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Revisiting the relationship between firm strategic capabilities and productivity in a multilevel analysis: Do labor market conditions matter?

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Abstract

This paper studies the relationship between managerial capital, social capital and firm productivity in Colombia, and explores whether this relationship depends on labor quality and formality. Results confirm a positive and significant effect of firm capabilities (managerial and social capital) on TFP (total factor productivity) and suggest a substitution effect between them. A positive effect of labor quality and formality on firm productivity is documented. Even though results are not conclusive, labor quality appears to increase the effect of managerial capital and reduce that for social capital, while labor formality seems to have no impact on their marginal effect. This is important for policy makers reinforcing the importance of quality education, labor formality and the relevance of programs promoting adoption of managerial practices and development of networks.

Keywords: Productivity, Managerial Capital, Social Capital, Labor formality, Developing countries.

JEL Codes: L10, L25, M21, O40

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1 Introduction

Improving firm-level productivity is fundamental for achieving overall economic growth (Solow, 1957; Romer, 1986; Aghion and Bolton, 1992; Lucas Jr, 1988; Devadas and Pennings, 2018). Economists have been interested for a long time in understanding determinants of firm productivity. Firm capabilities, among them, managerial capital (Lucas Jr 1978; Rosen 1982; Bloom and Van Reenen 2007; Bruhn et al. 2010, 2018) and social capital (Spence et al. 2003; Dar and Mishra 2020; Lee et al. 2019; Barr 1998), have been proposed as potential sources for improving productivity and firm performance. On one hand, managerial talent and management practices have shown a positive and economically significant relation with TFP (Syverson 2011). While several studies have also shown that knowledge transfers and structural social capital that facilitate resource acquisition are positively related to productivity (Syverson 2011; Clark Jr 2013; Lee et al. 2019).

Researchers from the institutional economics strand argue that the context in which the firms operate also matters for productivity (North 1990; Acemoglu et al. 2005; Acs et al. 2018). In particular, education (Barro 2001; Jorgenson and Fraumeni 1993; Liu and Bi 2019) and formalization (Kapsos and Bourmpoula 2013; Bruhn and McKenzie 2014; Lay and Tafese 2020) are factors at the macro and micro level that have shown to be related to firm productivity. This evidence on firm-related factors and context-related factors raises the question of how firm strategic capabilities and economic environment interact with each other. That is, whether context factors enable or moderate the effects of firm capabilities on productivity.

This paper provides evidence of the relationship between managerial capital, social capital and firm-level productivity in Colombia, and explores the role of labor market conditions into this relationship. The latter is measured through proxies of the labor force quality and labor formality at the regional level. While there is ample evidence of the positive relationship of each individual capability, evidence of the two -managerial and social capital- together, for developing countries, is still scarce. And to the best of our knowledge, the interaction

between these firm capabilities and labor market conditions has not been explored. Labor market conditions are part of the context in which firms operate. Labor quality and its right combination at the firm level, improves labor productivity, while labor formality facilitates allocation of employment towards more productive firms. For this analysis we use firm-level data from the Annual Manufacturing Survey (EAM in Spanish) and the Survey of Technological Development and Innovation (EDIT in Spanish). These sources of information can be integrated to provide a complete picture of the firm's operating characteristics and variables associated to managerial capital and connectivity as a proxy for social capital.

Using information from 2014 to 2018, we perform a two-step estimation process. In the first step we estimate firm-level total factor productivity. In the second step, we use linear mixed models with random coefficients to specify the relationship between managerial capital, social capital, and firm productivity. A mixed effects model is appropriate here since the effects of context and firm capabilities may vary by region, industry and firm and firms may form natural clusters. Including interacting terms, we test whether labor quality and labor formality play a role in the relationship between these firm capabilities and productivity. The intuition behind this is that with higher levels of human capital and job quality, managerial capabilities could be more effective in promoting productivity gains.

Our results confirm that managerial capital and social capital positively affect productivity. This is in line with the findings in Bloom and Van Reenen (2007); Schoar (2010); Bruhn et al. (2010); Yli-Renko et al. (2001); Clark Jr (2013); Lee et al. (2019). Interestingly, we find that these two firm capabilities may be substitutes. This implies that firms can strategically choose their investments for developing their capabilities. Moreover, what seems important for productivity, is the extensive margin of managerial capabilities, i.e., once firms establish relationships with other organizations, improve their processes and obtain certifications, there is no additional effect of an extension of these capabilities. Our results also confirm a positive association between labor market quality and firm productivity. We find that labor force quality and labor formality do play a specific role in the relationship between man-

agerial resources and productivity. Even though not conclusive, education quality appears to increase the marginal effect of managerial capital and moderate that of social capital. The interaction of labor formality with firm capabilities does not appear to be economically meaningful.

This study contributes to the existing research on productivity by exploring the role of managerial following the framework proposed by Bloom and Van Reenen (2007) and Bloom et al. (2016) complementing it with measures of social capital, exploiting a new data set for a developing country. Also, we consider how labor market conditions interact with firm capabilities to determine productivity This is an interesting case insofar as companies in Colombia are mostly small and face barriers to growth associated with labor quality, formality and capabilities (Lora, 2016; Eslava et al., 2019). Our results help build empirical evidence for public policies promoting education and labor formality and fostering development of managerial and social capabilities at the firm level.

The rest of the paper is organized following this structure: Section 2 presents the related literature, Section 3 summarizes describes the data and methodology. Results are presented in section 4; and Section 5 presents some final remarks.

2 Related literature

This paper relates to two threads of literature. First, studies related to the effect of firm capabilities on productivity, and second, literature analyzing the impact of education and formality on productivity. Regarding firm strategic capabilities, Wernerfelt (1984); Barney and Hoskisson (1990) and Penrose and Penrose (2009) argue that the heterogeneity in firm resources is what enables generation of extra rents. A firm achieves rents not because it has access to these resources but because it has developed a set of capabilities that allow better use of these resources. For instance, managerial capital defined as the "talent for managing" (see also Rosen, 1982; Lucas Jr, 1988) helps firms make better use of human capital and

better allocation of financial capital.

Bloom and Van Reenen (2007) develop a survey for measuring and assessing managerial practices and find that these practices are correlated with firm productivity across countries. Bruhn et al. (2018) in a randomized trial experiment in Mexico show that managerial capital is positively associated with productivity and acquirable by training. Cárdenas and Aparicio (2022) show that managerial capital, measured as an index of training and international certifications, is positively and significantly associated with firm's TFP in a sample of 102 developing countries.

But managerial capital is not the only capability a firm has to develop to access and adequately use resources, to increase absorptive capacity and improve access to knowledge and technology, a firm also needs to be connected. Social capital, defined as a firm capability, refers to the ability of the firm to obtain benefits from their social networks. It can be exploited to acquire knowledge, technology, practices and to improve collective learning. Empirical studies have confirmed a positive association between social capital and firm productivity and performance for entrepreneurs or in developing countries. See for example (Clark Jr 2013; Lee et al. 2019 Cardenas and Aparicio (forthcoming)).

Social capital, relationship capital or firm connectivity is a capability that rests on the networks of relationships and the resources inherent in this networks (Boumlik et al. 2021). It comprises resources acquired by associating and cooperating with other firms, entities or persons. Some researchers argue that social capital and networks in developing countries are a solution to the financial constraints of firms (Nahapiet and Ghoshal 1998; Beck and Demirguc-Kunt 2006). In developing countries, institutions and the regulatory environment affect the potential access to resources to develop entrepreneurial opportunities which increases the importance of social networks (Schoar 2010).

Several attempts have been made to measure social capital in different dimensions. The structural dimension of social capital focuses on the configuration of network ties and the rules and procedures used to use them (Nahapiet and Ghoshal 1998). The cognitive dimen-

sion focuses on shared languages, values and narratives and the relational dimension deals with the nature and quality of relationships (Nahapiet and Ghoshal 1998; Narayan and Cassidy 2001; Spence et al. 2003; Boumlik et al. 2021). In this paper we use available data on network connections at the firm level to assess social capital.

The second branch of literature refers studies exploring the relationship between education quality and formality, and productivity. High quality education is the base for the accumulation of human capital by means of building the required capabilities for production (Sheehan and Shi 2019; Lebedinski and Vandenberghe 2014; Becker 2009; Chevalier et al. 2004; Becker 1992). Better education also allows individuals to move across firms and across regions improving labor allocation (Sheehan and Shi 2019; Liu and Bi 2019).There are several studies linking education to productivity and overall economic growth (Pimenta et al. 2022; Liu and Bi 2019; Hanushek et al. 2013; Barro 2001; Knight and Sabot 1990). These studies show that additional years of schooling and the quality of education are positively related to productivity and earnings.

In developing countries only a small portion of the the work force is formally employed (Kapsos and Bourmpoula 2013). Reallocation of labor from the informal firms to the formal sector increases productivity and promotes economic growth. Taking advantage of an exogenous variation in import competition in China, Chakraborty et al. (2020) show that import competition causes an increase in formal labor employment. This reallocation of labor to formal employers improves aggregate labor productivity. Lay and Tafese (2020) use a firm-level panel of manufacturing firms in Vietnam to study productivity dynamics of formal and informal firms. Results show that productivity is lower and misallocation larger in the informal sector.

3 Data and methods

3.1 Data sources

Data for this research was obtained for manufacturing firms in different regions in Colombia, from three sources: EAM[1], EDIT[2], The National Council of Competitiveness (NCC)[3]. EAM is a survey that provides detailed information about manufacturing firms in Colombia and allows to quantify the factors of production. EDIT is the main source of information on the innovation levels of firms in different dimensions, and has recently included questions related to managerial practices and connections. Finally, NCC is a private organization that assesses regional competitiveness based on social, economic and political characteristics.

After integrating and cleaning the data we end up with a panel of 30,739 observations for 18 industries in 23 regions, for the period between 2014 and 2018. Given that EAM is an annual survey while EDIT is a biannual survey, the EDIT variables related to managerial and social capital are extrapolated to the average of the biannual surveys. This allows us to exploit the whole variation in EAM related to productivity and other firm characteristics. Although EAM and EDIT have a longitudinal structure, firms are not reported every year. Once these sources of information are integrated, the database has between 6,000 and 7,000 firms per year (see Figure 1). Tables 1 and 2 show the number of observations by region and industry.

Our specification also includes other firm variables that could affect productivity. In particular, firm size as the log of total assets, the percentage of export sales and the ratio of interest payments to total assets as a measure of funding intensity. To control for regional characteristics that may impact firm productivity we introduce GDP growth and the labor participation rate from the National Statistical Institute DANE[4]. In turn, variables related

[1]EAM is the Colombian Annual Manufacturing Survey (Encuesta Anual Manufacturera).

[2]EDIT is the Survey of Technological Development and Innovation (Encuesta de Desarrollo e Innovación Tecnologica).

[3]A private organization that researches determinants for competitiveness in Colombia at the regional level.

[4]Link of contact: https://www.dane.gov.co

to education quality and formality are the score of standardized college level tests (in logs) and labor formality measured as a percentage of total labor in the regional level, respectively. Both variables are taken from NCC. Table 3 presents a brief definition of the variables and their sources.

For the firm-level main effects, we constructed proxies for managerial capital and social capital for the period between 2014 and 2018. Managerial capital was measured by a dummy variable defining if a firm has at least one international certification, which has been also used by Goedhuys and Mohnen (2017). This measure reflects that certified firms adopt best practices that improve operating performance. Alternatively, the number of certifications was also considered to analyze possible differences between the extensive and intensive margin of managerial capital. For social capital we used a dummy variable indicating whether a firm has at least one connection with other firms, suppliers, universities and exhibitions/fairs for both national and international contacts. In this case, the analysis is also made separating national and international connections, using an index computed as a simple average of dummies for each kind of connection.

To analyze the incidence of managerial and social capital in Colombia, we present comparative statistics at the industry and regional level. In particular we compare the proportion of firms with social and managerial capital as well as the average level based on the number of certifications and the number of connections across industries and regions. Figure 2 shows the percentage of firms with at least one connection, per industry (social capital) and the percentage of firms with at least one international certification (managerial capital), for the 18 industries in this analysis. In general, there is a higher incidence of social capital than managerial capital, although in both cases it is low. Based on the distribution by industry, the highest levels are observed in Petroleum and chemicals (20) and pharmaceutical products and medicinal chemicals (21), where they do not exceed 30%. In contrast, the lowest levels are observed in industries such as wearing apparel (14) and leather (15). In addition, there seems to be a positive relationship i.e. the higher social capital, the higher managerial

capital, which can be explained by higher levels of sophistication of the sectors that favor the accumulation of both types of capital.

As for the average level, Figure 3 shows similar patterns and an increase in variation, particularly in the case of social capital. That is, industries with higher incidence seem to have higher average number of connections. While in the case of relational capital both the incidence and the average are relatively similar in most industries. At the regional level, both the incidence and the average level of managerial capital and social capital are found in medium-sized regions (see Figures 4 and 5). In the case of social capital, this can be explained by the fact that smaller regions tend to have higher levels of industrial specialization, which can facilitate interaction between firms. Moreover, the fact remains that in general the level of social capital is higher and is positively related to the level of managerial capital.

3.2 Estimation of TFP

We consider information for the period between 2014 and 2018 to construct the dependent variable which is the estimated TFP for manufacturing firms. To do so, we implement the Levinsohn and Petrin (2003) method[5] to estimate a production function including capital, labor and intermediate inputs as production factors, and assuming a common production technology at the two-digit ISIC industry level. To adjust labor by productivity differences between white and blue collar, we use a relative wage factor dividing white collar average wages by blue collar average wages at the firm level. Industries with small number of observations were aggregated [6]. Moreover, outliers were excluded following Gandhi et al. (2011) eliminating firms with growth above 200% in capital, labor, intermediate inputs or value added.

Table 4 presents general statistics for TFP (in logs) at the industry level. The average is

[5] Levinsohn and Petrin (2003) uses intermediate inputs to capture the productivity shocks which can smooth the estimation of the production function, which also avoids problems of invertibility related to firms with zero-investment. The latter is problematic in other methods like Olley and Pakes (1996).

[6] Industries 26 (Informatics products) and 27 (Manufacture of electric equipment) were included in sector 28 (Machinery and equipment fabrication). 30 (Production of other transportation equipment) was included in 29 (Manufacturing of vehicules).

3.19, with a wide variation. The highest average TFP is observed in wearing apparel (14), while sectors such as non-metallic mineral products (23) and Other manufacturing Industry (32) exhibit the lowest levels of productivity. Heterogeneity within industries is also observed. Figures 6 and 7 present the TFP distribution by industry for 2014 and 2018, respectively. There are interesting facts to highlight. First, differences in productivity between industries are persistent over time. Second, it is possible to find firms with similar levels of productivity across industries. Lastly, there are industries with lower within variation in productivity levels such as Basic metals, Publishing, printing and reproduction of recorded media, and Rubber and plastics products.

In turn, Figures 8 and 9 show the density of TFP for firms with and without managerial and social capital. There is no direct association between higher productivity and firm capabilities in our sample. That is, in general firms with social or managerial capital tend to have higher TFP. However, on the right of the distribution there is a group of firms with high productivity levels but without firm capabilities. This might be explained by differences in TFP at the industry level. In particular the Wearing apparel industry, where both managerial and social capital are relatively low, with the highest levels of productivity. This emphasizes two aspects in our analysis. First, the relationship between managerial and social capital is complex. Second, there are components that are industry-specific. This motivates consideration of a modelling strategy to capture idiosyncratic effects at the industry level.

3.3 Empirical strategy

Industry and region might determine the relationship between inputs and productivity. For example, there are industries with a higher level of sophistication or international exposure where the importance of social capital is higher than in others. These types of intuitions also apply to differences at the regional level. Therefore, our empirical approach uses a three-level mixed-effects model with random coefficients in which the firms (level 1)

are nested in industries (level 2) and industries are nested in regions (level 3).

In particular, our estimating model is described by Equations 1, 2 and 3 as follows:

$$Y_{ijk} = \beta_{0jk} + \beta_1 Size_{ijk} + \beta_2 Exports_{ijk} + \beta_3 Leverage_{ijk} + \beta_{4jk} MK_{ijk} + \beta_{5jk} SK_{ijk} + \beta_6 Context_k + \beta_7 GDPGrowth_k + \beta_8 LP_k + \xi_{ijk} \quad (1)$$

$$\beta_{0jk} = \gamma_{00k} + \rho_{0jk} \quad (2)$$

$$\beta_{pjk} = \gamma_{p0k} + \rho_{pjk} \quad (3)$$

Where Y_{ijk} is the TFP of the firm i in industry j in region k. β_{0jk} is the intercept which may vary acroos industries and regions as shown in Equation 2, where γ_{00k} is the productivity for region k and ρ_{0jk} is a random error for each industry j within each region, assumed to be normally distributed with mean zero and constant variance. MK_{ijk}, and SK_{ijk} are the variables of interest. MK_{ijk} is the proxy dummy variable for managerial capital and SK_{ijk} is the proxy for social capital or connectivity. β_{4jk}, and β_{5jk} are the slopes which are specified as random coefficients allowed to vary between industries and regions as explained in Equation 3. Here, γ_{p0k} is the overall mean for variable p ($p = 4$, managerial capital, and $p = 5$, social capital or connectivity) within region k and ρ_{pjk} is a random error for each firm characteristic p in industry j within each region k, assumed to be normally distributed with mean zero and constant variance. To test if the mixed model specification is adequate compared to OLS, we use the likelihood-ratio test.

$GDPGrowth_k$, and LP_k are the additional region controls for economic growth and labor force participation rate. $Size_{ijk}$, $Exports_{ijk}$ and $Leverage_{ijk}$ are firm controls for variables that can influence firm productivity. Firm size measured as the log of total assets, direct exports as percentage of total sales and leverage measured as interest expenses divided by total assets. $Context_k$ is the context variable either education quality or labor formal-

ity, measuring the labor market conditions at the regional level. Finally ξ_{ijk} is a random error, which is assumed to be normally distributed with zero mean and a constant variance. Further specifications include interaction between managerial and social capital as well as interactions between context variables and firms capabilities. These interactions capture possible complementarities and measure the role of education quality and labor formality in the relation between firm capabilities and productivity. Table 5 presents the summary statistics for all variables included in the regression models.

4 Results

As a base, we estimated a linear regression model including control variables and different measures of social and managerial capital (see Table 6). In general, coefficients of control variables at the firm level, have the expected sign. Firm size and percentage of exports have a positive influence on productivity. The regional control variables appear to have no significant effect on productivity. Coefficients for both of the variables of interest are significant and with similar magnitude. The presence of managerial capital increases productivity by 3.1 pp. while social capital improves it by 2.38 pp.

Using the average number of certifications and the average number of connections as alternative measures of social and managerial capital, confirm the statistical relevance of both variables in determining productivity. An increase in 1 certification will improve productivity by 1.47 pp., while an increase in one connection improves productivity by 0.64 pp. An interesting feature of EDIT is that it allows to separate between national (local) and international connections. This let us evaluate if there is a differential effect for these type of connections on productivity (see Columns 3-6). The effect of these connections may differ, as local connections may favor efficiency through informational spillovers, while international connections may strengthen penetration in other markets. We find that the overall effect is driven by local connections.

Mixed model specifications are used to analyze the contribution of different variables. Table 7 presents the results for these specifications with education quality as a context variable. They differ in the inclusion of interacting effects. Model 1 corresponds to the pooled OLS model, while Model 2 is the three-level mixed effects model with random coefficients. This and the rest of the specifications include random slopes for the main effects i.e. managerial capital and social capital. Estimates support the idea that firm capabilities are positively associated with firm productivity. A firm with extensive social capital increases productivity by 2.3 pp., a 0.53% increase with respect to the average firm productivity. The effect of managerial capital is slightly higher, 3.1 pp., which corresponds to a 0.72% improvement over the average firm productivity. Results for managerial capital are economically and statistically significant and aligned with Bloom and Van Reenen (2007). Managerial capital in our analysis is extensive while in Bloom and Van Reenen (2007) is measured on a scale averaging 18 practices. The effect of social capital is consistent with Domenech et al. (2015) and Luo and Bu (2016). However, the magnitude is difficult to compare since their methodologies are different. Although Education quality is not significant in this specification, it becomes significant in the mixed effects model. Results indicate that a 1% improvement in the region education quality score, increases firm productivity by 1.8%.

In model 3 we include the firm-level interactions between managerial capital and social capital. We find that firm capabilities appear to be substitutes. The coefficients for both individual capabilities increase and their interaction is negative. This is an interesting finding and similar to what Cárdenas and Aparicio (forthcomming) find in a cross country analysis for 102 developing countries, where the interaction is negative but not statistically significant.

Something interesting happens when we introduce the context-firm interactions in Models 4 and 5. The interaction between education quality and managerial capital is positive, but not significant and the coefficient for managerial capital turns negative and not significant. Similarly, in Model 5 the interaction between social capital and education quality is also not significant, but in this case, negative. Education quality is positively associated with firm

productivity.

Even tough the coefficients are not statistically significant, these results suggest two findings: First, the marginal effect of managerial capital increases with the regional education quality. This marginal effect may even be negative unless education quality is sufficiently high. The intuition behind this is that in a region with better labor quality, good management practices may be more effective for firm productivity. Increasing management practices in place in an environment of poor labor quality may even have a negative effect on productivity. Second, the marginal effect of social capital in the presence of high quality labor is of lesser magnitude. Networks and firm connectivity are more important for productivity in environments of lower labor quality. Model 6 considers a four-level mixed model with the survey year as level 1.

When we analyze the case of labor formality (see Table 8) the coefficients for firm capabilities and their interaction remain the same suggesting that our results are robust. The effect of labor formality on firm productivity is positive but not significant. According to Column 2 corresponding to the mixed linear model, a 1% increase in region labor formality, increases firm productivity by 0.716 pp. However, the interaction of labor formality and firm capabilities is not statistically nor economically significant. This suggests that the level of labor formality in the region, even though associated directly to firm productivity, does not have a meaningful impact on the marginal effects of managerial or social capital.

Previous estimates show the change in productivity and the association with firm capabilities of a marginal variation in context variables. This provides a first approximation to understanding how context shapes the relationship between firm capabilities and productivity. However, similar evidence can be inferred by comparing the relationship of firm capabilities and productivity between high quality of education and low quality of education contexts. Groups are defined separating the last quartile of education quality and formality at the regional level, from the rest of the regions. Tables 9 and 10 show the estimates for each context variable. First, we observe that the relationship between firm capabilities and

productivity is not homogeneous across groups. In the case of education, both managerial and social capital determine productivity for firms in regions with low education quality. In turn, social capital is not relevant in regions with high education quality. In contrast, labor formality strongly determines the relation between firm capabilities and productivity. For firms operating in a high informality context, social and managerial capital are not effective to foster productivity. This emphasizes the importance of formalization policies to improve the return of firm capabilities.

5 Concluding remarks

In this study we analyze the association between firm capabilities (managerial capital and social capital), labor market quality (education quality and labor formality) and firm productivity at the regional level in Colombia. We use a mixed effects multilevel model with panel data for the period 2014- 2018 for a sample of manufacturing companies in 23 regions.

This research has four main findings. First, in line with extant research, we confirm that there is a positive and meaningful relationship between firm capabilities -managerial and social capital- and firm productivity, and between labor quality and formality and firm productivity. Second, in Colombia, managerial capital and social capital appear to be substitutes. That is, for firms with better managerial capital or management practices, the marginal effect of social capital and networks is smaller. In the same way, for firms that are better connected, the marginal effect of managerial capital is smaller. Third, even though not conclusive, it appears that in regions with better educated labor force, the marginal effect of managerial capital increases and that of social capital is less important. This implies that firms in regions with better education quality should make an effort to improve managerial practices because their impact on productivity is higher. In better educated regions with higher quality of the labor force, the impact of social capital on productivity is less important. And finally, data suggests that labor formality, even though positively related to

productivity, does not affect the marginal effect of either managerial capital or social capital. The effects of managerial capital and social capital appear to be the same independent of labor formality.

This research has several limitations. The panel that we are using is not long enough to conclusively argue that the effects are casual within firms. As more data is available in the panel surveys of EAM and EDIT further research can be conducted to explore casual relationships. Another limitation is our use of proxy variables for managerial capital and social capital. Further research with detailed information about these constructs is required to better understand their effects on firm productivity.

This paper has practical contributions for policy makers and managers. Results from this research contribute to reinforce the importance of quality education and labor formality for productivity and growth. Policy makers should be aware of this and prioritize investments in education and regulations to formalize employment in those regions where labor quality and labor formality are low. Policies and programs promoting adoption of best managerial policies and the development of networks should also be considered to improve productivity. Managers and investors should consider the labor context to select the right region for their firms and investments. They also should promote adoption of managerial practices and try and connect their firms with external networks.

Researchers should continue the quest on understanding the determinants of firm productivity. Studies using panel data as they become available and research using more detailed surveys for the constructs of managerial capital and social capital could help us improve our knowledge about the mechanisms that determine firm productivity in developing countries.

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Tables

Table 1: Sample distribution by region

Region Code	Region	Obs.	Percent
5	Antioquia	6,980	22.62
8	Atlántico	1,159	3.76
11	Bogotá D.C.	11,178	36.23
13	Bolívar	343	1.11
15	Boyacá	253	0.82
17	Caldas	473	1.53
19	Cauca	287	0.93
20	Cesar	115	0.37
25	Cundinamarca	2,277	7.38
23	Córdoba	93	0.30
41	Huila	174	0.56
47	Magdalena	200	0.65
50	Meta	195	0.63
52	Nariño	159	0.52
54	Norte de Santander	458	1.48
63	Quindío	180	0.58
66	Risaralda	636	2.06
68	Santander	1,347	4.37
70	Sucre	62	0.20
73	Tolima	317	1.03
76	Valle del Cauca	3,853	12.49
85	Casanare	47	0.15
99	Vichada	66	0.21
Total		30,852	100.00

Note: The sample for this study was restricted to firms with information in the two main surveys. *Source:* Authors calculations using the technological development and innovation survey (EDIT) and the annual manufacturing survey (EAM).

Table 2: Sample distribution by industry

ISIC	Industry	Obs.	Percent
10	Manufacturing of food products	5,778	18.73
11	Manufacturing of beverages	206	0.67
13	Manufacture of textiles	965	3.13
14	Manufacture of wearing apparel	3,231	10.47
15	Tanning and dressing of leather; manufacture of luggage, handbags, etc.	1,277	4.14
16	Manufacture of wood and products of wood and cork, etc.	690	2.24
17	Manufacture of paper and paper products	450	1.46
18	Publishing, printing and reproduction of recorded media	1,853	6.01
20	Manufacturing of refined petroleum products and chemicals	1,703	5.52
21	Manufacture of pharmaceutical products and medicinal chemicals	648	2.10
22	Manufacture of rubber and plastics products	2,884	9.35
23	Manufacture of non-metallic mineral products	1,528	4.95
24	Manufacture of basic metals	464	1.50
25	Manufacture of fabricated metal products, except machinery and equipment	2,585	8.38
28	Manufacture of machinery and equipment	2,124	6.88
29	Manufacturing of motor vehicles, trailers and semi-trailers	784	2.54
31	Manufacture of furniture	1,508	4.89
32	Other Manufacturing Industry	2,174	7.05
	Total	30,852	100.00

Source: Authors calculations using the technological development and innovation survey (EDIT) and the annual manufacturing survey (EAM).

Table 3: Description of variables

Dependent variable	**Description**	**Source**
Firm productivity (TFP)	Firm productivity. The ability to generate greater outputs with less inputs measured as total factor productivity (TFP), the portion of output that is not explained by the amount of inputs utilized	Self estimation using Data form DANE, EAM. "Firm Level Productivity Estimates" for period 2014 to 2018
Main effects		
Managerial capital (MK)	Index between 0 and 1 of average of dummies for internationally recognized quality certification and formal training programs for full time employees	Computed based on data from DANE, EDIT for period 2014 to 2018
Social Capital Connectivity (SK)	Index between 0 and 1 of average of dummies for communication with clients, suppliers, competitors, universities and fairs domestic or foreing	Computed based on data from DANE, EDIT for period 2014 to 2018
Firm controls		
Firm size	Logarithm of firm size as number of current, total assets of the firm	Data from DANE, EAM for period 2014 to 2018
Leverage	Dummy variable if the firm has some amount of interest .	Date from DANE, EAM for period 2014 to 2018
Exports	Direct export as percentage of sales	Data from DANE, EAM for period 2014 to 2018
Regional controls		
GDP Growth	GDP annual growth rate at purchaser's prices	Data from DANE, department statistics for the period 2014 to 2018
Labor force participation	The total amount of labor related to the population in work age	Data from DANE, department statistics for the period 2014 to 2018
Context effects		
Education quality (EQ)	The logarithm of average grade of Saber pro test for each department	Computed base on data from IDC, for period 2014-2018
Labor formality (LF)	The percentage of the labor force who pays social security	Computed base on data from IDC, for period 2014-2018

Source: Information was obtain from the national department of statistics (DANE) and the national council of competitiveness (DNP).

Table 4: Descriptive statistics of the estimated productivity by industry

ISIC	Mean	SD	Min	Max
10	2.71	0.33	0.00	5.97
11	3.54	0.52	0.11	4.96
13	4.02	0.45	0.00	6.41
14	5.15	0.63	-1.14	7.95
15	3.65	0.44	0.00	5.78
16	2.49	0.35	-0.16	3.62
17	3.17	0.40	0.00	4.18
18	2.74	0.39	0.00	6.03
20	2.66	0.37	0.00	4.67
21	3.26	0.50	0.00	5.45
22	2.91	0.33	-1.81	4.70
23	1.66	0.33	0.00	3.52
24	2.56	0.38	0.00	4.92
25	3.63	0.49	0.00	6.26
28	4.11	0.49	0.00	7.36
29	2.80	0.35	0.00	4.03
31	2.99	0.41	0.00	5.49
32	2.21	0.50	0.00	6.38
Total	3.19	0.99	-1.81	7.95

Source: Authors calculations using the technological development and innovation survey (EDIT) and the annual manufacturing survey (EAM).

Table 5: Descriptive Statistics of variables included in regression models

	Mean	SD	Min	Max
Rate of GDP Growth	3.25	1.70	-5.89	9.34
TFP	3.18	0.99	-1.81	7.90
Labor force participation rate	0.71	0.04	0.58	0.77
Exports percentage	5.68	15.12	0.00	100
Size	14.81	9.06	0.00	671.54
Managerial Capital	0.10	0.30	0.00	1.00
Social Capital	0.14	0.35	0.00	1.00
Leverage	0.78	0.41	0.00	1.00
Education Quality	5.02	0.02	4.68	5.04
Labor formality	0.42	0.10	0.13	0.56

Source: Authors calculations using the technological development and innovation survey (EDIT) and the annual manufacturing survey (EAM).

Table 6: OLS estimates for the relation between firm capabilities and productivity

	(1)	(2)	(3)	(4)	(5)	(6)
Region Controls						
Rate of GDP Growth	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Labor force participation rate	0.434	0.428	0.435	0.432	0.436	0.435
	(0.31)	(0.31)	(0.31)	(0.31)	(0.31)	(0.31)
Firm Controls						
Size	0.004***	0.004***	0.004***	0.004***	0.004***	0.004***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Exports percentage	0.002***	0.002***	0.002***	0.002***	0.002***	0.002***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Leverage	0.033***	0.034***	0.033***	0.034***	0.033***	0.033***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Main Effects						
Social Capital	0.024***					
	(0.01)					
Managerial Capital	0.032***		0.032***	0.034***	0.032***	0.032***
	(0.01)		(0.01)	(0.01)	(0.01)	(0.01)
Level of Managerial Capital		0.015***				
		(0.00)				
Level of Social Capital		0.006*				
		(0.00)				
National Social capital			0.025***		0.026**	
			(0.01)		(0.01)	
Foreign Social capital				0.014	-0.004	
				(0.01)	(0.01)	
Only national Social capital						0.028**
						(0.01)
Only foreing Social capital						0.011
						(0.02)
Both Social capital						0.019
						(0.01)
Constant	2.712***	2.713***	2.712***	2.714***	2.712***	2.712***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Observations	30,739	30,739	30,739	30,739	30,739	30,739
adj R-squared	0.816	0.816	0.816	0.816	0.816	0.816
F-Test	2,836	2,834	2,836	2,835	2,778	2,722

Notes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, the dependent variable is the total factor productivity estimations. (1) OLS model with managerial and social capital, (2) OLS model with managerial and social capital in levels, (3) OLS model with managerial capital and national social capital, (4) OLS model with managerial capital and foreign social capital, (5) OLS model with managerial capital, national and foreign social capital (6) OLS model with managerial capital and social capital by national (only), foreign(only) and both. *Source:* Authors calculations using the technological development and innovation survey (EDIT) and the manufacturing annual survey (EAM).

Table 7: Models estimates for the relation between firm capabilities, education quality and productivity

	(1)	(2)	(3)	(4)	(5)	(6)
Region Controls						
Rate of GDP Growth	0.000	0.000	0.000	0.000	0.000	0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Labor force participation rate	0.259	0.187	0.188	0.188	0.183	0.162
	(0.32)	(0.31)	(0.31)	(0.31)	(0.31)	(0.23)
Firm Controls						
Size	0.004***	0.004***	0.004***	0.004***	0.004***	0.006***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Exports percentage	0.002***	0.002***	0.002***	0.002***	0.002***	0.001***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Leverage	0.032***	0.032***	0.031***	0.032***	0.032***	0.023***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Main Effects						
Social Capital	0.023**	0.022**	0.028**	0.022**	1.485	0.013
	(0.01)	(0.01)	(0.01)	(0.01)	(1.95)	(0.01)
Managerial Capital	0.031***	0.033**	0.043***	-1.284	0.033**	0.014
	(0.01)	(0.01)	(0.01)	(2.25)	(0.01)	(0.01)
Education Quality	1.338	1.788**	1.792**	1.765*	1.824**	1.344**
	(0.73)	(0.69)	(0.69)	(0.69)	(0.69)	(0.51)
Interactions						
Social capital× Managerial capital			-0.035			
			(0.02)			
Education × Managerial capital				0.263		
				(0.45)		
Education × Social capital					-0.291	
					(0.39)	
Constant	-4.282	-6.186	-6.210	-6.072	-6.364	-3.960
	(3.62)	(3.39)	(3.39)	(3.39)	(3.40)	(2.52)
Observations	30,739	30,739	30,739	30,739	30,739	30,739
Log-likelihood	-17,257.427	-17,686.365	-17,687.679	-17,686.078	-17,686.110	-13,714.881
AIC	34,615	35,409	35,413	35,410	35,410	27,472
adj R-squared	0.82					
Wald Test		434.688	438.263	434.838	435.069	419.169

Notes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. The dependent variable is the total factor productivity estimation. (1) OLS model, (2) Mixed three level model, (3) Mixed with Social Capital and Managerial Capital interaction, (4) Mixed with Education quality and Managerial Capital interaction, (5) Mixed with Education quality and Social Capital interaction and (6) Mixed model of 4 levels. *Source:* Authors calculations using the technological development and innovation survey (EDIT) and the manufacturing annual survey (EAM).

Table 8: Models estimates for the relation between firm capabilities, formality and productivity

	(1)	(2)	(3)	(4)	(5)	(6)
Region Controls						
Rate of GDP Growth	0.000	0.000	0.000	0.000	0.000	0.001
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Labor force participation rate	0.575	0.641*	0.642*	0.640*	0.639*	0.474*
	(0.33)	(0.31)	(0.31)	(0.31)	(0.31)	(0.23)
Firm Controls						
Size	0.004***	0.004***	0.004***	0.004***	0.004***	0.006***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Exports percentage	0.002***	0.002***	0.002***	0.002***	0.002***	0.001***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Leverage	0.032***	0.032***	0.031***	0.032***	0.032***	0.023***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Main Effects						
Social Capital	0.023**	0.022**	0.028**	0.022**	-0.011	0.013
	(0.01)	(0.01)	(0.01)	(0.01)	(0.04)	(0.01)
Managerial Capital	0.031***	0.033**	0.043***	0.037	0.034**	0.014
	(0.01)	(0.01)	(0.01)	(0.04)	(0.01)	(0.01)
Labor formality	0.417	0.716*	0.716*	0.717*	0.704*	0.424
	(0.39)	(0.31)	(0.31)	(0.31)	(0.31)	(0.25)
Interactions						
Social capital × Managerial capital			-0.035			
			(0.02)			
Labor formality × Managerial capital				-0.009		
				(0.11)		
Labor formality × Social capital					0.080	
					(0.08)	
Constant	2.064***	2.244***	2.242***	2.244***	2.250***	2.431***
	(0.33)	(0.27)	(0.27)	(0.27)	(0.27)	(0.21)
Observations	30,739	30,739	30,739	30,739	30,739	30,739
Log-likelihood	-17,258.520	-17,687.904	-17,689.236	-17,689.230	-17,689.010	-13,717.603
AIC	34,617	35,412	35,416	35,416	35,416	27,477
adj R-squared	0.82					
Wald Test		433.326	436.840	433.088	433.369	415.093

Notes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. The dependent variable is the total factor productivity estimation. (1) OLS model, (2) Mixed three level model, (3) Mixed with Social Capital and Managerial Capital interaction, (4) Mixed with Education quality and Managerial Capital interaction, (5) Mixed with Education quality and Social Capital interaction and (6) Mixed model of 4 levels. *Source:* Authors calculations using the technological development and innovation survey (EDIT) and the manufacturing annual survey (EAM).

Table 9: Mixed models estimates for firm capabilities and productivity by regional education quality

	(1)	(2)	(3)	(4)
Region Controls				
Rate of GDP Growth	-0.005	0.003	-0.005	0.003
	(0.00)	(0.00)	(0.00)	(0.00)
Labor force participation rate	0.113	-0.061	0.116	-0.064
	(0.45)	(0.70)	(0.45)	(0.70)
Firm Controls				
Exports percentage	0.002***	0.001***	0.002***	0.001***
	(0.00)	(0.00)	(0.00)	(0.00)
Size	0.009***	0.001***	0.009***	0.001***
	(0.00)	(0.00)	(0.00)	(0.00)
Leverage	0.023**	0.042***	0.023**	0.042***
	(0.01)	(0.01)	(0.01)	(0.01)
Main Effects				
Social Capital	0.010	0.040*	0.018	0.042*
	(0.01)	(0.02)	(0.01)	(0.02)
Managerial Capital	0.021	0.042**	0.036*	0.045*
	(0.01)	(0.02)	(0.02)	(0.02)
Interaction				
Social Capital × Managerial Capital			-0.048*	-0.012
			(0.02)	(0.03)
Constant	2.850***	2.908***	2.847***	2.910***
	(0.34)	(0.47)	(0.34)	(0.47)
Observations	22,508	8,231	22,508	8,231
Log-likelihood	-13,600.956	-3,877.360	-13,601.559	-3,879.749
AIC	27,235.912	7,788.720	27,239.117	7,795.499
Wald Test	522.417	71.752	527.110	71.706

Notes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. The dependent variable is the total factor productivity estimation. (1) Mixed model with the 25% regions with the highest education, (2) Mixed model with the 75% regions with the lowest education, (3) Mixed model with interaction between capabilities with the 25% regions with the highest education, (4) Mixed with interaction between capabilities with the 75% regions with the lowest education. *Source:* Authors calculations using the technological development and innovation survey (EDIT) and the manufacturing annual survey (EAM).

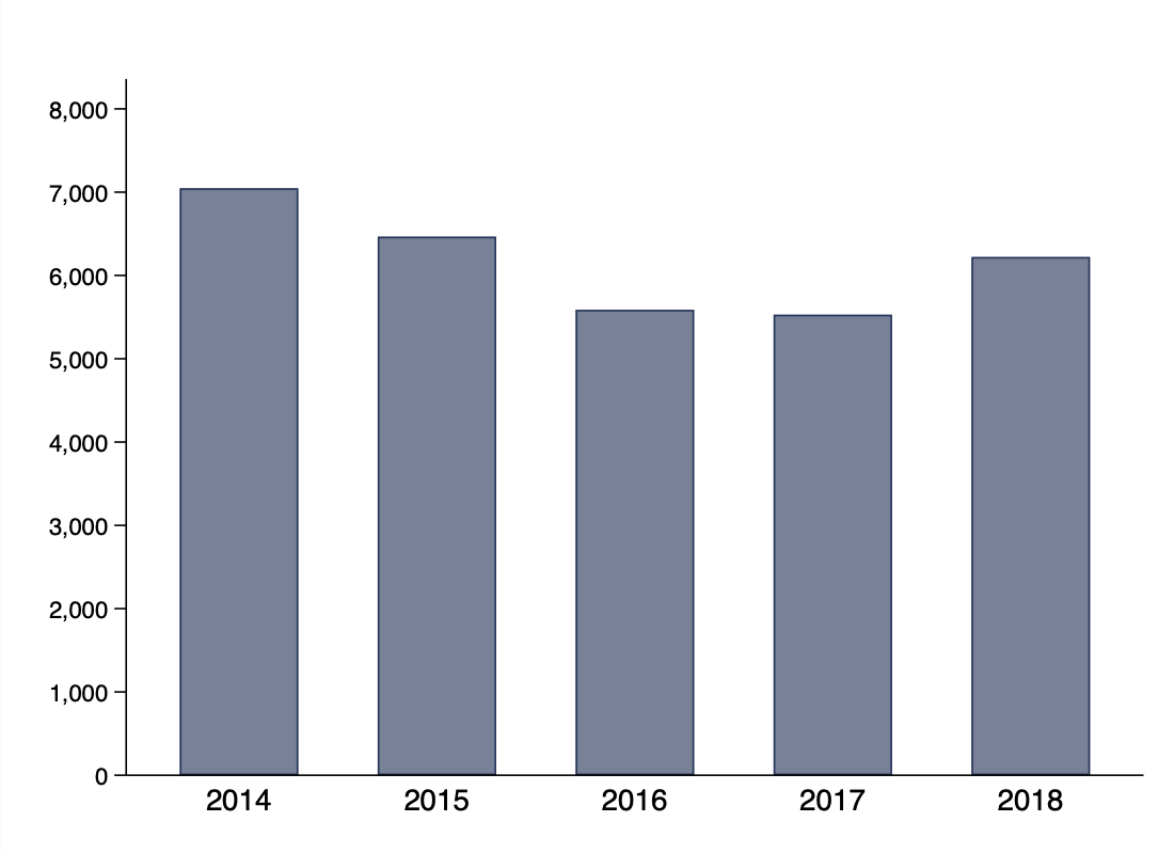
Table 10: Mixed models estimates for firm capabilities and productivity by regional formality level

	(1)	(2)	(3)	(4)
Region Controls				
Rate of GDP Growth	0.001	-0.001	0.001	-0.001
	(0.01)	(0.00)	(0.01)	(0.00)
Labor force participation rate	0.643	-0.004	0.645	-0.005
	(0.41)	(0.48)	(0.41)	(0.48)
Firm Controls				
Exports percentage	0.002***	0.001***	0.002***	0.001***
	(0.00)	(0.00)	(0.00)	(0.00)
Size	0.009***	0.001***	0.009***	0.001***
	(0.00)	(0.00)	(0.00)	(0.00)
Leverage	0.023**	0.041***	0.023**	0.041***
	(0.01)	(0.01)	(0.01)	(0.01)
Main Effects				
Social Capital	0.014	0.029	0.023*	0.026
	(0.01)	(0.02)	(0.01)	(0.02)
Managerial Capital	0.030*	0.029	0.046**	0.024
	(0.01)	(0.02)	(0.02)	(0.02)
Interaction				
Social Capital × Managerial Capital			-0.054*	0.018
			(0.02)	(0.03)
Constant	2.490***	2.881***	2.488***	2.882***
	(0.30)	(0.34)	(0.30)	(0.34)
Observations	23,120	7,619	23,120	7,619
Log-likelihood	-14,055.054	-3,348.988	-14,055.060	-3,351.364
AIC	28,144.109	6,729.976	28,144.121	6,738.728
Wald Test	536.781	65.319	541.786	65.563

Notes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. The dependent variable is the total factor productivity estimation. (1) Mixed model with the 25% regions with the highest formality, (2) Mixed model with the 75% regions with the lowest formality, (3) Mixed model with interaction between capabilities with the 25% regions with the highest formality, (4) Mixed with interaction between capabilities with the 75% regions with the lowest formality. *Source:* Authors calculations using the technological development and innovation survey (EDIT) and the manufacturing annual survey (EAM).

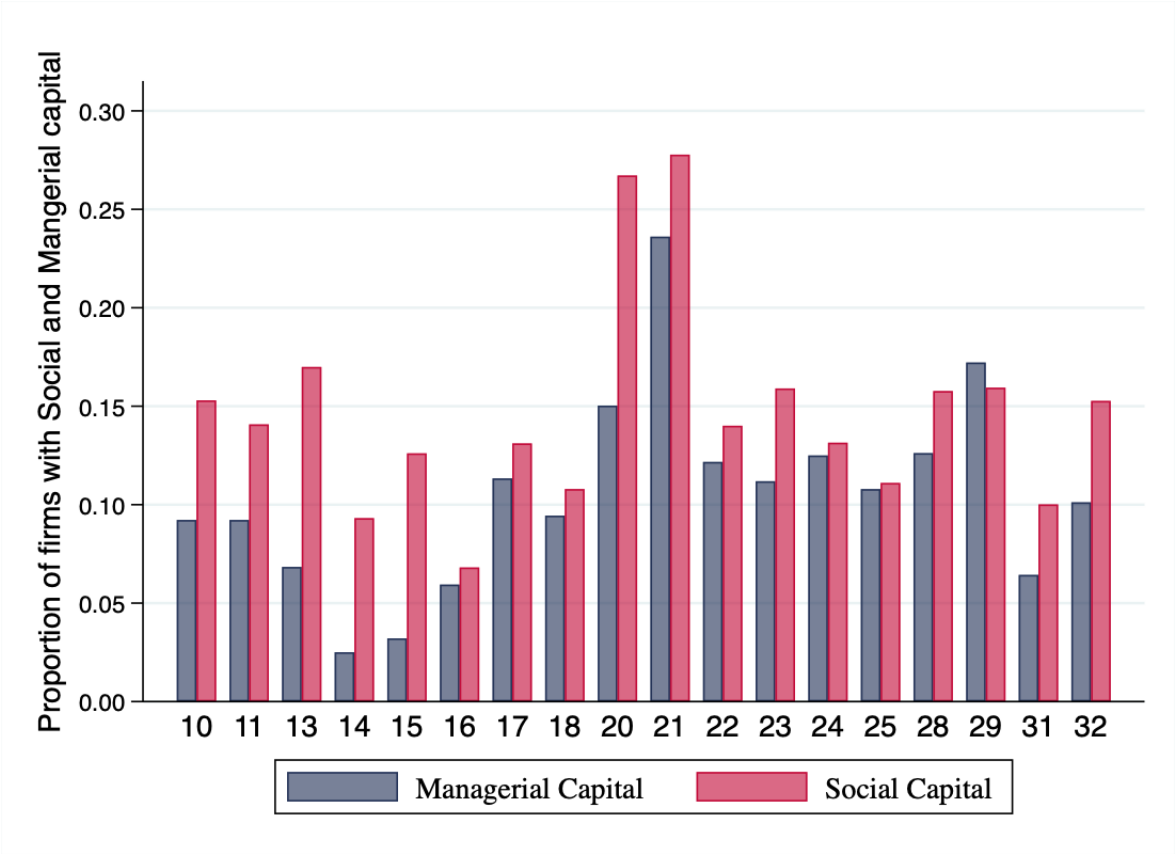
Figures

Figure 1: Number of observations by year



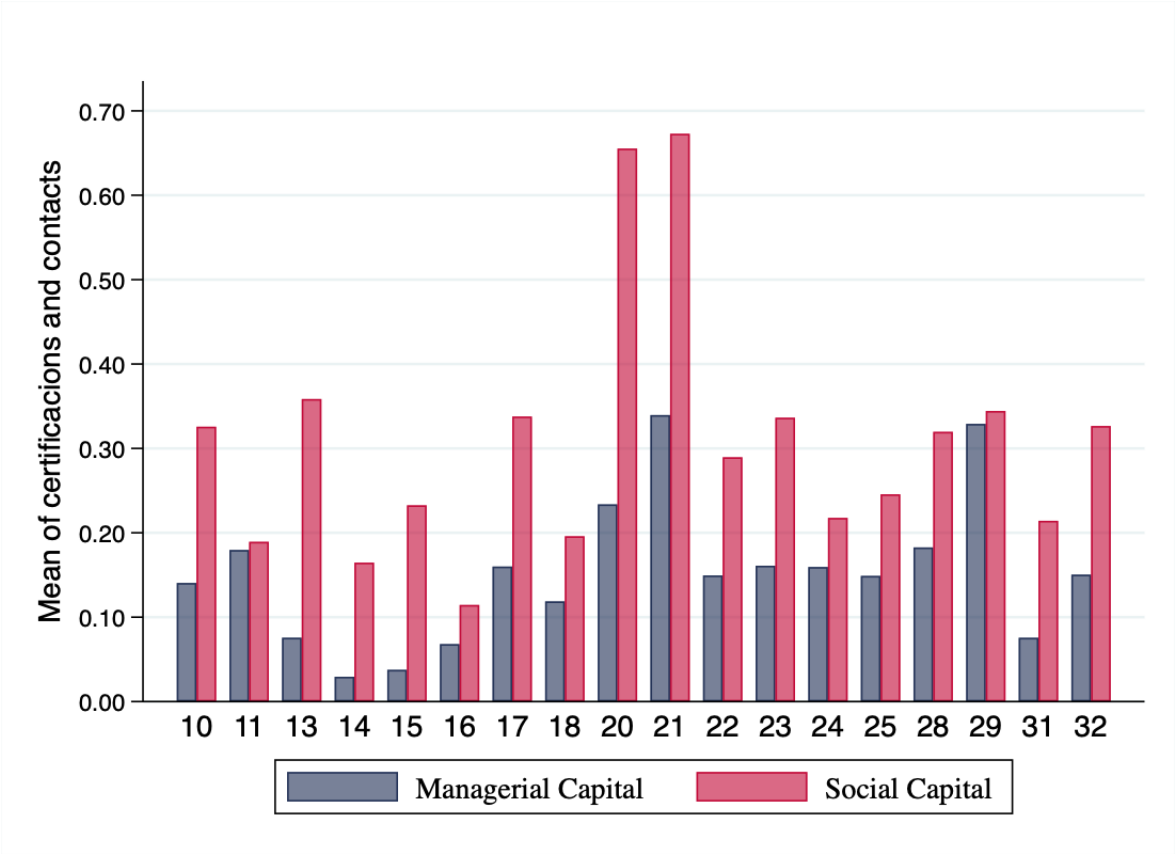
Source: Authors calculations using the technological development and innovation survey (EDIT) and the manufacturing annual survey (EAM).

Figure 2: Proportion of firms with social and managerial capital by Industry.



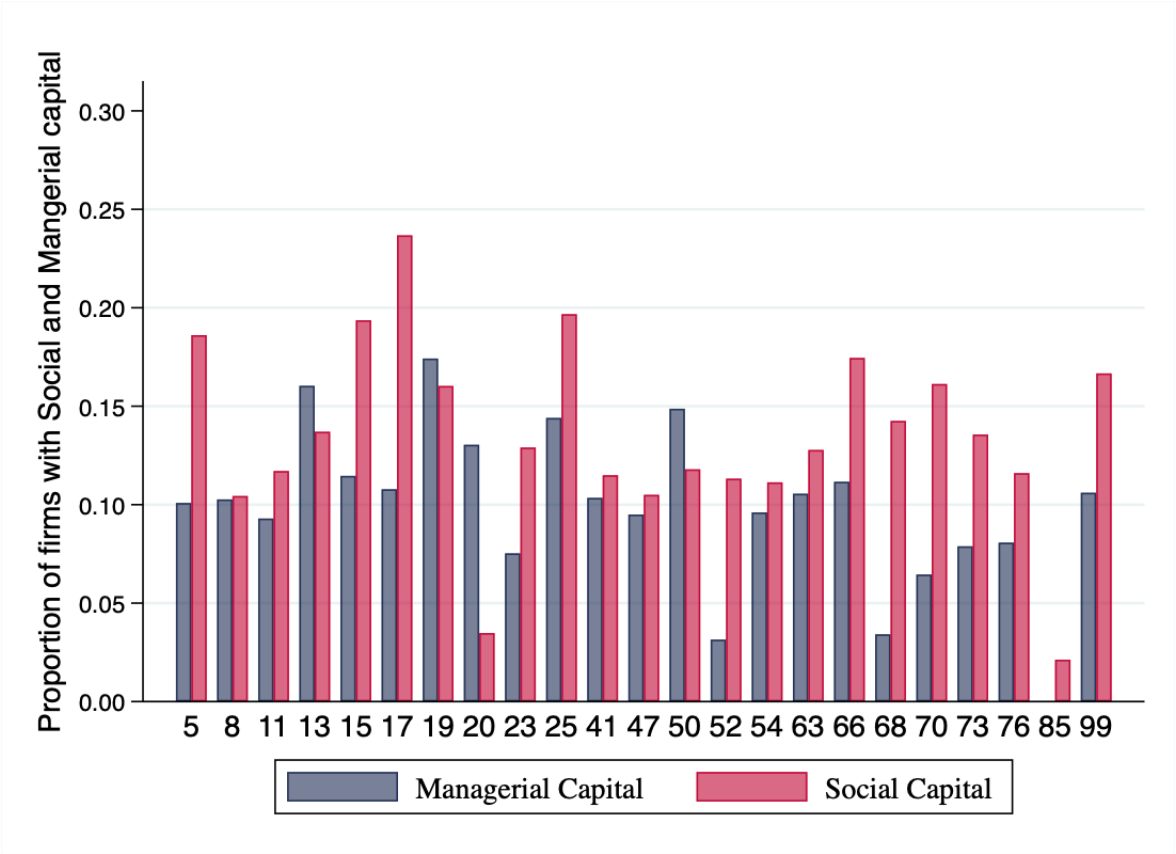
Note: Extensive margin represent the mean of the firms which has at least one process certification and at least one connection by each ISIC. *Source:* Authors calculations using the technological development and innovation survey (EDIT).

Figure 3: Average level of social and managerial capital by Industry.



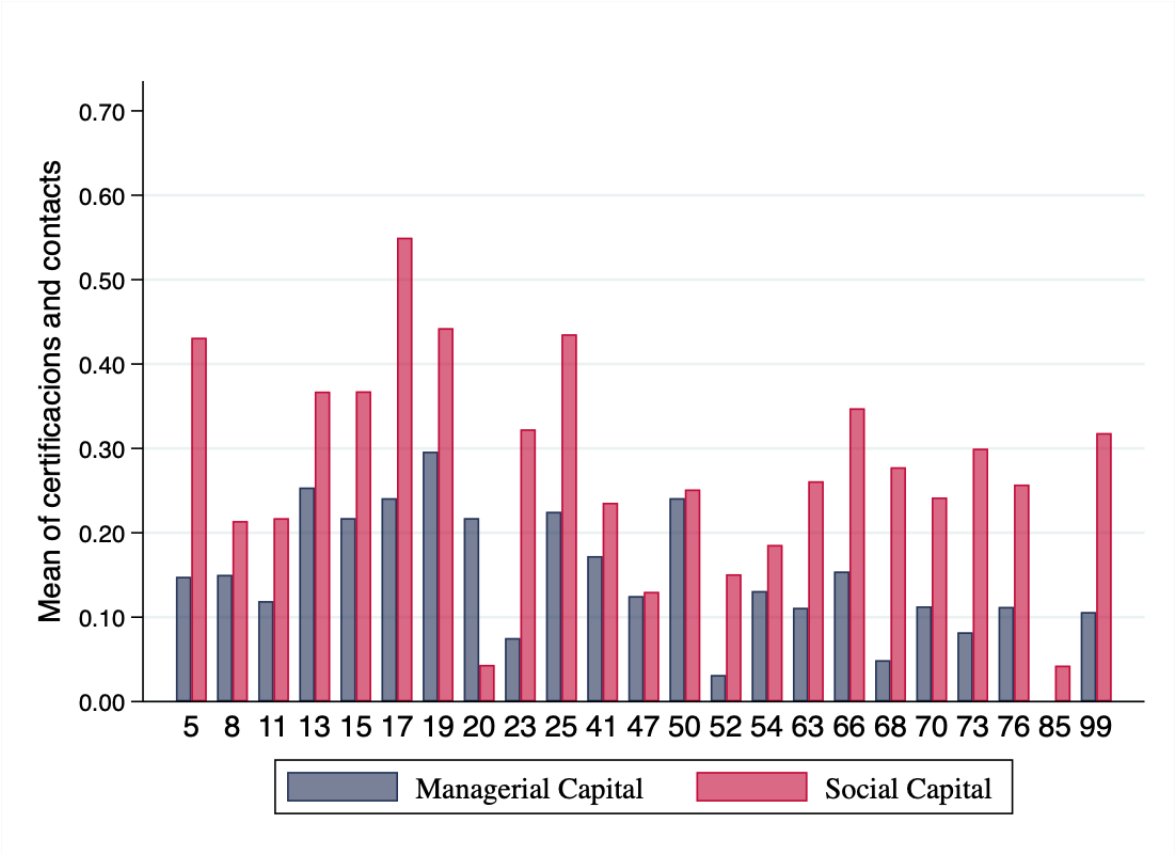
Note: Intensive margin represent the mean of the number of process certifications and connections by each ISIC. *Source:* Authors calculations using the technological development and innovation survey (EDIT).

Figure 4: Proportion of firms with social and managerial capital by Region.



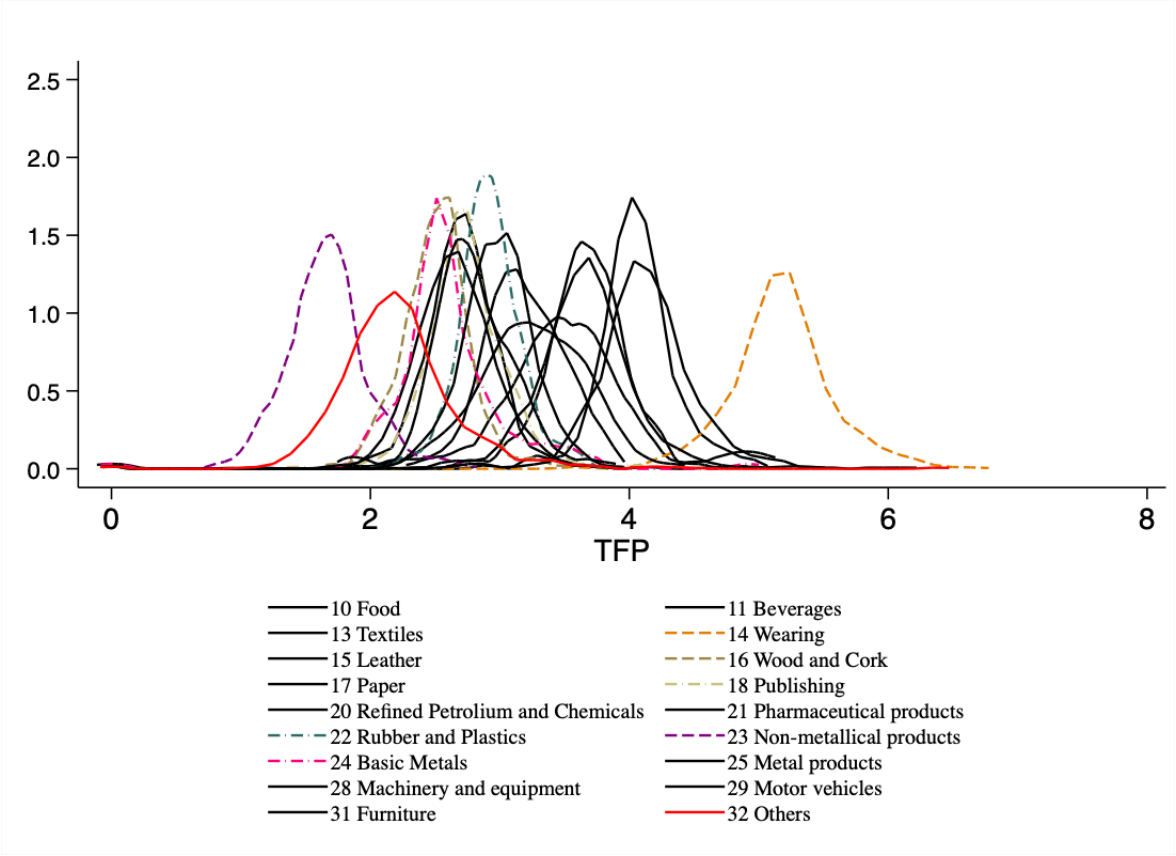
Note: Extensive margin represent the mean of the firms which has at least one process certification and at least one connection by each Region. *Source:* Authors calculations using the technological development and innovation survey (EDIT).

Figure 5: Average level of social and managerial capital by Region.



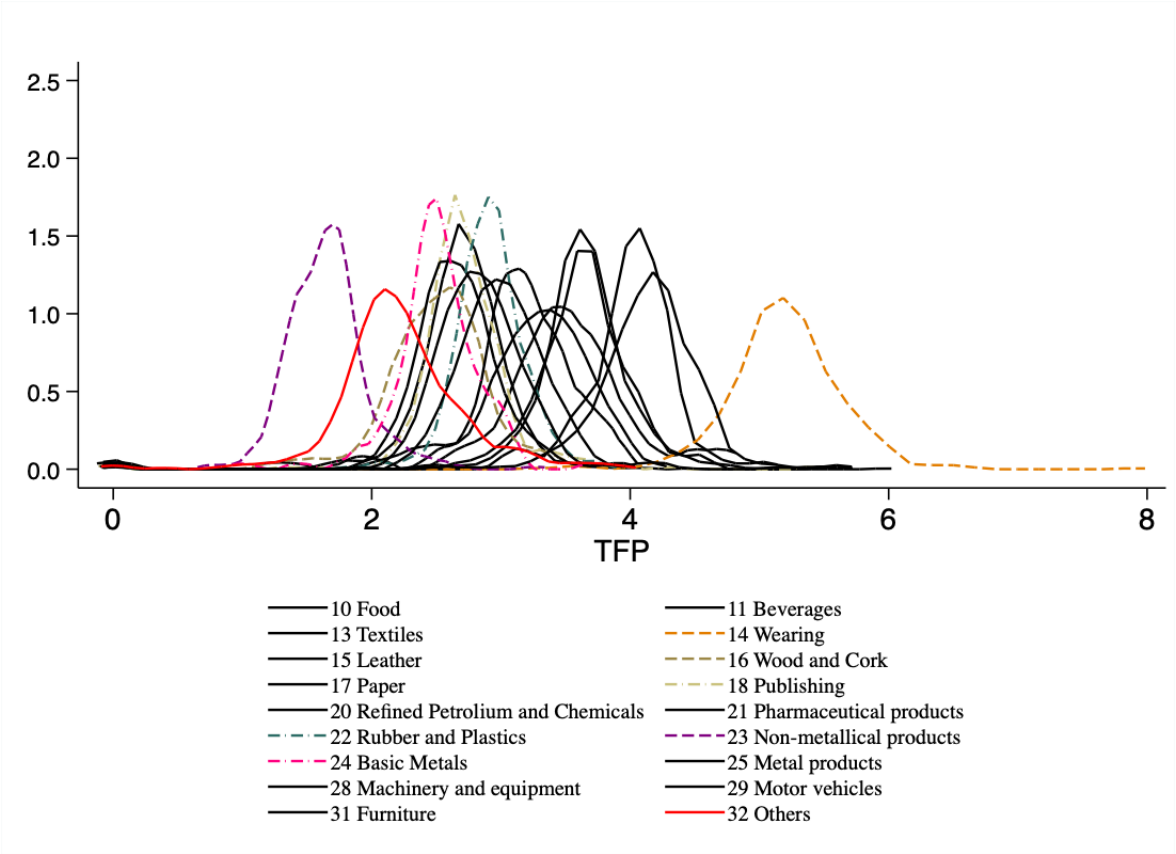
Note: Intensive margin represent the mean of the number of process certifications and connections by each Region. *Source:* Authors calculations using the technological development and innovation survey (EDIT).

Figure 6: TFP distribution by sector 2014.



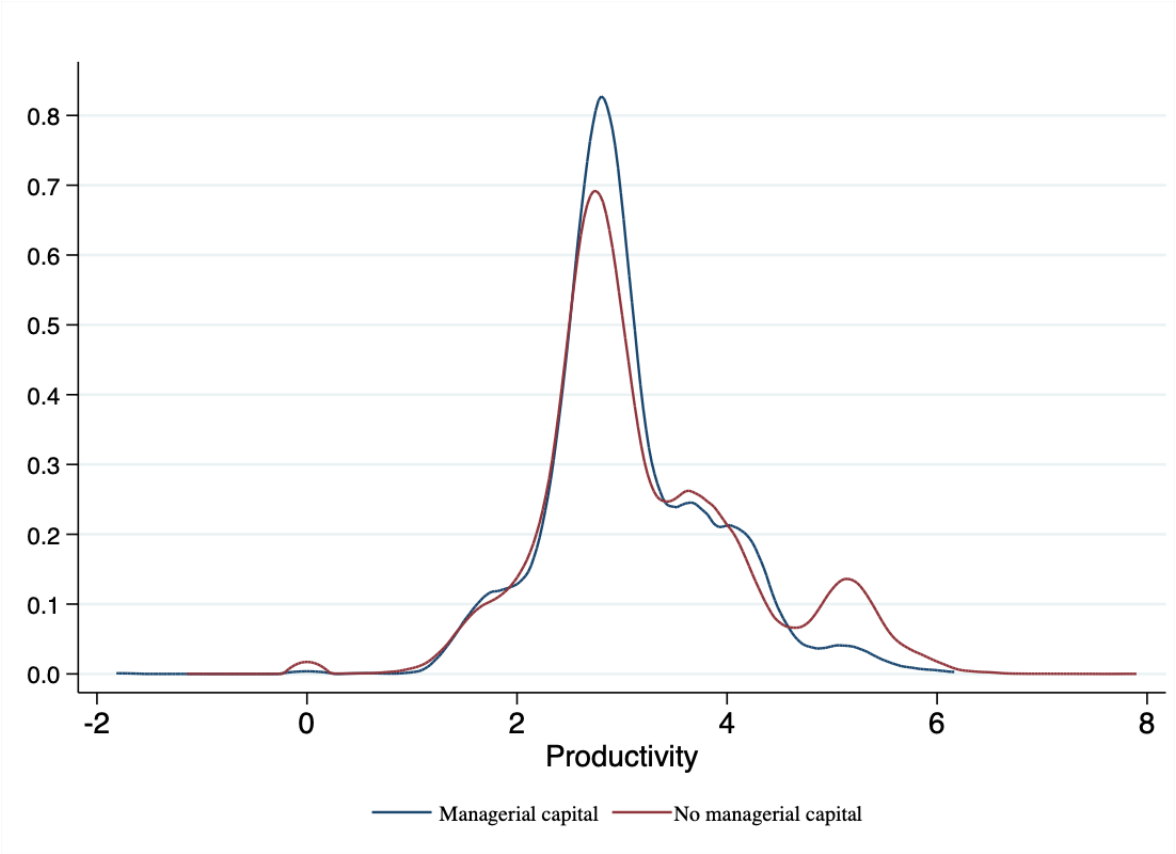
Source: Authors calculations using the technological development and innovation survey (EDIT) and the manufacturing annual survey (EAM).

Figure 7: TFP distribution by sector 2018.



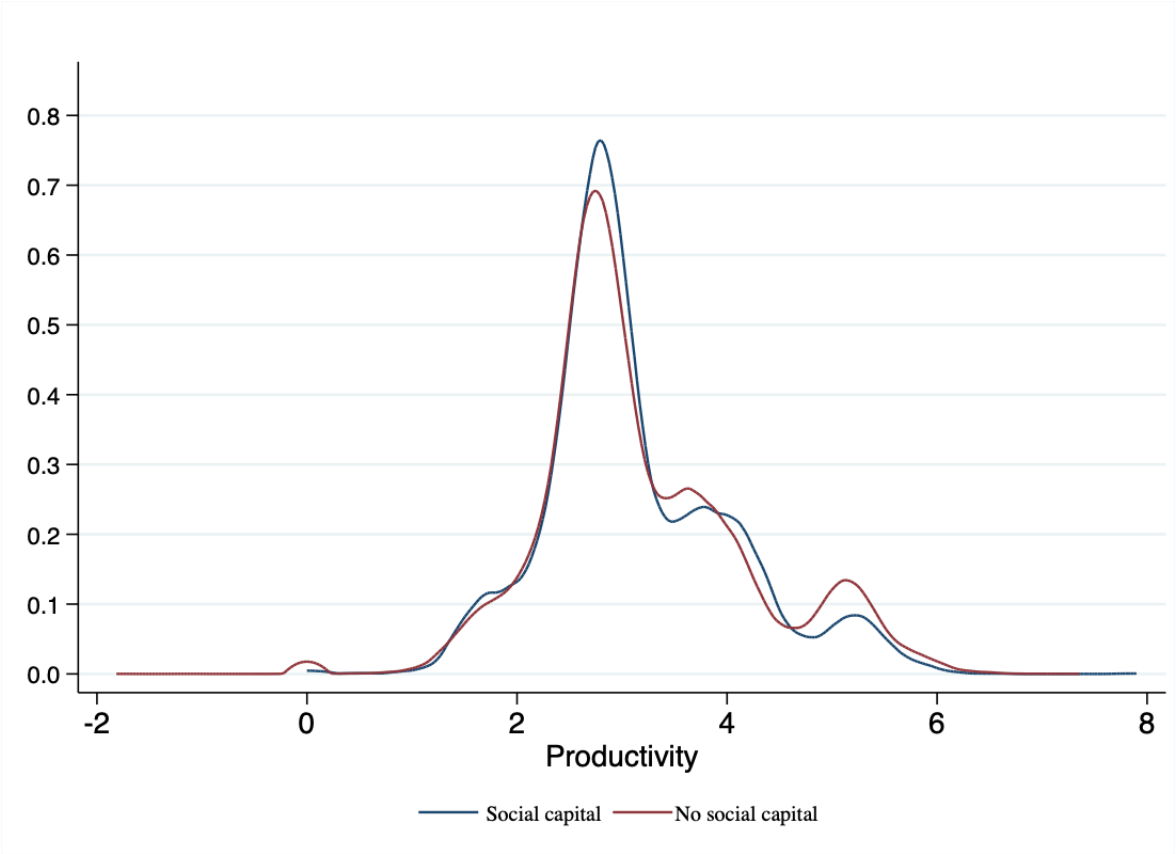
Source: Authors calculations using the technological development and innovation survey (EDIT) and the manufacturing annual survey (EAM).

Figure 8: Density function of productivity by managerial capital incidence.



Source: Authors calculations using the technological development and innovation survey (EDIT).

Figure 9: Density function of productivity by social capital incidence.



Source: Authors calculations using the technological development and innovation survey (EDIT).