)
Index_skill	0.061***	0.060*	0.008	0.058**	0.001	0.039**
	(0.017)	(0.039)	(0.019)	(0.020)	(0.038)	(0.018)
Index_demo	0.004	–0.009	0.012**	0.003	0.035***	0.015*
	(0.004)	(0.012)	(0.005)	(0.005)	(0.010)	(0.008)
R2	0.29	0.05	0.03	0.01	0.02	0.08
N	33056	3731	14393	23372	5311	8828

Notes: All regressions include all the firm specific characteristics, year and two-digit industry dummies. Estimated standard errors are shown in parentheses. Significance levels: ***1%, **5%, *10%.

Table 7: Robustness checks on the effects of diversity on productivity: estimates by size and TFP quartile and using the Herfindhal index.

	Estimates by size		**Estimates by quartiles**				**Herfindhal**
	Less than 50	**More than 50**	**q(25)**	**q(50)**	**q(75)**	**q(90)**	
Diversity Indexes:							
Index_fore	–0.030*	0.047*	–0.044	–0.013	–0.017*	0.049***	0.028
	(0.017)	(0.035)	(0.039)	(0.016)	(0.011)	(0.013)	(0.029)
Index_skill	0.008	0.039*	0.037**	–0.003	–0.003	0.014**	0.002
	(0.010)	(0.027)	(0.017)	(0.008)	(0.007)	(0.010)	(0.013)
Index_demo	0.007**	0.007	0.005	–0.000	0.005**	0.016***	0.003
	(0.003)	(0.008)	(0.005)	(0.002)	(0.002)	(0.003)	(0.022)
R2	0.14	0.23	0.09	0.02	0.02	0.10	0.51
N	65032	23659	22173	22173	22173	22172	88691

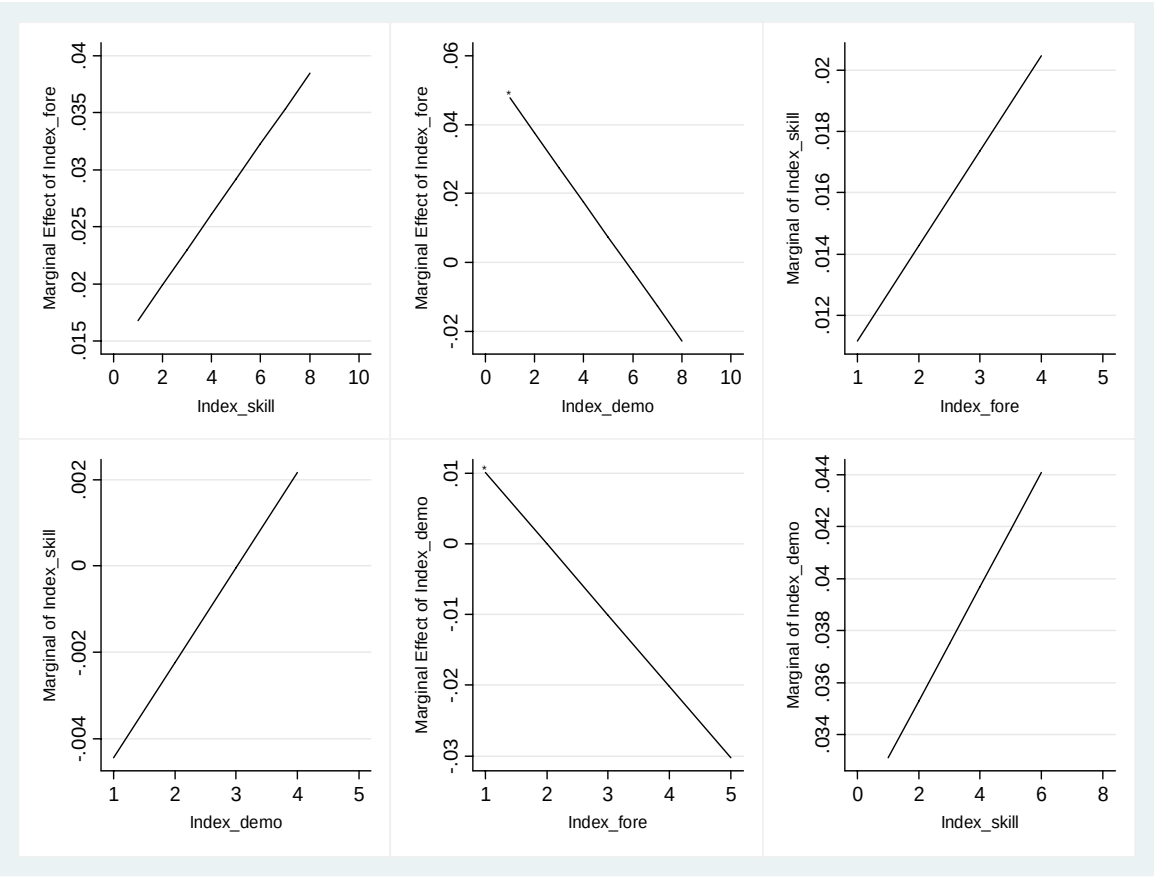
Notes: All regressions include all the firm specific characteristics, year and two-digit industry dummies. Estimated standard errors are shown in parentheses. Significance levels: ***1%, **5%, *10%.

Table 8: Robustness checks on the effects of diversity on productivity: estimates using occupational level diversity.

	Estimates using the occupational level diversity		
	Manager	**Middle manager**	**Blue collar/hourly paid workers**
Diversity Indexes:			
Index_fore	–0.018	–0.003	–0.006
	(0.014)	(0.024)	(0.014)
Index_skill	0.006*	0.055**	0.006
	(0.003)	(0.019)	(0.011)
Index_demo	–0.002	–0.014*	0.000
	(0.003)	(0.010)	(0.006)
R2	0.51	0.51	0.51
N	88691	88691	88691

Notes: All regressions include all the firm specific characteristics, year, size and three-digit industry dummies. Estimated standard errors are shown in parentheses. Significance levels: ***1%, **5%, *10%.

Figure 1: Marginal Effects of all indexes, cross interactions, OLS estimates.



Notes: * indicates significance at the 95 % level; the excluded index is always at the 50th percentile of the index distribution.

Figure 2: Industry average TFP over time.

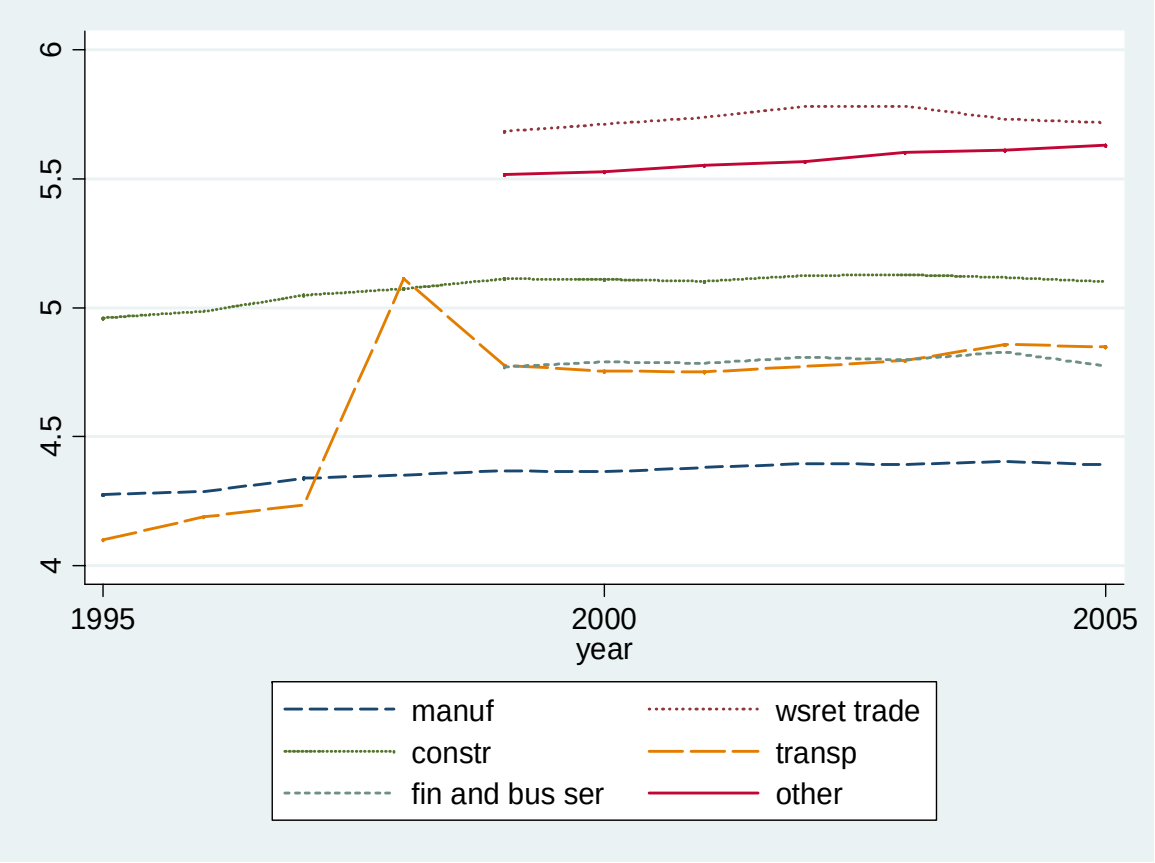
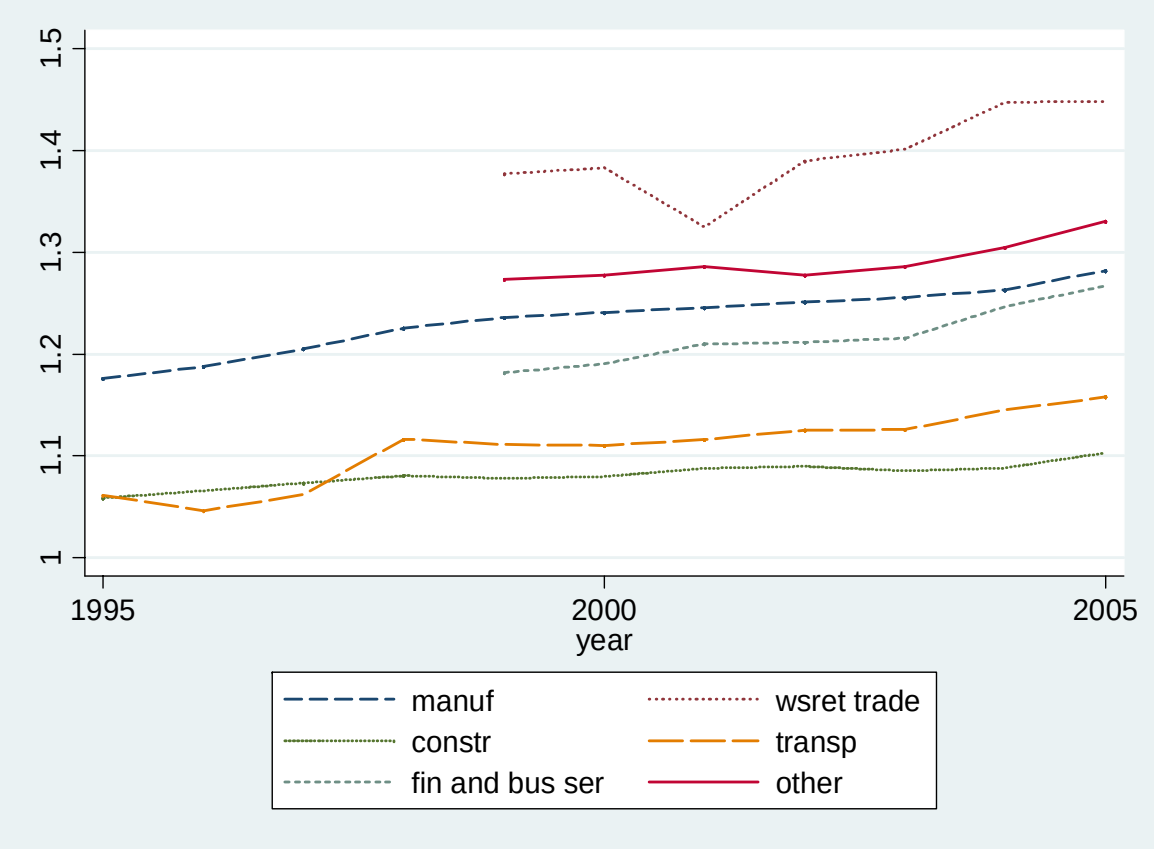
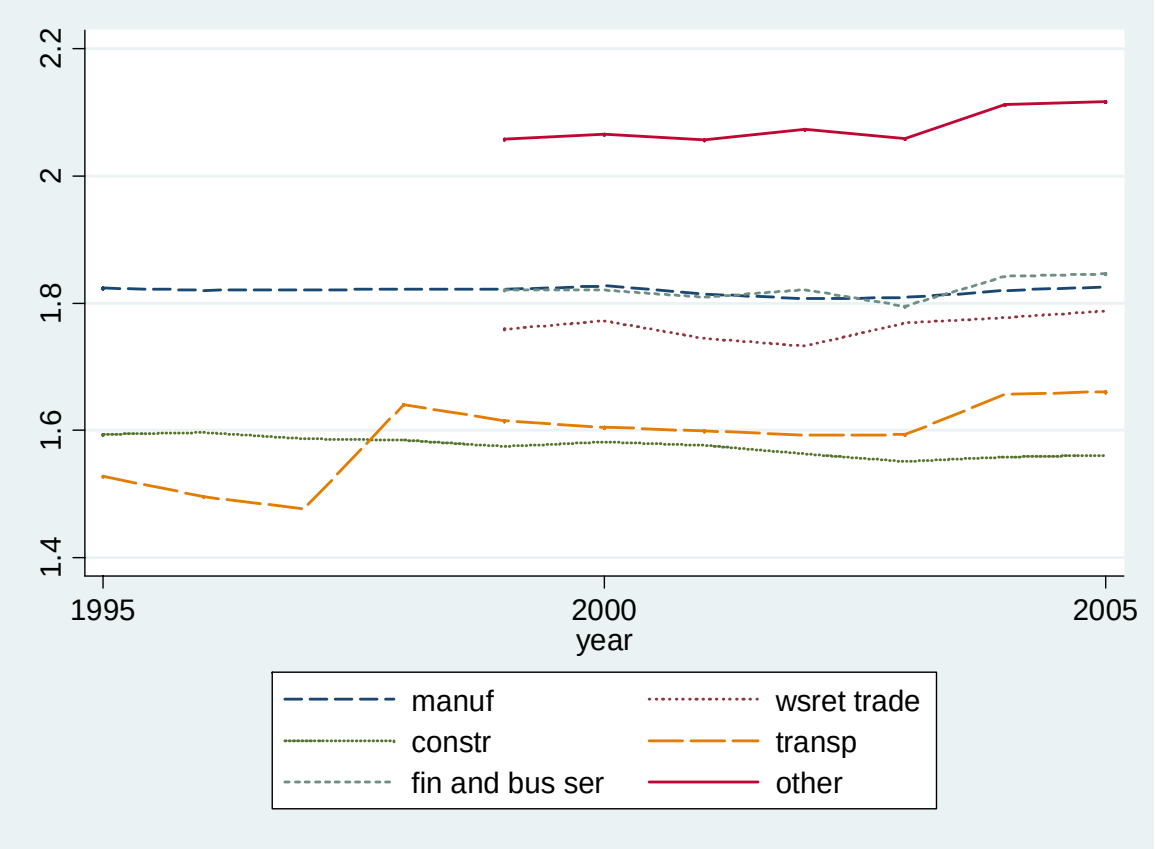


Figure 3: Industry average ethnic diversity over time.



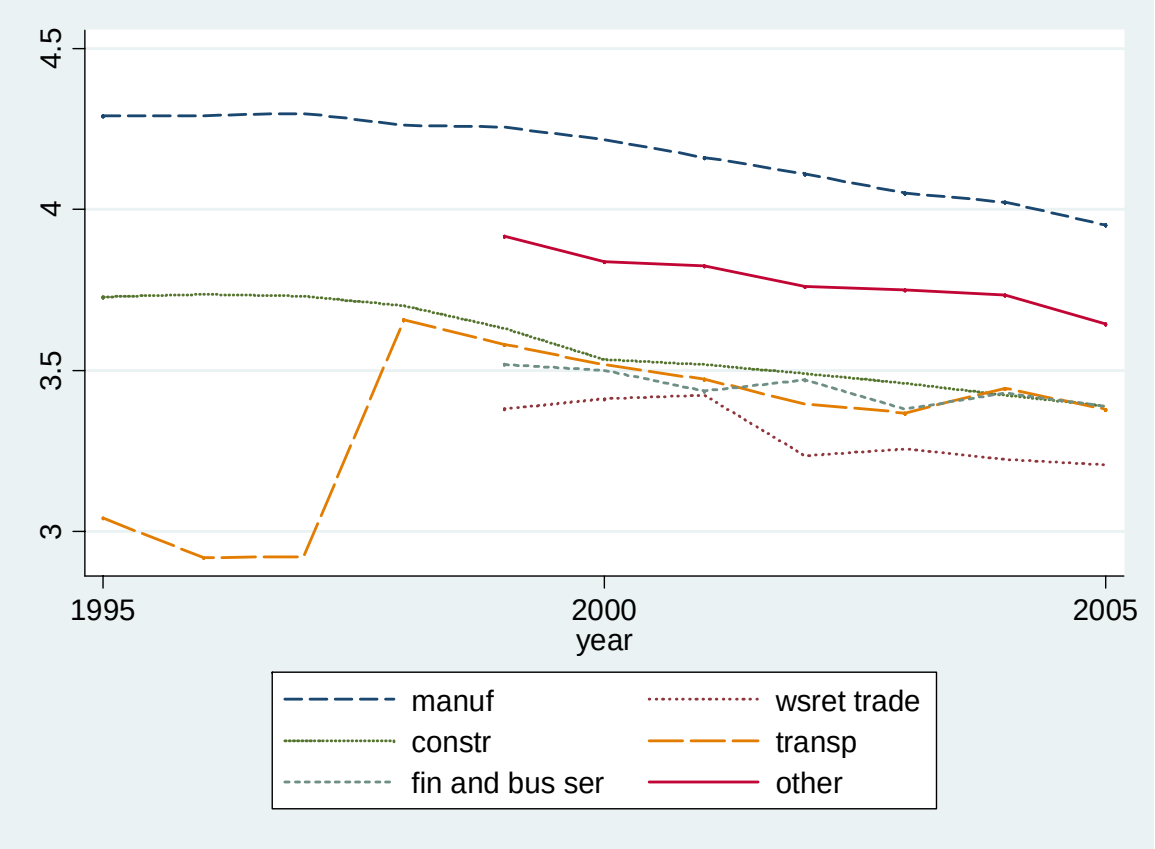
Notes: "manuf" includes: food, beverages and tobacco, textiles, wood products, chemicals, other non-metallic mineral products, basic metals, furniture; "wsret trade" includes: wholesale trade, retail trade; "constr" includes: construction; "transp" includes: transport; "fin and bus ser" includes: financial intermediation and business activities; other includes: sale and repair of motor vehicles, hotels and restaurants and post and telecommunications.

Figure 4: Industry average skill diversity over time.



Notes: "manuf" includes: food, beverages and tobacco, textiles, wood products, chemicals, other non-metallic mineral products, basic metals, furniture; "wsret trade" includes: wholesale trade, retail trade; "constr" includes: construction; "transp" includes: transport; "fin and bus ser" includes: financial intermediation and business activities; other includes: sale and repair of motor vehicles, hotels and restaurants and post and telecommunications.

Figure 5: Industry average demographic diversity over time.



Notes: "manuf" includes: food, beverages and tobacco, textiles, wood products, chemicals, other non-metallic mineral products, basic metals, furniture; "wsret trade" includes: wholesale trade, retail trade; "constr" includes: construction; "transp" includes: transport; "fin and bus ser" includes: financial intermediation and business activities; other includes: sale and repair of motor vehicles, hotels and restaurants and post and telecommunications.

Figure 6: Scatter plots of industry average TFP against workforce diversity.

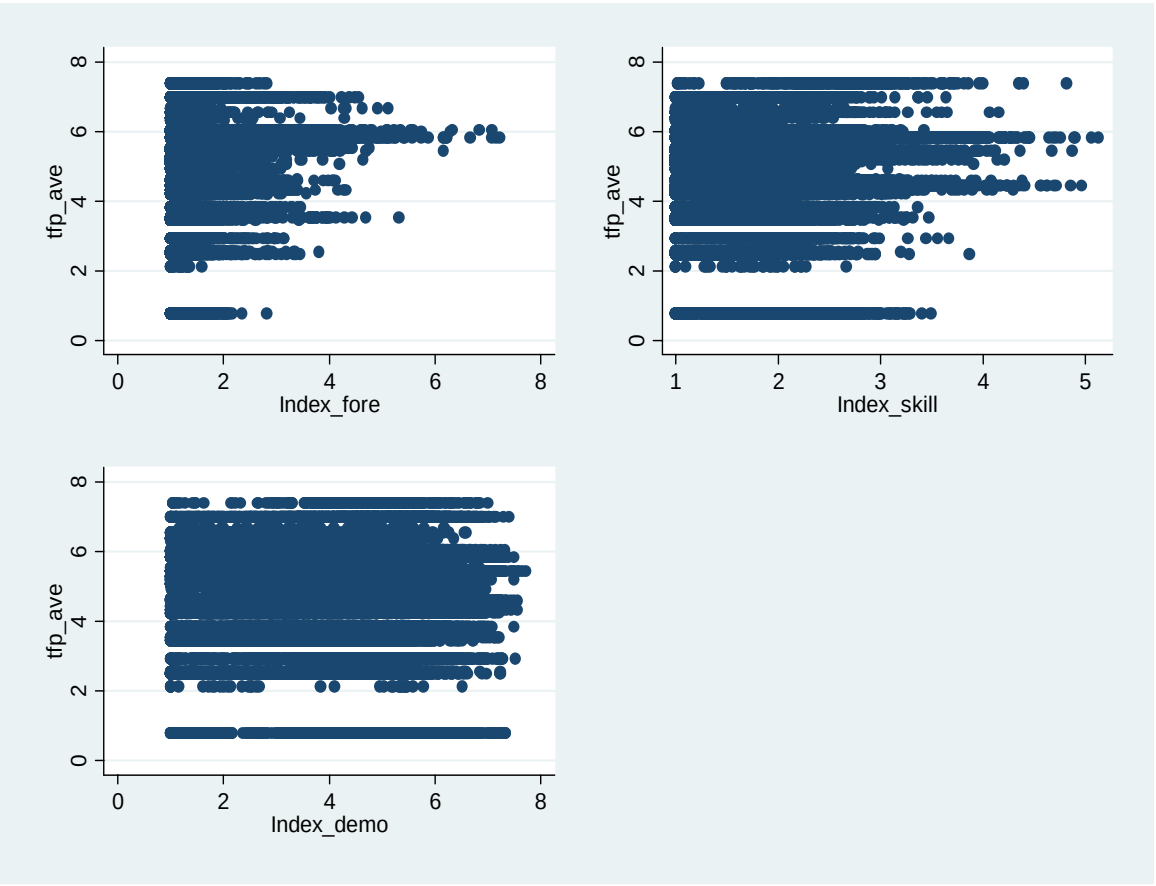


Figure 7: Kernel densities of TFP by workforce diversity.

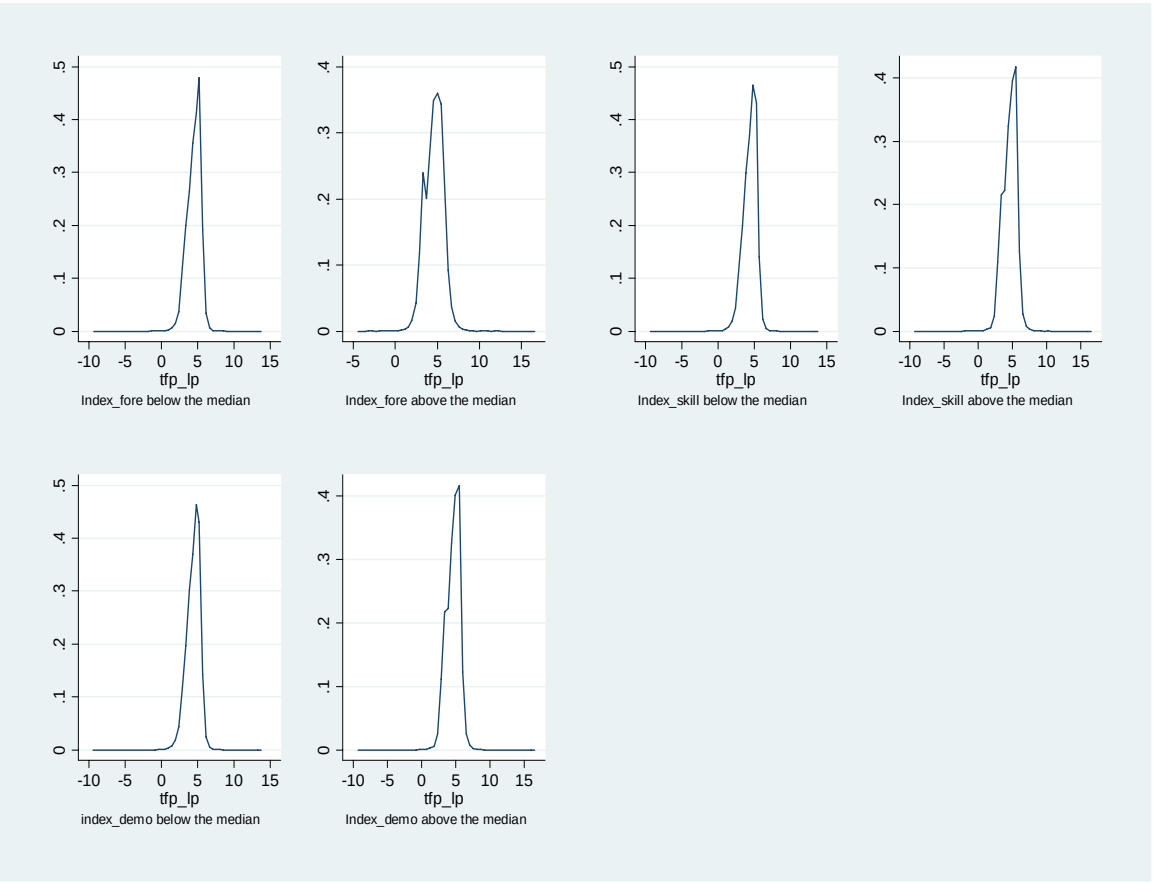
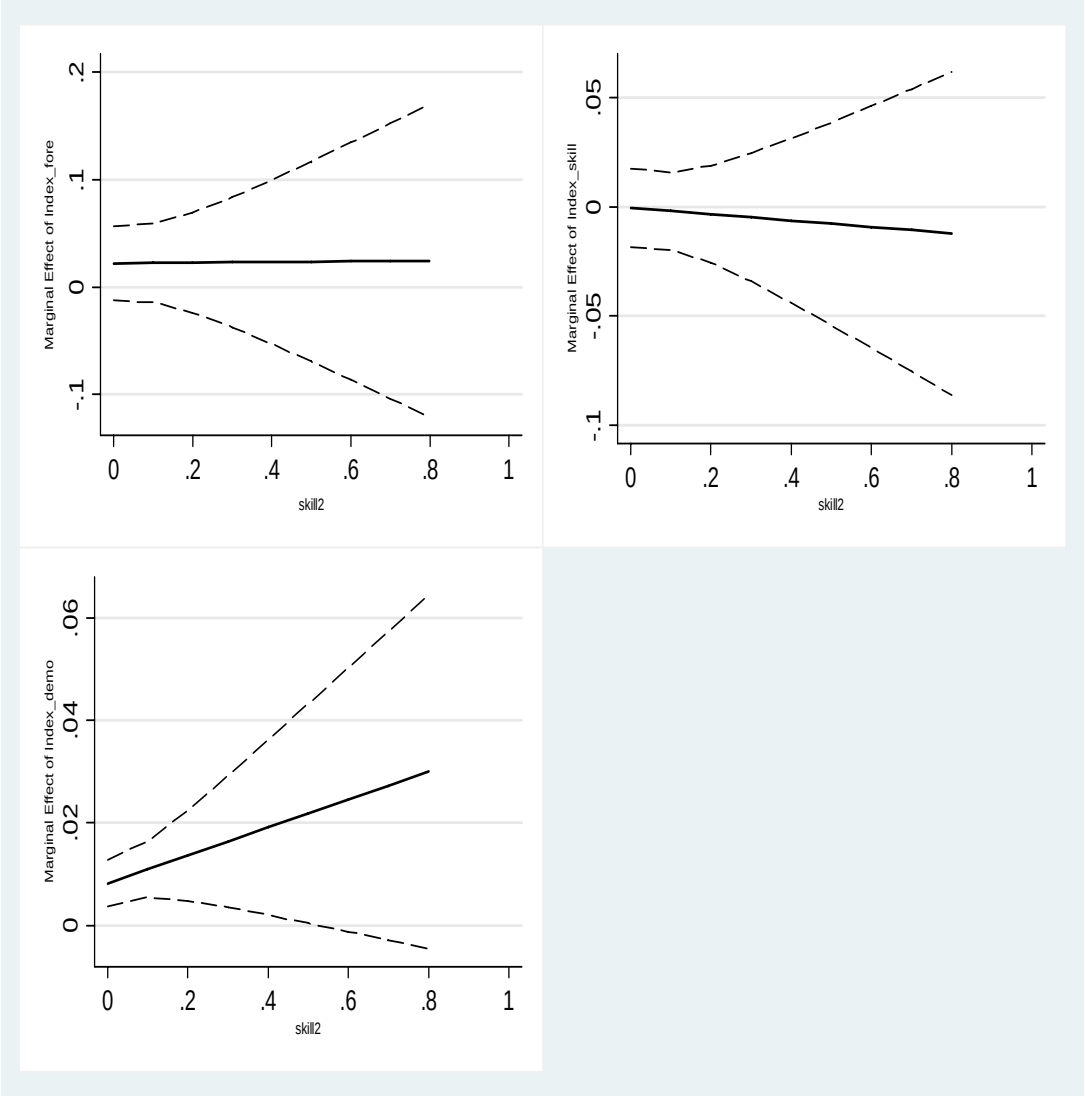
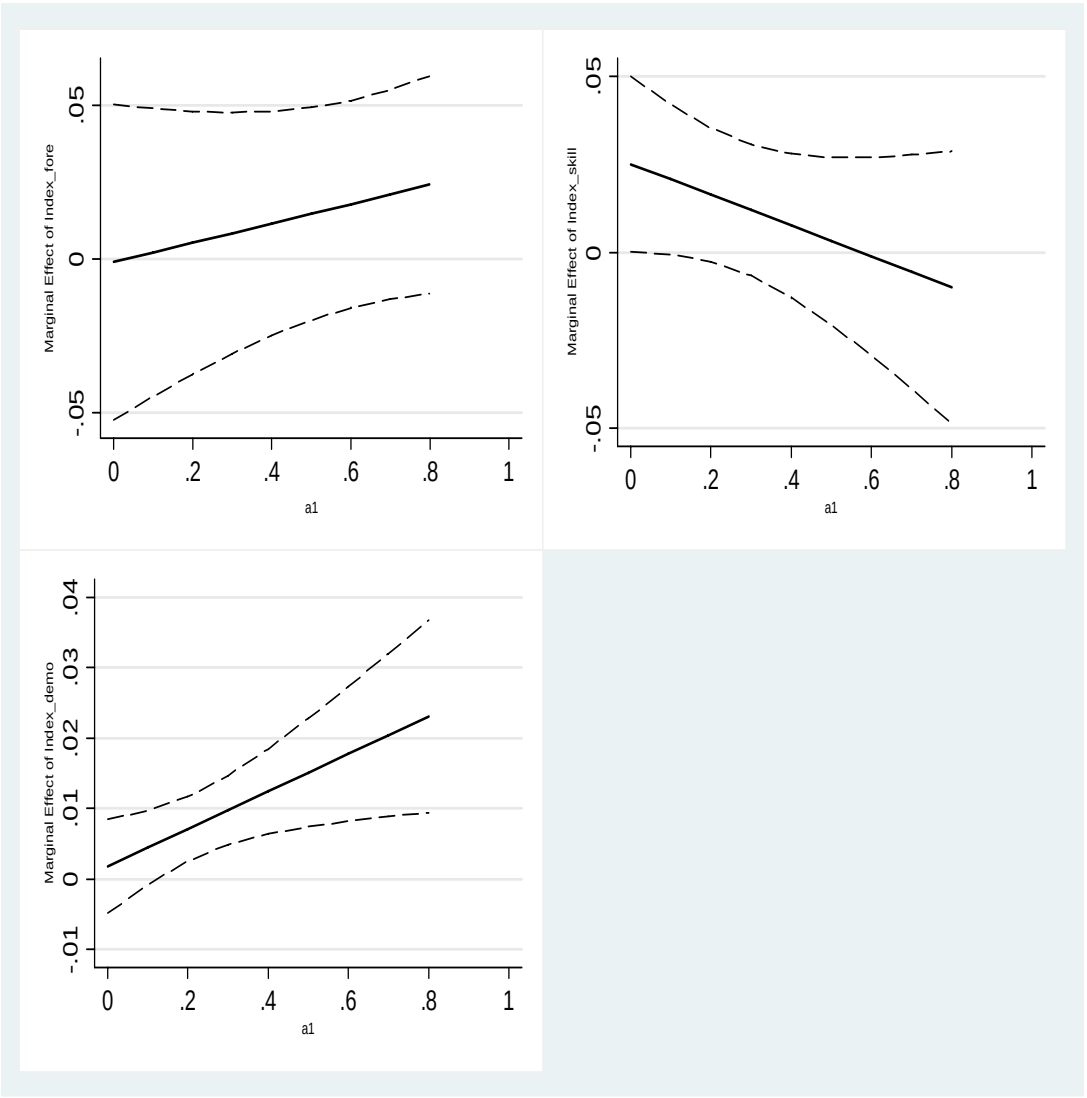


Figure 8: Marginal Effects of all indexes, interactions with the proportion of employees with a tertiary education, OLS estimates.



Notes: dashed lines indicates confidence intervals at the 95 % level.

Figure 9: Marginal Effects of all indexes, interactions with the proportion of employees aged 15-28, OLS estimates.



Notes: dashed lines indicates confidence intervals at the 95 % level.