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MANAGERIAL TALENT AND MANAGERIAL PRACTICES: ARE THEY COMPLEMENTS?

by Audinga Baltrunaite, Giulia Bovini and Sauro Mocetti*

Abstract

We examine the role of managerial talent and its interaction with managerial practices in determining firm performance. We build a matched firm-director panel dataset for the universe of limited liability companies in Italy, tracking individuals across different firms over time. We define managerial talent as their capacity to boost firms' total factor productivity, estimated in a two-way fixed effects model. Combining the data with survey information on a representative sample of firms, we then document that our measure of talent correlates with ex-ante and ex-post indicators of ability, i.e., managers' educational attainment and forecasting precision of the firm's future performance. Most important, we leverage information on the adoption of managerial practices within the firm to examine potential synergies between managerial talent and structured managerial practices, thus building a bridge between two separate strands in the current literature. While talent and structured practices do boost firm productivity on their own, there is evidence of complementarities between the two. These findings hold both in a cross-sectional setting and in a panel analysis that accounts for time-invariant firm heterogeneity. Overall, our results indicate that the effectiveness of managerial practices depends on the managers' ability to use them.

JEL Classification: Board of directors, managers, corporate governance, productivity, managerial practices.
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1 Introduction*

The productivity differences among firms are strikingly large (Melitz, 2003; Syverson, 2011).[1] Several studies argue that such heterogeneity can be determined by management quality, both in terms of people who run the firm (e.g., Bertrand and Schoar, 2003) and practices adopted within the firm (e.g., Bloom and Van Reenen, 2010). The two strands of literature, however, have run on parallel paths: up to date, very little is known about the interaction between the talent of firm leaders and the adoption of structured managerial practices in influencing firm performance (Syverson, 2011; Gibbons and Henderson, 2013). This stands at a sharp contrast with the common wisdom that the effectiveness of tools may to a large extent depend on the ability of their masters. For example, while some practices in principal may appear optimal (e.g. promotion of competent employees), their efficiency in practice may largely depend on the talent of managers who adopt them (e.g. decide whether an employee is competent or not).

Following this rationale, we use unique administrative and survey data on Italian firms and their managers to explore the presence of complementarities between management talent and managerial practices in explaining the firm-level total factor productivity (TFP henceforth). First, we derive a measure of time-invariant and portable component of talent for individuals responsible for the key corporate decisions. To do so, we build a matched firm-director dataset covering the universe of the non-micro limited liability companies in Italy and identities (and personal characteristics) of their directors. The data cover the period

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[1] In a typical four-digit manufacturing industry in the U.S., establishments at the 90th percentile of total factor productivity distribution make almost twice as much output with the same inputs as plants at the 10th percentile (Syverson, 2004).

2005-2018, tracking individuals across different firms over time.[2] Our proxy for managerial talent is based on the director fixed effect in a two-way fixed effects model – inspired by the work of Abowd et al. (1999) – and represents the individual contribution to the variation of the firms' TFP, conditional on firm fixed effects and sectoral and geographical non-parametric time trends. The average of the estimated director fixed effects at the firm level is, therefore, our measure of its management talent.

We find evidence that managerial talent matters for the firm productivity which rises when a better manager takes charge. The estimated impact is sizable: a one standard deviation change in management talent leads to about three fourths of a standard deviation variation in the firm performance. Including management talent in a regression of firms' TFP on firm-fixed effects increases the predictive power of the model by 19% (adjusted R-squared rises from 0.54 to 0.64). This impact is in the ballpark of the estimates obtained by previous studies (Bertrand and Schoar, 2003; Graham et al., 2012).[3] We also document the heterogeneity of the talent role across different firms and across different contexts in which they operate. Namely, the effect grows with firm size and age (and, arguably, the complexity of organizational processes to be managed within the firm) and it is larger in firms exposed to higher competition (e.g., in more agglomerated areas or in sectors more exposed to international trade).[4]

We then combine our data with information from a yearly survey conducted by the Bank of Italy. First, we document that our talent measure correlates with other (observable) proxies for leaders' talent: individuals we identify as talented managers more often possess ade-

[2]We exclude firms constantly below the 20-employee-threshold in the period analyzed in order to consider companies above a minimum threshold of size and, therefore, complexity. Moreover, in this way we impose a common size threshold across the different data sources used in the paper.

[3]The estimation of managerial talent via a high-dimensional two-way fixed effect model relies on the assumption that sorting of directors into companies is as good as random, conditional on firm time-invariant characteristics and other observed covariates. The empirical tests of this assumption lead to a conclusion that endogenous sorting based on the idiosyncratic value of the match or on the transitory component of firms' productivity does not seem to be relevant in this setting. Yet, there is some evidence of sorting based on the trend component of productivity, thus suggesting that our estimates of the contribution of managerial talent to a firm TFP could be slightly overstated in levels.

[4]These results mirror those by Bloom and Van Reenen (2010) with reference to the managerial practices.

quate education or training, and are better in precisely forecasting the firm's performance.[5] In other words, both ex-ante and ex-post ability measures validate the informational content in our talent indicator.

Finally, we use the information on management practices to explore their role – on their own or in combination with managerial talent – in determining firm performance. Namely, we exploit ad-hoc questions on firm organization and the adoption of managerial practices in the 2010 and 2019 waves of the survey. We find that the use of structured managerial practices boosts firm productivity on its own and, most importantly, there is evidence of synergies with managerial talent. Our results are sizable and statistically significant. The main impact comes from the use of specific schemes to measure performance, the proper definition of operational targets and the adoption of performance-based workforce promotion systems. Furthermore, the latter feature of structured management is observed both in the 2010 and 2019 survey waves, allowing us to estimate panel specifications that exploit within-firm variation and control for observed and unobserved firm heterogeneity. In quantitative terms, the adoption of a performance-pay system is associated to a nearly 9% increase in the TFP, while moving from the 25th to the 75th percentile of the managerial talent distribution is associated to a 21% increase of the TFP. Interestingly, the same increase of managerial talent leads to a further 8% increase of the TFP if associated to the adoption of performance-related workforce remuneration, indicating the presence of significant complementarities between management talent and performance-based pay.

Our paper is related to a growing literature examining the role of managers. In a seminal paper Bertrand and Schoar (2003) examine top executives (e.g., CEOs, CFOs, Presidents, etc.) who manage at least two firms in their sample period and find that the individual manager fixed effects are significantly correlated with firms' performance.[6] Other studies

[5]Malmendier and Tate (2005) and Ben-David et al. (2013) show that managerial overconfidence and miscalibration can account for significant corporate investment distortions.

[6]In a similar vein, Lieberman et al. (1990) find that manager fixed effects are significant in explaining productivity variation in the U.S. and Japanese automobile industry. Interestingly, Graham et al. (2012) identify manager fixed effects using both individual-level regressions – where the dependent variable is manager compensation – and firm-level regressions – where the outcomes are different indicators of firm

exploit a similar strategy to identify manager fixed effects within a single firm or organization (Lazear et al., 2015; Fenizia, 2020).[7]

Another strand of literature has emphasized the role of managerial practices. In a seminal paper, Ichniowski et al. (1997) find that the adoption of advanced management practices (e.g. incentive pay and employee participation in problem-solving teams) are significantly correlated with plant-level productivity. The interest in this topic has increased enormously thanks to the surveys managed by Bloom and Van Reenen and their research team, who collect information on managerial practices at the plant level for a wide set of industries and countries. Bloom and Van Reenen (2007) and Bloom and Van Reenen (2010) contain a comprehensive analysis of the relationship between management practices and productivity. Bloom et al. (2013) find a large causal role for such management practices in a field experiment with Indian textile plants.[8]

Our paper contributes to the existing literature along two main directions. First, our measure of managerial talent is close to Bertrand and Schoar (2003) and to the subsequent papers based on a similar two-way fixed effect model. We extend their analysis by exploiting additional sources of variation due to board-interlocking and, more importantly, by using a larger and more representative sample of firms. In fact, the empirical evidence on the importance of managers for firm performance is typically carried out on small and not representative samples: Bertrand and Schoar (2003) base their analysis on the sample of 500 CEOs of large publicly traded companies; Lazear et al. (2015) and Fenizia (2020) focus instead on a single large firm operating in service or public sector, respectively, with the sample

performance as in Bertrand and Schoar (2003). They find that manager fixed effects in compensation are significantly correlated with manager fixed effects estimated in the regression of firm outcomes.

[7]Instead of focusing on manager fixed effects, other related studies investigate the role of managers' characteristics on firm performance: Bennedsen et al. (2007) show that family CEOs have a negative causal effect on firm performance; Kaplan et al. (2012) document how differences in CEOs psychological traits explain the performance of the firms they manage; and Bandiera et al. (2020) build an individual-level index of behavior by parsing CEOs diaries and find that "leaders" are more likely to manage more productive and profitable firms. Partly related, Adams et al. (2018) and Bernile et al. (2018) examine the role of skill composition and diversity of the boards on firm performance.

[8]See Giorcelli (2019) for long-run causal effect of management on firm performance. See Lazear and Shaw (2007) for an analysis on human resource management practices like compensation, hiring practices, and teamwork.

size limited to several hundred individuals.[9] The larger sample size allows us to explore the role of managers' quality in smaller firms and to examine heterogeneity of the effects. Last, but not least, we further enrich our data with survey information to examine correlation with other firm characteristics often unobserved by researchers, such as education of the firm leader or the firms' ability to forecast its future performance.

Second, we examine the complementarities between managerial talent and the use of managerial practices bridging the gap between two different strands of literature that have examined these factors separately.[10] Previous research shows that the same "best practice" or innovation may produce heterogeneous results across firms, possibly due to the presence of complementarities among production inputs and/or different organizational features (Brynjolfsson and Milgrom, 2013). Our results show that talented managers – the actors responsible for main strategic and organizational choices within the firm – are able to extract more value added from the same managerial practice. Overall, our results indicate that able leaders are valuable to the firm not only because of wise decisions they make, but also because of how such decisions are put in practice.

The structure of the paper is as follows. Section 2 describes the data and variables. Section 3 discusses the construction of our measure of managerial talent and provides descriptive evidence. Section 4 examines complementarities between managerial talent and managerial practices. Section 5 concludes.

[9]Similarly, the literature on managerial practices relies on detailed data on a moderate number of firms. For example, Bloom and Van Reenen (2007) explore managerial practices of around 700 firms in the U.S., the U.K., France, and Germany, while Bloom and Van Reenen (2010) - of around 6000 large firms in 17 countries worldwide.

[10]One notable exception is Bender et al. (2018) who examine complementarities between managerial practices and managers, although the latter are not directly observed and proxied with the employees at the top quartile of the skill distribution. See Cornwell et al. (2021) for an analysis on the relationships between management practices and workforce composition.

2 Data and variables

The analysis relies on three main datasets. First, we use the *Infocamere* database which is based on administrative data on the Italian firms gathered by provincial Chambers of Commerce. It contains information on the registration data of the universe of Italian limited liability firms. Most important, this dataset includes personal information on firms' stockholders and directors, i.e., name, surname and personal identification code. We use this information to identify the governance structure and the age, gender and place of birth of the directors.

Limited liability firms are typically organized under the traditional corporate governance model, whereby firm's stockholders appoint the governance body.[11] In particular, key corporate decisions may be concentrated in the hands of a single director (*amministratore unico*) or granted to a collegial governance body, i.e., the board of directors (*consiglio di amministrazione*). Director selection is essentially unregulated, as there are no restrictions regarding directors' independence, their stock ownership, previous experience or education.[12] While directors have the standard – advising and monitoring – duties, their *de facto* primary role is that of running the company as they are naturally small. Motivated by these considerations, we interchangeably use the terms *directors* and *managers* throughout the paper.

Second, we use the database managed by the *Cerved Group* which gathers balance sheet information of the universe of the Italian limited liability firms in the private non-financial sector. The dataset includes the value added and the revenues of the firm, its productive inputs and other anagraphic information such as firm's age, sector of economic activity and the municipality where the headquarter is located.[13] We use balance sheet information to

[11] The 2003 Italian corporate law reform introduced the possibility for joint-stock companies (*società per azioni*) to adopt a two-tiered model or a one-tiered model in alternative to the traditional one. The adoption of these new governance structures, however, remained remarkably low (less than 1% of firms in the universe of limited liability companies).

[12] See Baltrunaite et al., 2019 for descriptive analysis on the characteristics of directors in Italian companies.

[13] For obtaining information about firms' employees, we have also used firm-level data drawn from social security records (*INPS* dataset), which contains the distinction between (middle) managers, white- and blue-collar workers and their corresponding monthly wages. This enables us to construct efficiency units as alternative to total employment at the firm level, giving different weights to (middle) managers, white- and

compute the TFP using the Levinsohn and Petrin (2003) estimator with the Ackerberg et al. (2015) correction.

Our main sample (i.e., the matched firm-director panel dataset) comprises all the firms included in the intersection of the *Infocamere* and *Cerved* databases for the years from 2005 to 2018 (the longest panel for both datasets) for which there are available data to compute measures of firm performance. We exclude from the analyisis the micro firms and we restrict the analysis to the private non-financial sector.

Third, to validate our measure of managerial talent and to examine its complementarity with structured managerial practices, we merge our data with the Bank of Italy Survey of Industrial and Service Firms (*Invind*), containing yearly information on firm organization for a representative sample of firms with at least 20 employees operating in the private non-financial sector. In particular, each wave contains firm's forecast about future performance, while the 2006 wave includes information on the education level of the firm leader. Concerning firm organization and managerial practices, the 2010 wave contains questions on the presence and the extent of team work in the production process, the adoption of performance-related pay, and employees' involvement in the decision-making within the firm. Moreover, the 2019 wave contains a special section on the structured managerial practices, including questions drawn from the Management and Organizational Practices Survey (MOPS) described in Bloom et al. (2019). Specifically, the survey contains 8 management questions in three main areas: monitoring, targets, and incentives. The monitoring section asked firms about their collection and use of information to monitor and improve the production process. For example, the survey asked, "How many key performance indicators are monitored in your firm?" with response options ranging from "none" to "10 or more". The targets section asked about the design, integration, and feasibility of production targets. For example, the survey asked, "How easy or difficult is it in your firm for people to typically achieve their operational targets?" with answers ranging from "Possible to achieve without much effort" to "Only possible to achieve with extraordinary effort". Finally, the incentives sec-

blue-collar, with weights being proportional to the relative wage premia.

tion asked about bonus, promotion, and reassignment/dismissal practices. For example, the survey asked, "How were workers promoted in your firm?" with answers ranging from "no promotion" or "mainly on factors other than performance and ability, for example tenure or family connections" to "solely on performance and ability".

It is worth noting that, although the structure and nature of the questions in the two waves is different, it is possible to construct an indicator capturing – for each firm in two points in time – the adoption of performance-pay systems. Although we cannot properly identify the intensive margin (i.e., how important it is in the remuneration of the worker), we can nevertheless analyze the extensive one (i.e., its adoption or not) within firm in a panel setting.

3 Measure of managerial talent

Good manager characteristics reflect observable (and, ideally, observed) personal traits such as education, qualifications or previous experience. Moreover, they do comprise also unobserved ones, such as ability, charisma or leadership skills. Throughout the paper, we define talent as the individual portable and time-invariant contribution that a director brings to the TFP of the firm that she/he runs. Following this definition, the talent can be captured by the director's fixed effect in a regression that explores the determinants of firms' TFP. The idea that the talent of organization leaders can be measured by their fixed effects is present in the seminal work of Bertrand and Schoar (2003) on the role of top managers' identities on corporate policies of U.S. largest companies. More recently, it has been exploited in other settings by Graham et al. (2012), Lazear et al. (2015), Best et al. (2019) and Fenizia (2020).

3.1 Connected set of firms and directors' mobility

A two-way estimation of directors' and firms' fixed effects can be done, as shown by Abowd et al. (1999) (AKM, henceforth), insofar as there are directors who hold a seat in multiple

firms, either in the same year or over time.[14] The existence of such directors allows to separately estimate directors' and firms' fixed effects within each set of firms that are connected via directors' mobility and interlocking.

We observe around 470,000 directors (Table 1) of over 140,000 limited liability companies in our panel (Table 2). Nearly one fifth of the directors in our sample are observed in at least two different firms over the period considered in the analysis and we refer to such directors as "movers" in the remainder of the paper. The category of movers comprises individuals who are involved in the management of more than one firm either due to board interlocking or due to switching (i.e., the same manager moves from one firm to another over time). As shown in Figure 1, about 11% of the directors sit every year on boards of two different firms (9% in two firms, nearly 3% in three or more firms). Moreover, every year about 6% of the directors exit from or enter into the board of a firm. In our sample period, about 15% of the directors move at least once (8% at least twice).[15]

In our analysis, we focus on the largest connected set of firms. This set includes 44% of firms with more than 20 employees and around 57% of their directors. Table 1 displays the observable characteristics of directors, separately for movers and non-movers, in the universe of the Italian limited liability companies (columns 1-2) and in the largest connected set of firms (columns 4-5). Columns 3 and 6 show whether differences between movers and non-movers within each of the two samples are statistically significant or not. Among the directors, nearly 80% are male and the corresponding figure is even larger among movers, indicating that men are more often involved in managing more than one firm. Furthermore, directors in the movers sample appear to be more often native Italians, born outside the province in which the firm is located and slightly older. The differences between mover and non-mover directors in the largest connected set are similar to those in the entire sample.

Table 2, columns 1 and 2 display the observable characteristics of firms in the largest

[14]The AKM model was first used to separately estimate the effect of workers' and firms' time-invariant characteristics on individual wages. Card et al. (2013) provide a neat and detailed application of the AKM method to explain the drivers of the increasing wage inequality observed in West Germany.

[15]We provide additional information on the labor market of corporate directors in Appendix A.1.

connected set and other firms, respectively, while column 3 shows the test of statistical significance of the difference between the two samples. Firms in the largest connected set have 97 employees, on average, against the average size of 35 employees in other firms.[16] Figure 2 illustrates the distribution of firms in the largest connected set by their size category. The left panel shows that the majority of firms in the largest connected set are small, representing 67% of the total (medium-sized and large firms, respectively, correspond to 27% and 6% of the total). Importantly, the right panel shows that the largest connected set is more representative of the universe for medium-sized and large firms, as it contains 63% and 86% of the total in these categories. Moreover, Table 2 reveals that firms in the largest connected set are also older and less likely to be located in Southern Italy, suggesting that firms' networks, defined in terms of their directors' linkages, are seemingly more dense in Northern and Central Italy. Finally, firms in the largest connected set are more often managed by a board of directors, on average composed of three components.

3.2 Estimation

The largest connected set consists of N firms and each firm i is observed over T_i years. We have therefore an unbalanced panel of $T = \sum_{i=1}^{i=N} T_i$ firm-year observations. In each year t a firm i is run by one or some among J directors, whose identities are known to us. This allows us to estimate the following high-dimensional two-way fixed effect model:

$$y = F\alpha + D\psi + X\beta + \varepsilon \tag{1}$$

y is a $T \times 1$ vector whose j-th element is the TFP of firm i in period t;[17] F is a $T \times N$ matrix that collects firm dummies; D is a $T \times J$ matrix that collects directors dummies; X is a $T \times K$ matrix of year dummies; ε is the $T \times 1$ vector containing the error terms.

The OLS estimation of equation (1) provides a meaningful estimate of the coefficients ψ of interest as long as directors do not systematically sort into firms based on factors that are not

[16] In the international comparison, the firms in our connected set are rather small: the average establishment size (arguably even smaller than firm size) in Bloom et al. (2019) is 180 employees.

[17] We use a measure of TFP that has been purged of sector-year and province-year fixed effects.

observed by the econometricians and are thus included into the error term. As specification (1) features firm fixed effects, sorting based on companies time-invariant characteristics would not constitute a threat to identification. Following Card et al. (2013) we assume that the error term is composite and captures three forms of endogenous mobility: first, mobility patterns that depend on the idiosyncratic component of the firm-director match; second, mobility patterns based on the drift/trend component of firm TFP; third, mobility patterns that arise as a response to the transitory component of firm TFP. This amounts to assuming that directors do not sort into firms based on their comparative advantage. Moreover, directors should neither systematically leave or join firms whose productivity is declining or increasing over time, nor companies which experience a sharp change in their productivity. In sub-section 3.4 we discuss the validity of these assumptions in our setting.

Figure 3 shows the distribution of directors' and firms' fixed effects, estimated based on specification (1). Both sets of fixed effect display a considerable dispersion, suggesting that there is substantial variation in directors' talent and firms' efficiency.[18] After estimating individual fixed effects, we derive our measure of time-varying managerial talent available to the firm q as the average of its director fixed effects in any given year. We therefore compute:

$$q_{it} = \frac{\sum_{j \in J_{it}} \psi_j}{\sum_{j \in J_{it}} 1} \tag{2}$$

where J_{it} is the set of directors who run firm i in year t.

3.3 Managerial talent and firm productivity

In Table 3 we explore how much our measure of managerial talent available to the firm explains the variation in TFP. We begin by estimating a parsimonious model that only features sector-year and province-year fixed effects (column 1) and has a considerably low explanatory power. The model which adds firm fixed effects in column 2 has the adjusted R^2

[18] Also the dependent variable, a firm TFP, is highly dispersed: in our data, the output of firms at the 90th percentile of TFP distribution is three times larger than that of firms at the 10th percentile (keeping constant the inputs).

equal to 0.54. In column 3 we further include the average observable board characteristics (i.e., gender, age, share of foreign-born and local-born director), but the explained variance of the model remains virtually unchanged. The inclusion of our measure of average managerial talent (q), in contrast, improves substantially the fit of the regression model (column 4): the adjusted R^2 goes up 0.64, corresponding to a 19% increase with respect to the previous specification. This finding suggests that variation in board talent explains a significant portion of variation of the firm TFP, with an elasticity of around 0.75.

In Table 4 we explore other measures of board talent, going beyond the simple average of directors' fixed effects. In particular, column 1 replicates the baseline result, while column 2 indicates that a more homogeneous distribution of the talent within the board (measured by the standard deviation of directors' fixed effects) positively affects the TFP. Column 3 shows that the overall level of talent matters more than just the talent of the most capable manager. In column 4 we examine the role of the executive directors. We observe this information only for a subset of firms. In order to overcome this data limitation, we attempt to identify executives within the board using their observable characteristics: instead of the simple average (as for the board talent), we use a weighted average of the directors fixed effect giving more weight to those who are more likely to be executives on the basis of the observables.[19] The impact of executives on the firm TFP has an order of magnitude that is comparable to that of the overall board talent. This is likely due to the fact that the average board size is relatively small – nearly half of the firms have at most two directors – and, in such cases, all directors have executive powers.

Table 5 explores heterogeneous effects of management talent. In line with the idea that more able managers are better at dealing with complex tasks, the effect of board talent increases both with firm size (column 1) and (non-linearly) with firm age (column 2). Column 3 shows that board talent has a stronger impact on firms in Northern Italy, while the effect

[19]Namely, we examine characteristics of the executives in the subsample of firms for which we are able to make this distinction within the board of directors. We find that executives are more likely male, natives, older, local and holding a share of the equity of the firm. Then we use these results to estimate the probability of being an executive on the basis of such observables.

decreases as we move to the Central and Southern parts of the country. Finally, columns 4 and 5, using a different and complementary perspective, show that managerial talent matters more in competitive environments. Indeed, the impact on the firm TFP is higher in urban and metropolitan areas than in rural ones – i.e., where agglomeration forces impose a tougher local competition – and in sectors more exposed to international trade. These findings mirror those obtained by Bloom and Van Reenen (2010), who show that product market competition is positively associated with the quality of management practices.

3.4 Validation and informative content of our measure of talent

Does our measure of talent meaningfully capture the portable and time-invariant ability of directors? To start with, we test the plausibility of the assumptions underlying the additive model of firms' efficiency and managerial ability postulated in equation (1). Based on a regression that controls for the interaction between firm fixed effects and board talent fixed effects, we document that endogenous sorting based on the idiosyncratic value of the match does not seem to be a relevant concern in our setting.[20] Furthermore, we examine the dynamics of TFP in the years preceding and following changes in the composition and the quality of the board and show that sorting based on the transitory component of firms' productivity does not seem to pose a serious threat in our setting. This exercise also reveals that the largest departure from the assumptions is related to sorting based on the trend component of productivity, i.e., more (less) talented directors appear to sort into firms whose performance is improving (deteriorating) over time. Although the data clearly exhibit a significant change in this trend upon the change in firm management quality, consistent with the TFP-enhancing talent effect, we acknowledge that our measure of managerial talent may be somewhat overestimated in levels (this bias, however, is neutralized in the estimates of the interaction terms).

An alternative strategy to validate our measure of managerial talent is to examine its correlation with other observable measures of ability. To this end, we combine our data with

[20]See the appendix A.2 for more details on the results of the validity checks proposed in Card et al. (2013).

the *Invind* survey information on firms' leaders and corporate performance. About 80% of the *Invind* sample firms are also present in the *Infocamere-Cerved* largest connected set. The combined *Infocamere-Cerved-Invind* sample includes around 6,200 firms. Compared to the overall sample, those firms are relatively larger (Table 2, column 4): the mean (median) size corresponds to 370 (90) workers. We use survey data to obtain *ex-ante* and *ex-post* indicators of ability, i.e., managers' educational attainment and forecasting precision of the firm's future performance.

The 2006 wave of the survey includes information on the level of education and on other anagraphic characteristics of the head of the companies. Exploiting these variables we identify the chief within the board of directors and examine whether his/her education is correlated with our measure of talent (Bloom et al., 2014). In particular, in Table 6 we regress managerial talent of the firm leader on his/her education attainment. The reference category comprises individuals with at most secondary school degree, while we estimate the coefficients of having a generic college degree, a college degree with some training in management and a college degree followed by a master or a PhD. The regression specification holds region, sector and firm size constant, and includes individual controls such as age or gender. The estimated coefficients indicate that while individuals with general college education are not characterized by higher talent, those with further training in management or post-graduate degrees are captured as high managerial talent leaders. This evidence is particularly compelling, given that the two exercises are based on completely different data and measurement approaches.

Being accurately informed about the company and the environment in which it operates is essential for making optimal corporate decisions, e.g., on the use of production factors and on the organization of the production process. A growing literature, in fact, has emphasized the importance of systematic errors in managerial forecasting in terms of investment decisions and firm performance (Malmendier and Tate, 2005; Ben-David et al., 2013). Using our survey data, we examine whether talented managers are associated with lower forecasting errors in the assessment of future firm performance. We define the forecasting error as the absolute

difference between the predicted firms' revenues in the current year for the following year and the realized firm revenues in the following year (Ma et al., 2020). This variable is available in every survey wave, providing as with a firm-level panel for the period 2005-2018. We regress the absolute value of the prediction error on our measure of managerial talent, controlling for firm and year fixed effects. Table 7 shows that our measure of managerial talent is negatively associated with forecasting errors made. The effect is sizable: a one standard deviation change in managerial talent is associated to more than a one fifth standard deviation change in the forecasting error (column 1). The estimated impact is confirmed when we control for sectoral and local economic cycles (column 2) and for firm-specific demand shocks (column 3). Overall, this evidence strongly suggests that talented managers possess a more accurate set of information to assess the business environment in which the firm operates and to gear corporate decisions.

4 Complementarities

Modern production processes are complex – only rarely do they rely on using a single input. Typically, the final output is obtained from a combination of multiple factors; some of which are substitutes and can be used interchangeably, while others are complements. Following the definition in Brynjolfsson and Milgrom (2013), complementarities exist if the output produced by combining two or more economic factors in a production process exceeds what would have been otherwise generated through the use of the same factors in isolation. Generating such synergies allows to increase the "size of the pie" by merely combining different inputs rightly, without augmenting their quantity.

There is extensive evidence that differences in firm- and country-level productivity partly reflect variation in management practices (Bloom and Van Reenen, 2010). However, little is known on whether good managerial practices matter *per se* or whether they are complementary to the talent of those who implement them (Syverson, 2011).[21]

[21]See Bandiera et al. (2015) for an empirical analysis on the empirical links between firm governance, incentives, and performance.

To explore complementarities between managerial talent and managerial practices, we rely on the 2010 and 2019 waves of the *Invind* survey that include questions on the adoption of structured managerial practices within the firm. See Table 8 for the main descriptive statistics. Since the majority of questions differ in the two waves, we start by analyzing the two cross-sections of the data separately.[22]

We use the following cross-sectional regression specifications:

$$TFP_i = \alpha + \beta q_i + \gamma z_i + \theta q_i z_i + \rho x_i + \epsilon_i \tag{3}$$

where TFP_i is the firm's total factor productivity; q_i is the managerial talent; z_i is the managerial practices' score; x_i is a vector of firm-level controls (namely, the measure of firm quality, i.e. its fixed effect estimated in the largest connected set, sector, region and size fixed effects). The dependent variable and the key explanatory variables are all standardized, in order to guarantee an easier comparison of the relative size of the estimated effects and improve the readability of the results.

First, we condense the information contained in the three variables present in the 2010 wave that refer to firm-level organization and managerial practices into a composite indicator using the principal component analysis.[23] In Table 9 (column 1) we present the most parsimonious specification which includes the managerial score measure. The estimated coefficient confirms its positive effect on firm efficiency, in line with the existing literature. In column 2 we augment the specification with our measure of managerial talent; positive and significant coefficients on both variables show that, on average, each of them contributes positively to firms' efficiency, although the coefficient for the managerial score index is nearly halved, plausibly due to its positive correlation with the measure of managerial talent. In column 3 we add the interaction between the two terms. In column 4 we show that this

[22] See Figure A.7 in the Appendix for the questions asked in each wave.

[23] The first principal component explains about 66% of the total variance of the underlying variables and is positively associated, as expected, with each of the input variables. We use the first principal component as the main explanatory variable of interest, as it is well-suited to capture a multidimensional phenomenon such as the managerial and organizations structures. Moreover, the large fraction of variance explained by the first component is reassuring about the informational content of this variable. Nevertheless, for the easier interpretation of the results, we also replicate the analysis using the three single items separately.

relationship is robust to inclusion of firm-level controls. These findings indicate that managerial talent and practices appear as complements - good practices matter more for firm productivity if they are adopted by talented managers.

In Table 10, we examine the separate components of managerial practices in isolation, with an aim to shed some light on what features of structured organization are more productivity-boosting and for which of them the presence of talented manager is more relevant. More specifically, we explores the role of team work (column 1), the adoption of performance-pay systems (column 2) and the involvement of lower hierarchical layers in the decision-making processes (column 3). The coefficients on the interaction terms show that the presence of complementarities is primarily due to synergies between managerial talent and performance-pay. The interaction with the higher participation in decision-making exhibits a positive sign, yet it is not significant to the conventional levels. Moreover, complementarities seem to be absent for the team-work. Not surprisingly, the presence of good managers enhances the efficiency of those practices which require the direct involvement of top management of the company. For example, performance-pay is more effective in firms where top managers who set the employee objectives and assess their performance are talented. Similarly, higher workforce inclusion in decision-making may deliver better results in firms where talented leaders are able to aggregate different opinions and to translate them into corporate strategies.

Table 11 turns to examining the 2019 wave and uses the regression specifications that are analogous to the ones in Table 9. We highlight two key advantages of using this wave. First, the managerial score is built as in Bloom et al. (2019) and therefore our results square well within the existing literature. Second, we use a pre-determined measure of managerial talent in these regressions: we estimate director fixed effects using director-firm panel for the period 2005-2018 and relate it to the TFP and management score in 2019. Therefore, the forward-looking bias of our talent estimates is mitigated by the fact that only past firm performance is used to determine the ability of directors. The regression results show that the managerial score is significantly correlated with firm productivity and, more importantly,

a significant coefficient on the interaction term between managerial score and talent confirms the existence of synergies between the two.

We then explore the interaction between managerial talent and each of the 8 items used to derive the managerial score. In the interest of brevity, we plot the coefficients on the interaction term in Figure 4. Although all coefficients are positive, they are statistically significant in half of the cases. More precisely, the interaction term is significant for the number of monitored performance indicators, the frequency with which they are reviewed, the time frame of the operational targets and the criteria on which promotions are based.

Last, but not the least, for the subset of questions that were asked both in 2010 and 2019, we build a two-year panel. Although this exercise is more narrow in scope, it serves as an important robustness check allowing to argue that our results do not stem from the time-invariant firm-level confounders, jointly determining the presence of the complementarities and the firm performance. Indeed, the importance of "management panel data" has been greatly emphasized by Bloom and Van Reenen (2010), Syverson (2011)) and Bloom et al. (2019). For a sub-sample of 168 firms we jointly observe the TFP, our measure of board talent and the existence of performance-pay systems in both survey waves. For this sample we run the following panel regressions which exploit the within-firm variation in our variables of interest:

$$TFP_{it} = \alpha + \beta q_{it} + \gamma z_{it} + \theta q_{it} z_{it} + \rho_i + \tau_t + \epsilon_{it} \tag{4}$$

where TFP_{it} is the firm's total factor productivity in 2010 and 2019; q_{it} is the time-varying measure of managerial talent; z_{it} is an indicator equal to 1 if the firm has a performance-pay system and is, again, time-varying; ρ_i and τ_i are firm- and year-fixed effects, respectively.

Table 12 shows that firms that adopt incentives related to performance between 2010 and 2019 increase their TFP (column 1). The positive impact of the adoption of these schemes is confirmed when we control for managerial talent (column 2), although the point estimate is slightly lower. Moreover, an increase in managerial talent is also associated to a significant improvement in firm productivity. Finally, the coefficient on the interaction term

is positive and statistically significant (column 3), revealing the presence of complementarities between acquisition of structured management practices and hiring of talented managers. In quantitative terms, the coefficients estimated in the last column show that the adoption of a performance-pay system is associated to a nearly 9% increase in the TFP, while moving from a firm at the 25th to one at the 75th percentile of board talent is associated to a 21% increase of the TFP. Interestingly, the same increase of managerial talent leads to a further 8% increase of the TFP if associated to the adoption of performance-related workforce remuneration.[24]

5 Concluding remarks

This paper explores the presence of complementarities between talended management and structured managerial practices in determining firm-level productivity. The analysis exploits a novel and rich dataset on Italian limited liability companies to derive a measure of time-invariant and portable component of talent for individuals responsible for the key corporate decisions. We present evidence that managerial talent matters on its own, contributing significantly to the firm's TFP. Importantly, our talent measure appears to be informative about other dimensions that proxy for talent. In particular, individuals whom we identify as talented managers more often possess adequate education or training, and are better in precisely forecasting the firm's performance.

Most importantly, we relate our measure of managerial talent to the detailed survey data on management practices to better understand their role separately and jointly in determining firm's performance. The data reveals synergies between managerial ability and managerial practices. While managerial talent and the use of good managerial practices do boost firm productivity on their own, there is evidence of complementarities between them.

While we admit our inability to make strong causal claims, our findings are new and intuitive. Although our measure of managerial talent relies on the assumption that, conditional

[24]See Lazear (2000) for a seminal paper on the relationship between incentive-based pay and productivity. Using a case study, he found that the adoption of incentive based pay was associated to a 44% increase in the output per worker.

on firm time-invariant characteristics and other observed covariates, the manager mobility across firms is exogenous, we detect evidence indicating that directors' fixed effects reflect (albeit noisily) true managerial acumen and talent.[25] Furthermore, the current literature still faces the chicken-egg question regarding manager selection and managerial practices. On the one hand, structured managerial practices may facilitate the match between firms and talented managers. On the other hand, the causality may run in the other direction, if talented managers happen to implement better organizational and managerial practices. Even though both explanations remain plausible, our novel evidence is interesting because it documents the positive interaction between the two factors in affecting firm performance: more talented managers are better able to make use of structured managerial practices.

Drawing policy implications in the field of corporate governance is difficult, because the manager selection and the adoption of certain organizational practices are decisions ultimately taken within the firm. The public interventions may, nevertheless, affect the general environment in which firms operate. We find that higher education achievements are associated with higher managerial talent. The policy maker may, therefore, invest in human capital, thus improving – quantitatively and qualitatively – the talent pool from which managers are selected. We also find that managerial talent is more important in more competitive markets. Favoring market competition, therefore, may seem a powerful tool to increase management efficiency within the firm and across firms, e.g., by removing frictions in talent allocation within the economy. More generally, promotion of organizational and managerial culture may help spreading productivity-boosting practices in the private sector.

[25]Similarly, while managerial practices are not randomly allocated across firms, their causal impact on firm productivity has been documented in other studies (Bloom et al., 2013; Giorcelli, 2019).

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Tables and figures

Table 1: Descriptive statistics on directors

	(1)	(2)	(3)	(4)	(5)	(6)
	universe of firms			connected set		
	Non-movers	Movers	Δ	Non-movers	Movers	Δ
Female	0.249	0.143	0.107***	0.231	0.131	0.100***
Foreign-born	0.105	0.084	0.021***	0.109	0.082	0.027***
Age	49.623	51.277	-1.655***	50.187	51.733	-1.546***
Local	0.693	0.619	0.074***	0.666	0.603	0.063***
Shareholder	0.347	0.248	0.099***	0.220	0.198	0.023***
Talent				-0.005	-0.003	-0.002
Share	0.811	0.189		0.734	0.266	
N	472,067			269,927		

Notes: Data are drawn from the combined *Infocamere-Cerved* sample, including the universe of limited companies with more than 20 employees in the private non-financial sector in the years 2005-2018. Columns (1) and (2) report mean values for movers and non-movers for the full sample, while columns (4) and (5) report the same figures for the subsample of firms included in the largest connected set; Δ indicates the corresponding difference in means; N represents the total number of directors in the period considered.

Table 2: Descriptive statistics on firms

	(1)	(2)	(3)	(4)
	other firms	connected set	Δ	*Invind* sample
# employees	34.660	97.057	-62.397***	370.000
Firm age	14.231	18.107	-3.876***	30.800
# directors	1.874	3.229	-1.356***	4.430
% manufacturing	0.355	0.321	0.034***	0.603
% South	0.288	0.146	0.142***	0.252
TFP	-0.060	-0.040	-0.020***	-.0256
Share	0.559	0.441		
N	144,632			6,224

Notes: Data are drawn from the combined *Infocamere-Cerved* sample, including the universe of limited companies with more than 20 employees in the private non-financial sector in the years 2005-2018, in the first two columns and from the combined *Infocamere-Cerved-Invind* sample in the last column. Columns (1) and (2) report mean values for firms outside the largest connected set and within it, respectively; Δ indicates the corresponding difference in means; the last column reports mean values for the subsample of the connected firms included in the *Invind* survey. N represents the total number of firms in the period considered.

Table 3: Board talent and firm productivity: analysis of the variance

Dependent variable:	TFP					
	(1)	(2)	(3)	(4)	(5)	(6)
Industry × Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Province × Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE		Yes	Yes	Yes	Yes	Yes
Board characteristics			Yes	Yes	Yes	Yes
Board talent				0.761***		
				(0.005)		
Board FE					Yes	Yes
Board FE × Firm FE						Yes
Adj-R^2	0.024	0.536	0.536	0.637	0.658	0.634
N	479,038	479,038	479,038	479,038	479,038	479,038

Notes: Data are drawn from the combined *Infocamere-Cerved* sample in the years 2005-2018. Panel with fixed effects. The table shows how much of the variation of firm TFP is explained by: industry- and province-year FEs (column 1); firm FEs (column 2); the observable characteristics of the board of directors (column 3); the talent of the board (measured as the average of director fixed effects at the firm-year level), both as a continuous variable (column 4) and as a set of fixed effects corresponding to its centiles (column 5); the interaction between firm fixed effects and board talent fixed effects (column 6). Standard errors clustered at the firm level in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Table 4: Board talent and firm productivity: various measures of board talent

Dependent variable:	TFP			
	(1)	(2)	(3)	(4)
Board talent (mean)	0.761***	0.761***		
	(0.005)	(0.005)		
Board talent (sd)		−0.009**		
		(0.004)		
Board talent (max)			0.424***	
			(0.006)	
Executives talent (mean)				0.741***
				(0.005)
Firm FE	Yes	Yes	Yes	Yes
Industry × Year FE	Yes	Yes	Yes	Yes
Province × Year FE	Yes	Yes	Yes	Yes
Board characteristics	Yes	Yes	Yes	Yes
Adj-R^2	0.637	0.637	0.569	0.630
N	479,038	479,038	479,038	479,038

Notes: Data are drawn from the combined *Infocamere-Cerved* sample in the years 2005-2018. Panel with fixed effects. The table shows how much of the variation of firm TFP is explained by industry- and province-year FEs, firm FEs, the observable characteristics of the board of directors and the talent of the board. In column 1 board talent is the average of directors fixed effect at the firm-year level; in column 2 it is captured by both the average and the standard deviation of directors fixed effects; in column 3 board talent is the highest among directors' fixed effects; in column 4 it is the average of executive fixed effects. Standard errors clustered at the firm level in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Table 5: Heterogeneous effects

Dependent variable:	TFP				
	(1)	(2)	(3)	(4)	(5)
Board talent (BT)	0.745***	0.739***	0.823***	0.731***	0.685***
	(0.005)	(0.007)	(0.007)	(0.009)	(0.010)
BT × medium	0.054***				
	(0.008)				
BT × large	0.109***				
	(0.022)				
BT × age 10-30		0.005			
		(0.007)			
BT × age 30+		0.044***			
		(0.009)			
BT × Centre			−0.104***		
			(0.013)		
BT × South			−0.193***		
			(0.012)		
BT × urban area				0.037***	
				(0.013)	
BT × metropolitan area				0.048***	
				(0.013)	
BT × mid export					0.073***
					(0.013)
BT × high export					0.133***
					(0.014)
Firm FE	Yes	Yes	Yes	Yes	Yes
Industry × Year FE	Yes	Yes	Yes	Yes	Yes
Province × Year FE	Yes	Yes	Yes	Yes	Yes
R^2	0.677	0.677	0.678	0.677	0.677
N	479,038	479,038	479,038	756,283	479,038

Notes: Data are drawn from the combined *Infocamere-Cerved* sample in the years 2005-2018. Panel with fixed effects. The dependent variable is firm TFP. Board talent is interacted with various firm characteristics. The residual categories are small firm (column 1), aged less than 10 (column 2), North (column 3), rural area (column 4) and low export sectors (column 5). Standard errors clustered at the firm level in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Table 6: Managerial talent and education achievements

Dependent variable:	Managerial talent		
	(1)	(2)	(3)
College	0.039	0.049	0.070
	(0.052)	(0.053)	(0.054)
+ training in management	0.287*	0.303**	0.283*
	(0.148)	(0.145)	(0.145)
+ master/PhD	0.390**	0.407***	0.459***
	(0.154)	(0.156)	(0.163)
Individual controls		Yes	Yes
Firm controls			Yes
R^2	0.006	0.008	0.041
N	1,585	1,585	1,585

Notes: Data are drawn from the combined *Infocamere-Cerved-Invind* sample, using the the 2006 wave. OLS cross-section regression. The dependent variable is managerial talent of the firm leader while the explanatory variables are her/his education achievements: the reference category is "no college", while the estimated dummies refer to "college degree", "college degree plus a training in management of at least three months" and "college degree plus a master or a PhD". Individual controls include age and gender; firm controls include region, sector and size fixed effects. Standard errors clustered at the individual level in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Table 7: Managerial talent and forecasting error

Dependent variable:	Forecasting error		
	(1)	(2)	(3)
Board talent	-0.235^{***}	-0.231^{***}	-0.166^{***}
	(0.026)	(0.025)	(0.023)
Log of revenues			-0.520^{***}
			(0.048)
Firm FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Industry × Year FE		Yes	Yes
Region × Year FE		Yes	Yes
R^2	0.376	0.402	0.415
N	26,745	26,745	26,745

Notes: Data are drawn from the combined *Infocamere-Cerved-Invind* sample in the years 2005-2018. Panel with fixed effects. The dependent variable is the managerial forecast error defined as the absolute value of the percentage difference between the predicted revenues in the current year for the subsequent year and realized revenues in the subsequent year. Standard errors clustered at the firm level in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Table 8: Descriptive statistics on organization and managerial practices

	(1)	(2)	(3)	(4)
	Mean	Standard deviation	Min	Max
		2010 wave		
Managerial score	0.010	1.414	-1.663	3.264
Team Work	1.996	1.109	1.000	4.000
Performance pay	1.992	1.124	1.000	4.000
Decision-making	2.060	0.955	1.000	4.000
		2019 wave		
Managerial score	0.510	0.187	0.000	0.979
Monitoring score	0.586	0.237	0.000	1.000
Targeting score	0.613	0.275	0.000	1.000
Incentives score	0.365	0.262	0.000	1.000

Notes: Data are drawn from the combined *Infocamere-Cerved-Invind* sample. In the 2010 wave the managerial score is the first principal component of the following managerial practices: presence of team work, adoption of performance-pay and involmnent of lower hierarchical levels in the decision-making process. In the 2019 wave the managerial score is computed following Bloom et al. (2019) on the basis of 8 scores that can be aggregated in three groups: monitoring activity, targets and incentives. See the Appendix for the questions included in the survey and the associated scores.

Table 9: Complementarities: management talent and managerial score (2010)

Dependent variable:	TFP			
	(1)	(2)	(3)	(4)
Managerial score (MS)	0.110***	0.059**	0.056*	0.031
	(0.036)	(0.029)	(0.029)	(0.031)
Board talent (BT)		0.768***	0.766***	0.738***
		(0.063)	(0.064)	(0.066)
MS × BT			0.074*	0.072*
			(0.042)	(0.042)
Firm controls				Yes
R^2	0.012	0.409	0.415	0.459
N	836	678	678	678

Notes: Data are drawn from the combined *Infocamere-Cerved-Invind* sample, using the 2010 wave. OLS cross-section regression. The dependent variable is firm TFP while the explanatory variable is the managerial score (the first principal component of the following managerial practices: presence of team work, adoption of performance-pay and involmnent of lower hierarchical levels in the decision-making process). Firm controls include firm fixed effects - those estimated using the two-way fixed effect model described in specification (1) - and sector, region and size fixed effects. Standard errors clustered at the firm level in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Table 10: Complementarities: management talent and managerial practices (2010)

Dependent variable:	TFP		
	(1)	(2)	(3)
Board talent (BT)	0.740***	0.738***	0.741***
	(0.065)	(0.062)	(0.065)
Team work (TW)	0.023		
	(0.032)		
TW × BT	−0.023		
	(0.049)		
Performance-pay (PP)		0.058*	
		(0.031)	
PP × BT		0.183***	
		(0.046)	
Decision-making (DM)			−0.007
			(0.031)
DM × BT			0.028
			(0.043)
Firm controls	Yes	Yes	Yes
R^2	0.454	0.487	0.454
N	678	678	678

Notes: Data are drawn from the combined *Infocamere-Cerved-Invind* sample, using the 2010 wave. OLS cross-section regression. The dependent variable is firm TFP while the explanatory variables are the following managerial practices: presence of team work, adoption of performance-pay and involmnent of lower hierarchical levels in the decision-making process. Firm controls include firm fixed effects - those estimated using the two-way fixed effect model described in specification (1) - and sector, region and size fixed effects. Standard errors clustered at the firm level in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Table 11: Complementarities: management talent and managerial score (2019)

Dependent variable:	TFP			
	(1)	(2)	(3)	(4)
Managerial score (MS)	0.046*	0.045	0.039	0.012
	(0.026)	(0.028)	(0.027)	(0.030)
Board talent (BT)		0.748***	0.765***	0.786***
		(0.060)	(0.060)	(0.060)
MS × BT			0.124***	0.130***
			(0.038)	(0.039)
Firm controls				Yes
R^2	0.002	0.307	0.405	0.320
N	1,566	1,001	1,001	1,001

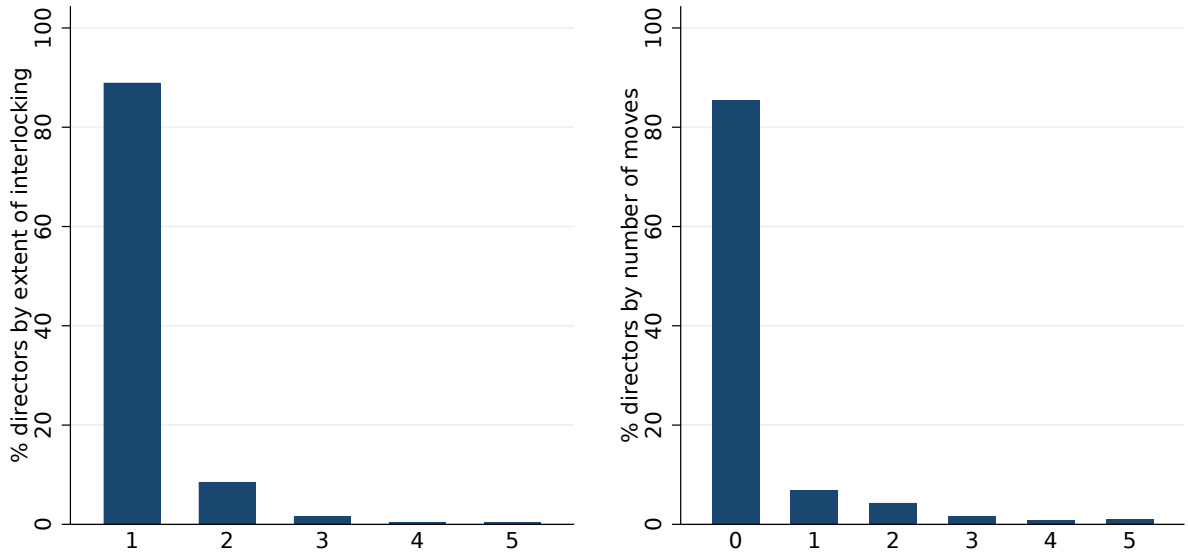
Notes: Data are drawn from the combined *Infocamere-Cerved-Invind* sample, using the 2019 wave. OLS cross-section regression. The dependent variable is firm TFP while the explanatory variable is the managerial score computed following Bloom et al. (2019). Firm controls include firm fixed effects - those estimated using the two-way fixed effect model described in specification (1) - and sector, region and size fixed effects. Standard errors clustered at the firm level in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Table 12: Complementarities: management talent and managerial score (panel analysis)

Dependent variable:	TFP		
	(1)	(2)	(3)
Incentives related to performance (I)	0.103**	0.084**	0.086**
	(0.041)	(0.041)	(0.040)
Board talent (BT)		2.206***	1.900***
		(0.374)	(0.308)
I × BT			0.731***
			(0.224)
Firm FEs	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes
R^2	0.785	0.861	0.870
N	336	336	336

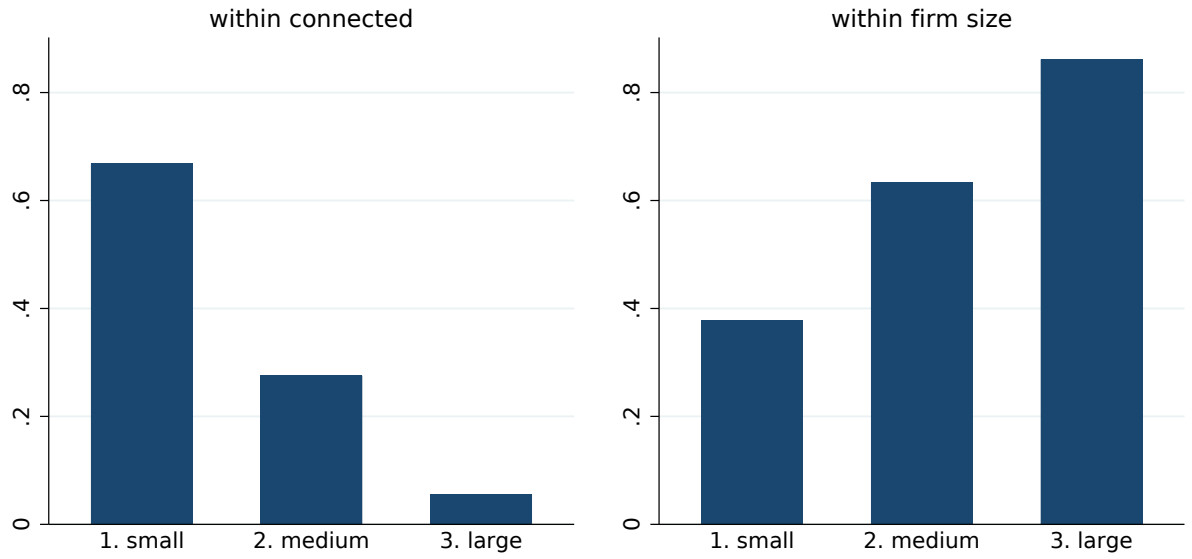
Notes: Data are drawn from the combined *Infocamere-Cerved-Invind* sample, using the 2010 and 2019 waves. Panel with fixed effects. The dependent variable is firm TFP while the explanatory variable is an indicator for the presence of performance-related pay systems. The model includes firm and year fixed effects, thus exploiting within firm variation in TFP, board talent and incentives. Standard errors clustered at the firm level in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Figure 1: Extent of interlocking and switching among directors



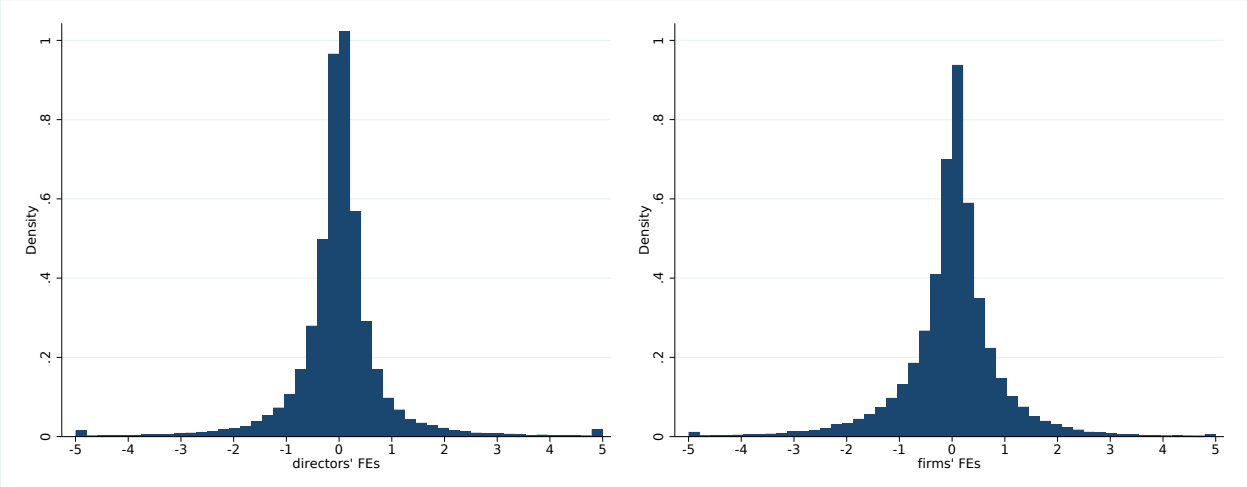
Notes: Data are drawn from the combined *Infocamere-Cerved-Invind* sample, including the universe of limited companies with more than 20 employees in the private non-financial sector in the years 2005-2018. The left panel shows the extent of interlocking, i.e. the distribution of directors by the number of boards (of different firms) on which they seat in the same year; the right panel shows the extent of switching, i.e. the distribution of directors by the number of switch (from one firm to another across time) over the period 2005-2018.

Figure 2: Distribution of firms in the connected set by size



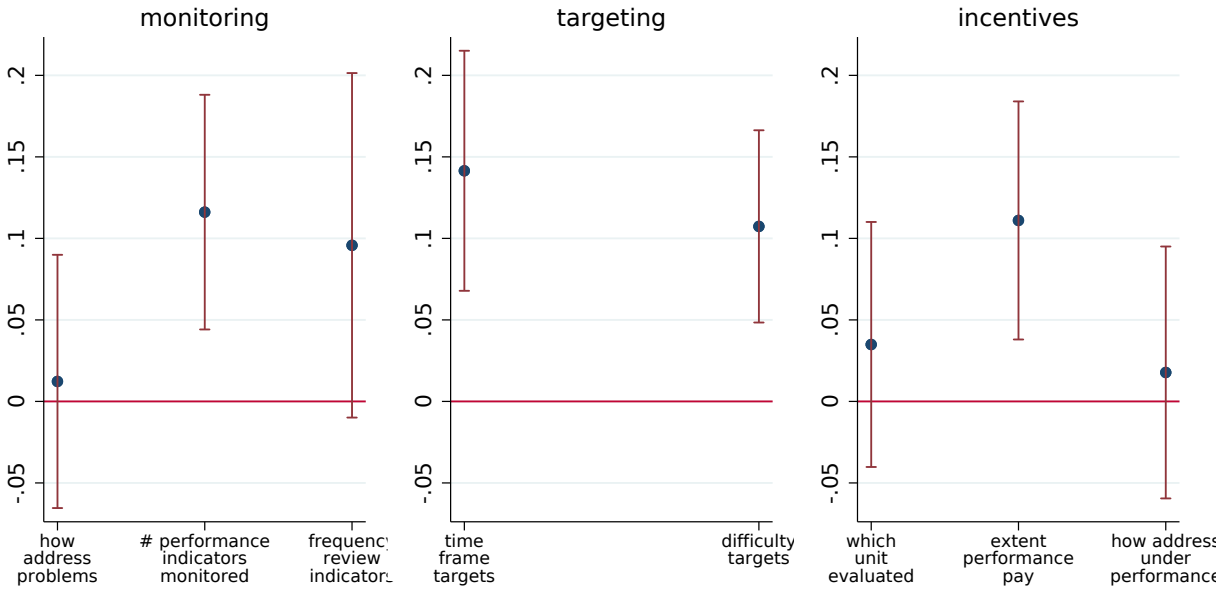
Notes: Data are drawn from the combined *Infocamere-Cerved-Invind* sample, including the universe of limited companies with more than 20 employees in the private non-financial sector in the years 2005-2018. The left panel shows the distribution of firms in the connected set by size; the right panel shows the share of firms in the connected set with respect to the universe by size. Small firms have from 20 to 50 employees, medium-sized firms have up to 250 employees while large firms have more than 250 employees.

Figure 3: Distribution of firms' and directors fixed-effects



Notes: Data are drawn from the combined *Infocamere-Cerved* sample. Distribution of firms' and directors' fixed effects estimated through the two-way fixed effect model. Both variables are standardized.

Figure 4: Complementarities: management talent and managerial practices (2019)



Notes: Each point represents the estimated coefficient of the interaction term between managerial talent and managerial practices, for different managerial items. Vertical bandsrepresent + / - 1.66 time the standard error for each point estimate. Data are drawn from the combined *Infocamere-Cerved-Invind* sample. The score for each items capture, respectively, "what happens when a problem in the production process arises", "how many key performance indicators are monitored", "how frequently are key performance indicators typically reviewed", "what is the time frame of operational targets", "how easy or difficult is it for workers to typically achieve their operational targets", "what are performance bonuses usually based on", "what is the primary way workers are promoted", "when is an under-performing worker usually reassigned or dismissed". See Bloom et al. (2019) for more details on the questions and the relative scores.

Appendix

A.1 Stylized facts on the labour market of directors

As shown in Section 3, many directors sit on the board of multiple firms over the period 2005-2018. Directors tend to move across firms that are "close" from both a geographical and sectoral point of view (Figure A.1).[26] We find that 45% of the moves (interlocking and/or switching) occur between firms that are located within the same municipality, while around 22% of the moves occur between firms more than 100 kilometers away. Similarly, directors tend to sit on the boards of firms belonging to the same sector of activity: the likelihood that the two firms belong to the same section (alphabetical classification), division (2 digit numerical classification) or group (3 digit numerical classification) of the NACE classification of economic activities are, respectively, around 56%, 39% and 32%. These probabilities are significantly larger than those that would be recorded by observing a random shift from one sector to another.[27]

A.2 Validity checks on the AKM model

As explained in Section 3, specification (1) relies on the assumption that directors do not systematically sort into firms based on factors that enter in the error term. In this section, we test three patterns of endogenous mobility that would violate this assumption. To this end, we perform the validity checks proposed in Card et al. (2013).

[26] To construct measures of geographical or sectoral distance we need the manager to be present in at least two firms, one of origin and one of destination, simultaneously (as in the case of interlocking) or sequentially (as in the case of switching). To simplify the analysis we have considered all the cases with interlocking equal to two (for the cross-sectional component) and all the cases in which the administrator leaves a company and, in the following year, enters another (for the longitudinal component).

[27] An alternative way to capture sectoral proximity is to examine if the move of the director takes place between firms belonging to the same production chain. Using the input-output matrices we consider, for each combination of branches of economic activity, the average between the fraction of output of the branch of origin used as input in the branch of destination and the fraction of output of the destination branch used as input in the branch of origin. This figure, that captures how much two branches are integrated in the same production chain, is equal to 11% for the moves that we observe, 6 times larger than the simple average obtained from a random move.

First, we consider sorting based on the idiosyncratic component of the match. If this form of endogenous mobility is not relevant, a fully saturated model that features the interaction between the fixed effects of directors and firms should not have a significantly larger explanatory power than our baseline model. To test this, in column 6 of Table 3 we regress a firm TFP on the interaction between fixed effects for the average managerial talent q (obtained after discretizing the continuous measure into centiles) and firm fixed effects.[28] The adjusted R^2 of this model is not larger than that of the additive model in column 5, suggesting that match-specific effects should not have a first-order relevance in determining the sorting of directors into companies.

Moreover, if match-specific effects are not relevant the additive model should not deliver abnormally large residuals. Figure A.2 plots mean residuals in each of the 100 cells defined by the interaction of deciles of firms' and directors' fixed effects estimated in specification (1): the mean residuals in each cell are small and never exceeding the rule-of-thumb value of 0.02.

Furthermore, if this form of endogenous mobility is not important, we should observe that productivity gains experienced by companies that improve their managerial talent are roughly symmetric to productivity losses undergone as a result of a decline of similar extent in managerial talent.[29] To check for this, we focus on a balanced panel of firms that (i) change at least one director in year-to-event 0 and (ii) do not experience any other significant change - in terms of management quality - in the 3 years before the event and in the 3 years following it. We classify these companies into 9 groups, based on the terciles of managerial talent of the old board and the new board. Figure A.3 plots the evolution of TFP from year-to-event -3 to year-to-event 2 for firms whose old director/board belongs to the bottom or top tercile of managerial talent. The figure shows no change in TFP if changes in the composition of

[28] In column 5 we estimate the same model as in column 4, substituting the continuous measure of board talent with indicators for each centile of the corresponding discretized measure. Although the discrete variable has less informative value than the continuous variable, the use of fixed effects allows capturing potential non-linearities in the relationship between board talent and firm TFP. The fit of the model is however only marginally affected by this change.

[29] On the other hand, if match effects are relevant, gains would be larger than losses, as directors would systematically sort into companies where they have a better match.

the board do not result in a change in managerial talent (i.e., for transitions of the type 1 to 1 or 3 to 3). Focusing on changes of intermediate intensity (i.e., for transitions of the type 1 to 2 and 3 to 2), TFP is fairly flat before year-to-event 0, while it starts to increase (decrease) when a higher (lower) talented board takes over. Extreme changes in the managerial talent available to the firm (i.e., for transition of the type 1 to 3 and 3 to 1) are associated with larger changes in TFP from year 0, although these positive (negative) extreme changes are also preceded by increasing (declining) trends in TFP. However, these (mild) pre-trend do not seem to explain entirely the jump observed when extreme changes in board talent occurs, as shown in Figure A.4 that plots the observed pattern of the TFP and that predicted extrapolating from the trend observed before the change in the board quality. Finally, Figure A.5 plots the overall change in TFP (between year-to-event -3 and year-to-event 2) for downward movers against that of upward movers making the opposite change in managerial talents.[30] Dots are close to the the -45 degree line, indicating that TFP gains and losses for companies that experience opposite changes in board talent are roughly symmetric.

Second, we turn our attention to endogenous mobility based on the trend component of TFP. If sorting based on trends was not important, TFP should display a flat dynamic before a director leaves or joins the firm. As commented in the above paragraph, this appears to be the case when considering board changes that involve little or medium changes in the level of managerial talent available to the firm. On the other hand, this assumption seems less plausible when larger changes in managerial talent occur. A consequence of this is that we could be overstating the impact of managerial quality on TFP. However, Figure A.3 also shows that, even in these types of transitions, the changes in TFP before a new director of different talent joins/leaves the firm are lower than those observed after: the evident change in the slope suggests therefore that managerial talent still has an effect. Stated differently, the kink in the TFP can be attributed to the variation in board talent.

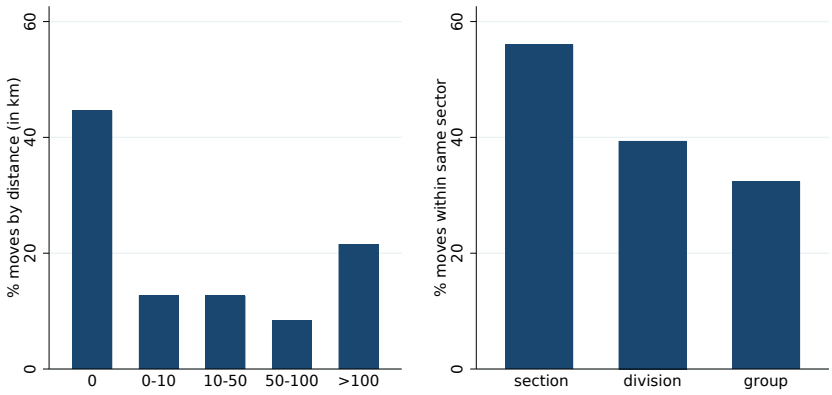
[30]This figure also includes transitions from the middle to either the bottom or the top tercile of managerial talent.

Third, we examine endogenous mobility related to the transitory component of TFP. If this type of sorting was relevant, we should observe dips or spikes in TFP just before the change in the composition of the board. Such patterns do not emerge from Figure A.3, suggesting that this type of endogenous mobility is likely not of first-order relevance.

Last, more talented directors tend to be in firms with higher total factor productivity, as shown in Figure A.6. The joint distribution of firms and directors fixed effects, in contrast, highlights the presence of the negative assortative matching, in line with what has been found in other studies examining workers-firms matching processes and possibly due to standard estimation error (Andrews et al., 2008). Yet, it is worth noting that this is not problematic for the estimation of the managers fixed effects, as the model already absorbs all time-invariant firm characteristics.

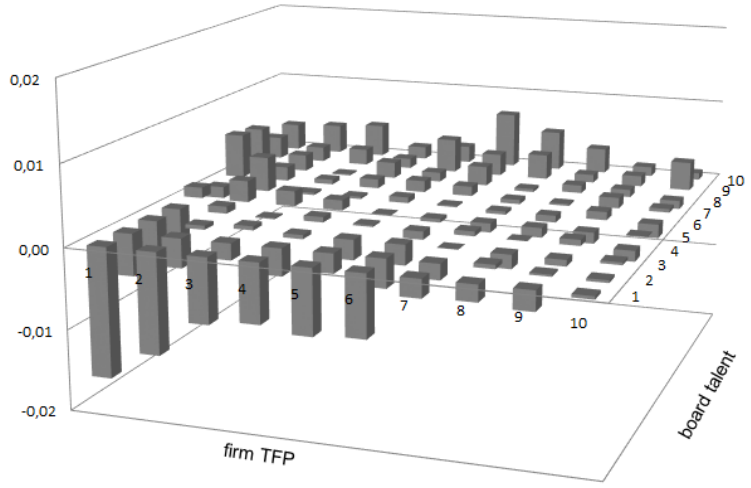
A.2.1 Supplementary figures and tables

Figure A.1: Geographical and sectorial distance of "moves" between firms



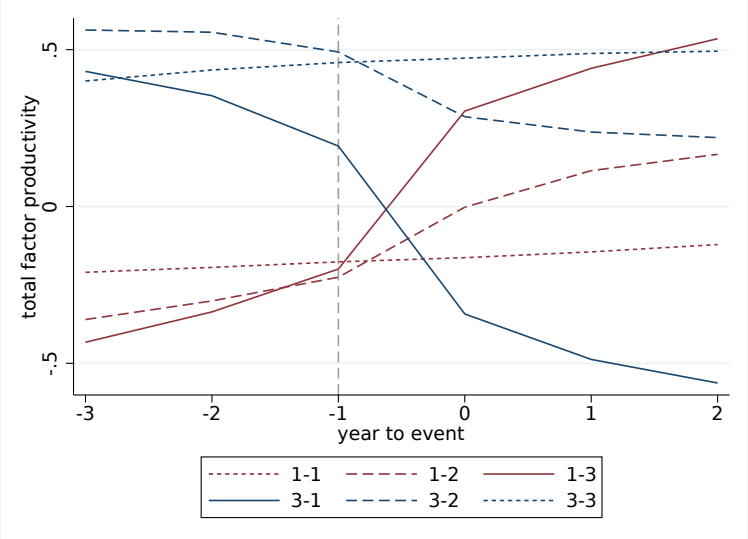
Notes: Data are drawn from the combined *Infocamere-Cerved* sample. We consider as moves both the presence in the board of two different firms in the same year and the switch from one firm to another across time.

Figure A.2: Residuals



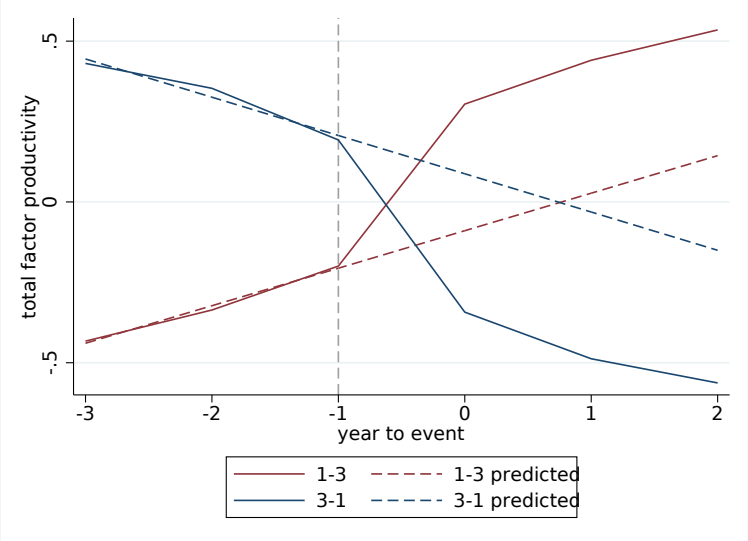
Notes: Data are drawn from the combined *Infocamere-Cerved* sample. Figure shows mean residuals from model (1) on the largest connected set with cells defined by deciles of board talent, interacted with deciles of estimated firm fixed effects.

Figure A.3: Evolution of TFP following a change in board talent



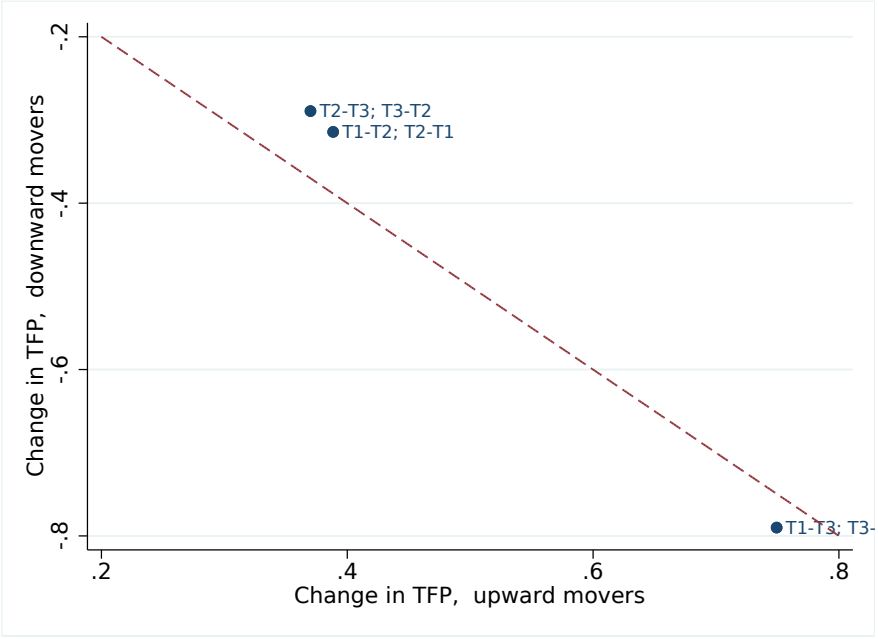
Notes: The figure plots the evolution of TFP from year-to-event -3 to year-to-event 2 on a balanced subset of firms that (i) change at least one director in year-to-event 0 and (ii) remain in the same tercile of board talent both in the 3 years before the event and in the following 3 years.

Figure A.4: Predicted and observed evolution of TFP following a change in board talent



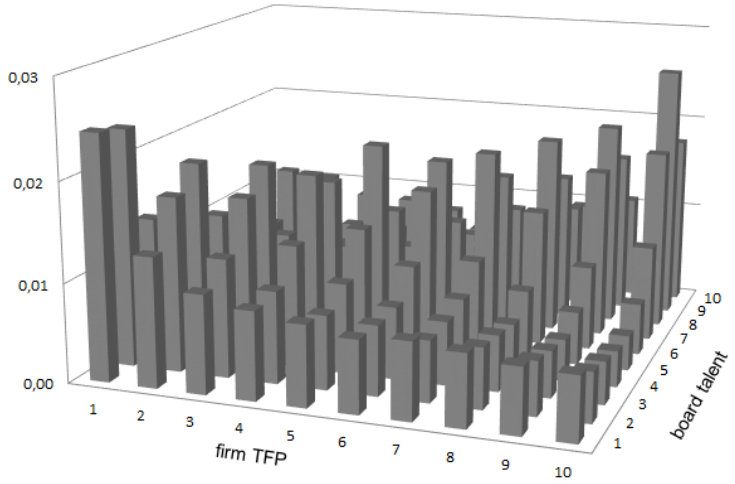
Notes: The figure plots the evolution of observed and predicted TFP from year-to-event -3 to year-to-event 2 on a balanced subset of firms that (i) change at least one director in year-to-event 0 and (ii) remain in the same tercile of board talent both in the 3 years before the event and in the following 3 years.

Figure A.5: Symmetry of gains and losses in TFP following a change in directors



Notes: The figure plots the change in TFP between the years preeceding and following the event.

Figure A.6: Assortative matching



Notes: Data are drawn from the combined *Infocamere-Cerved* sample. Joint distribution of (deciles of) firms' TFP and board talent.

Figure A.7: Questionnaire

***Invind* survey- 2010 wave**	
For each of the following personnel management practices, specify the extent of their use in your company:	
• use of team work made up of employees	*none (1); poor (2); moderate (3); high (4)*
• use of forms of management remuneration based on results	*none (1); poor (2); moderate (3); high (4)*
• involvement in the decision-making of the lower hierarchical levels	*none (1); poor (2); moderate (3); high (4)*
The score associated to each answer is reported in parenthesis.	

***Invind* survey- 2019 wave**	
Monitoring section:	
• What best describes what happens at your firm when a problem in the production process arises? (e.g., *finding a quality defect in a service or a product; a piece of equipment breaking down)*	*we fixed it but did not take further action (1/3); we fixed it and took action to make sure that it does not happen again (2/3); we fixed it and took action to make sure that it does not happen again, and had a continuous improvement process to anticipate problems like these in advance (1); no action was taken (0)*
• How many key performance indicators are monitored in your firm? *(e.g., metrics on production, cost, waste, absenteeism, and quality of services)*	*1-2 key performance indicators (1/3); 3-9 key performance indicators (2/3); 10 or more key performance indicators; no key performance indicators (0)*
• How frequently are key performance indicators typically reviewed/updated?	*yearly (1/6); quarterly (1/3); monthly (1/2); weekly (2/3); daily (5/6); hourly or more frequently (1); never (0)*
Targets section:	
• What best describes the time frame of operational targets at your firm?	*short-term (less than one year) targets (1/3); long-term (more than one year) targets (2/3); combination of short-term and long-term targets (1); no targets (0)*
• How easy or difficult typically is it for people to achieve their operational targets in your firm?	*without much effort (0); with some effort (1/2); with normal amount of effort (3/4); with more than normal effort (1); with extraordinary effort (1/4)*
Incentives section:	
• What are performance bonuses usually based on in your firm?	*own performance (1); team performance (3/4); local establishment's or branch's performance (1/2); entire company's performance (1/4); no performance bonuses (0)*
• What is the primary way workers are promoted in your firm?	*solely on performance and ability (1); partly on performance and ability, and partly on other factors (e.g., tenure or family connections) (2/3); mainly on factors other than performance and ability (e.g., tenure or family connections) (1/3); normally no promotions (0)*
• When is an under-performing worker usually reassigned or dismissed?	*within 6 months of identifying worker under-performance (1); after 6 months of identifying worker under-performance (1/2); rarely or never (0)*
The score associated to each answer is reported in parenthesis.	

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