# Assortative Matching in Managerial Labor Markets: Theory and Measurement

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**Abstract**

This paper provides evidence on the importance of complementarities in production within executive teams. I construct a simple structural model of production and pay rates, where productivity of each individual is affected by the productivity of his or her colleagues and managers' compensation is set through the Nash bargaining mechanism. Estimation results show that the managerial labor market is characterized by the high degree of within-firm positive assortative matching, which implies that better managers are matched with better co-workers. This result explains high skewness of observed distribution of firm sizes and executive compensation. I find that 32% of observed inequality in executive pay is explained by the complementarities within executive teams. Applying the model to analyze the degree of sorting between managers and directors, I find evidence of significant complementarities in production between managerial and director skill. This result points to the importance of advisory role of the board of directors.

Keywords: Managerial talent, complementarities in production, assortative matching, executive compensation, director compensation, structural estimation.

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# 1 Introduction

*A small team of A+ players can run circles around a giant team of B and C players.*

*-Steve Jobs, former CEO of Apple Inc.*

It is widely accepted that management teams are important for the success of the firm. For example, a few months after Steve Jobs's departure from Apple, the board of directors approved an unprecedented payout of $400 million to the top seven executives of the firm. The board has realized that the success of the firm was dependent on every single member of the team and tried to prevent the team from breaking down. By doing this, the board of Apple has acknowledged that there are significant complementarities in production within their team of top managers.[1]

In this paper I analyze the assortative matchup in the managerial labor market. The goal is to understand whether more skilled managers choose to work with more (or less) skilled co-workers. The answer to this question has important economic implications. If there are significant complementarities in production between managers, we will observe that better managers are matched together at the firm level. As a consequence, firms that assemble better executive teams will significantly outperform their peers over time, contributing to the skewness of the distribution of firms' market values and sizes. This in turn will contribute to the skewness of the distribution of executive compensation. On the other hand, in a modern managerial labor market with free movement, the ultimate location of talent is largely unplanned and results from managers' utility-maximizing and firms' hiring decision. In the end, this may result in a distribution of managers across firms that does not exhibit any significant assortativity.

To understand whether such complementarities are important, I construct a simple structural model of production and pay rates based on Kremer's (1993) O-Ring model, which implies

[1]Definitive Proxy Statement, DEF 14A, filed with the SEC on January 9, 2012: http://www.sec.gov/Archives/edgar/data/320193/000119312512006704/d275281ddef14a.htm.

positive assortative matching between executives at the firm level in the spirit of Becker (1973). Productivity of each individual in the model is affected by the productivity of his or her colleagues and managers' compensation is set through the Nash bargaining mechanism. The structural model implies that a managers' compensation is a function of his own skill and the aggregate ability of his co-workers. This decomposition allows me to use Abowd, Kramarz, and Margolis (1999) technique to estimate the structural parameters of the model that capture managers' ability levels. Because Kremer's model combined with Nash bargaining to determine compensation predicts positive assortative matching (PAM) displayed in the compensation equation, estimated ability parameters of managers should be correlated at the firm level.

I find strong evidence of positive assortative matching between managers within firms. The correlation between manager's own ability level and ability of his co-workers is 0.62. This result is surprising for two reasons. First, there is no a priori reason to expect any degree of assortativity in this market, let alone a very strong one. Second, the degree of sorting I find in this market is much higher than what is typically found in other labor market (see, for example, Rogerson, Shimer, and Wright (2005) for an overview). This result suggests that complementarities in production between top executives play a much bigger role in the economy than complementarities between regular workers.

This result has two significant implications. First, the strong degree of PAM between managers at the firm level has a potential to explain empirical facts about the distributions of firm size and market value. The distribution of firm size is known to be highly skewed (see, for example, Sutton (1997) for a survey of literature on the distribution of firm size). One of the potential mechanisms through which this can happen over time is the complementarities in production within executive teams. These complementarities accelerate the growth in firms that are able to assemble better teams, making the distribution more skewed.[2]

Second, the strong degree of positive assortative matching explains several empirical facts about executive compensation. Because of the PAM and wage-setting mechanism, hiring a more skilled colleague increases compensation of all members of the executive team. Once the talent accumulates at the firm level, relatively small differences in skills can lead to a much bigger differences in income.[3] This explains the severe income inequality among top executives we observe in the data. I quantify how much skewness in the observed empirical distribution of pay is due to within-firm sorting of top executives. I find that 36% of skewness can be attributed to the sorting, making it a very substantial source of income inequality among executives.

In the last part of the paper, I analyze whether the matching between corporate directors and managers exhibit positive sorting as well. Since one of the functions of corporate boards is to provide advice to the management, one can argue that the expertise and skill of directors is an important input to the firm's production function. If managerial and director skill are complements, we can expect to see PAM between managers and directors at the firm level. If, on the other hand, managers and directors are substitutes, the market would not display any significant levels of PAM.

I find strong evidence of PAM between managers and directors. In particular, I find that the correlation between average director and average executive measure of skill at the firm level is 0.41. This result suggests that complementarities in production between executives and directors are important, albeit less so than complementarities within executive teams. In other words,

[2]Consider, for example, a case of two rival firms, Microsoft and Apple. In January 2004 Apple was roughly 1/35 of the size of Microsoft in terms of market capitalization. As of January 2014, Apple is 1.6 times bigger than Microsoft (again, in terms of market capitalization). Put differently, while Microsoft grew 4.6% over the last ten years, Apple grew roughly by 6,000%. One can argue that these striking differences in outcomes between these two rival firms can be explained by the superior leadership of the management team that ran Apple.

[3]Academic analogy may be useful here. One can argue that there is a high sorting of talent within finance and economics departments. Hiring a more thoughtful colleague increases the quality of the output of all members of the group. The quality of the output increase more if the group is of a higher quality. A person's own quality of work is also higher if the group is of a higher quality.

better managers are able to attract better directors and assemble better boards. This result may also indirectly point to the importance of advisory role of corporate boards, and can potentially justify why individual directors account for a substantial fraction of the firm value.[4]

Finally, I show that strong degree of sorting between executives and directors explains high correlation between executive and director pay we observe in the data. This correlation has been widely interpreted as evidence of "backscratching". As pointed out in Bebchuk and Fried (2003), CEOs have significant influence over the board. Directors have incentives to favor management and "go along" with the CEO's pay arrangement, and in turn the CEO can affect directors' compensation and perks.[5] Theoretical literature suggests that the three-level hierarchy of shareholders-directors-management generates possibility for collusion between directors and management, which would potentially allow directors and managers influence each other's compensation (see, for example, Tirole (1986) and Kofman and Lawarree (1993)). Empirically, Brick, Palmon, and Wald (2006) show a strong positive correlation between excess CEO and excess director compensation, where *excess compensation* is defined as a residual from compensation regressions. If the regression residuals were truly random errors, then they should be uncorrelated; otherwise, correlation indicates systematic factors within each firm. This correlation has been interpreted as evidence of "cronyism" between directors and the CEO: directors and CEO collude together against the shareholders to increase their pay.

Results in this paper show that this correlation is primarily driven by the positive assortative assortative matching we observe in the market between executives and directors. I find no evidence of significant correlation in residuals from our structural compensation regressions. When I run counterfactual analysis failing to account for PAM, this correlation emerges and its

[4]See, for example, Nguyen and Nielsen (2010) who show that outside directors account on average for up to 1% of the firm value.

[5]This view is wide-spread in popular press, for example, "Behind Every Underachiever, An Overpaid Board?", by Gretchen Morgenson, *New York Times*, January 22, 2006; "In the Boardroom, Every Back Gets Scratched", by Ben Stein, *New York Times*, April 6, 2008.

magnitude is significant. In particular, 10% increase in director compensation is associated with 8.16% increase in executive compensation. After accounting for PAM association goes down to 3.09% and becomes insignificant. The structure of my empirical setup gives the following interpretation to this result. Executive and director skill is priced in the labor market. Since there are complementarities in production between managerial and director skill, which in turn induces positive assortative matching, it gives us another significant source of correlation between executive and director pay. If this sorting is not taken into account, it can be erroneously attributed to other factors, such as "cronyism" between executives and directors.

The rest of this paper is organized as follows. I discuss related literature below. Section 2 lays out the foundations of the model. Section 3 describes the sources of data, sample construction, identification, and estimation methodology. Results are given in the section 4. The last section concludes.

### 1.1 Related Literature

An extensive literature in economic and finance theory studies sorting patterns of heterogeneous agents. Important examples include sorting in the labor markets between workers and firms, partners in marriage, players and teams, and student and teachers. A common feature in all these matching markets is that positive (negative) complementarities in production between agents induce positive (negative) sorting in equilibrium. For example, Becker (1973) and Shimer (2005) show that if production function is supermodular, the unique equilibrium allocation of workers across firms is efficient and is characterized by perfect sorting: more productive worker always has a better job than a less productive one.

This paper is first and foremost related to the recent literature that applies assignment models to the CEO labor markets. Terviö (2008) and Gabaix and Landier (2008) show that observed growth rates in executive compensation can be explained by growth rates in market capitalization of the firms assuming that complementarity between firm size and managerial skill induces sorting in the market. One common feature among these papers is that the firm size is assumed to be exogenous. In contrast, my approach does not rely on any assumptions regarding distribution of firm sizes. My results complement this literature by offering a potential microeconomic foundation. If firm size arises endogenously as a function of skill of all managers and directors participating in production, then existence of complementarities would make firms with better teams significantly bigger over time. This would imply skewed firm size distribution we observe in the data, which in turn feeds into high levels and high degree of skewness of executive compensation.

I also add to the literature on empirical regularities and determinants of executive and director pay. Kaplan and Rauh (2010) and Frydman and Jenter (2010) provide stylized fact on trends in executive compensation, including increasing skewness of CEO pay.[6] There are several existing results in the literature that address the increasing skewness. Katz and Murphy (1992) provide a skill-based technological change explanation. Murphy and Zábojník (2004) suggest that there has been a gradual shift in manager's required skill set from firm-specific to general skills, which resulted in greater labor market mobility and increased competition for executive talent. Bebchuk and Fried (2003) explain rise in CEO pay by weakening corporate governance. Finally, and mostly related to the current paper, Rosen (1982) (theoretically) and Gabaix and Landier (2008) (empirically) suggest that the increasing skewness can be explained by the economics of superstars, which, together with technological advances, makes talent to matter on a greater scale. This paper suggests that complementarities in production and increasing agglomeration of talent in firms increases the pay of executives in firms with greater concentration of talent more than it does in firms with lower skill level of co-workers. This over time exacerbates skewness of the distribtion of executive compensation. Finally, my results suggest that the skill of colleagues

[6] See also Piketty and Saez (2003) for the discussion of the increasing inequality in general population.

is a determinant of executive pay, and has to be accounted for in the empirical models of executive compensation. The skill of the executive team through complementarity in production channel also feeds into director compensation, and hence has to accounted for in the empirical models of director pay.[7]

From the methodological perspective, this paper estimates a structural model in the spirit of Becker (1973) and Kremer (1993). Hence it is related to the recent literature that calibrates structural models of executive compensation (see, for example, Dittmann and Maug (2007) and Maug, Dittmann, and Spalt (2013)). Estimation technique is based on Abowd, Kramarz, and Margolis (1999) who develop econometric methodology that makes it possible to separately identify person-specific and firm-specific effects from compensation regressions. This methodology has recently been applied in finance literature that emphasizes the importance of unobserved firm and manager heterogeneity in explaining various corporate outcomes. Graham, Li, and Qiu (2012) show that managerial heterogeneity, captured by manager-specific fixed effects, explains most of the variation in executive compensation. They find evidence that manager fixed effects from compensation regression capture unobserved managerial ability. Similarly, Coles and Li (2011) apply this methodology to study the importance of this two-sided unobservable heterogeneity in explaining executive incentive, as captured by the sensitivity of managerial wealth to stock price.

Finally, this paper is related to Hayes, Oyer, and Schaefer (2006) who study how complementarities affect executive turnover.

## 2 Setup

The sketch of the model is based on Kremer (1993) co-worker quality model. I assume that each firm requires an input of executive team to produce the final output. Each firm is run by

[7] See, for example, Ryan and Wiggins (2004) and Brick, Palmon, and Wald (2006) for recent literature on the determinants of director compensation.

executive team of $n$ members.[8] I assume that each member of the executive team is endowed with a productive quality $q_i$, which can be interpreted as manager's skill. The output produced by firm $k$ is a function of skill level of all members of the executive team and takes the form $y_k = f(q_{1k}, \ldots, q_{nk})$. I assume that this function is increasing in all of its arguments and is strictly supermodular.

This output is shared between the members of the executive team and the remaining stakeholders in the firm. The outside option for all executives is assumed to be zero and the compensation is determined by Nash bargaining with utility functions that are linear in production characteristics. We also impose that the bargaining power is constant and equals $\beta$ for every manager.

The above implies that the compensation function for each executive $i$ in firm $k$ captures the productive characteristics of all members of the executive team:

$$w_{ik} = \beta f(q_{1k}, \ldots, q_{nk}) \tag{1}$$

The extension of a classic result in Becker (1973) implies that in a competitive and frictionless labor market, the above market structure implies positive assortative matching in this market. Better managers would match with better co-workers at the firm level. Since compensation of every manager captures the skill measure of all his co-workers as shown in (1), our goal is to use observable $w_{ik}$ in the data and recover skill characteristics $q$ for every manager and every firm. Estimated skill characteristics from compensation equations will be interpreted within the structure that is set up here.

To operationalize the above, I use a Cobb-Douglas production function $y_k = \prod_{i=1}^{n} q_{ik}^{\alpha_i}$ which results in compensation $w_{ik} = \beta \prod_{i=1}^{n} q_{ik}^{\alpha_i}$ for every manager $i$. Intuitively, if we would like to

[8] In the later part of the paper I add board as a required input to the firm's production.

recover $q_i$'s from $w_i$'s, we would not be able to do it statistically since cross-sectionally we have as many unobservables as equation. To circumvent this identification problem, I decompose the wage equation as

$$w_{ik} = \beta q_{ik}^{\alpha_i} \prod_{j \neq i} q_{jk}^{\alpha_j} = \beta q_{ik}^{\alpha_i} Q_k, \tag{2}$$

where $Q_k$ is the aggregate quality of $i$'s colleagues in firm $k$. I take logs of the above equation to get a wage equation that I will be able to bring to the data:

$$\log w_{ik} = \log \beta + \alpha_i \log q_{ik} + \log Q_k. \tag{3}$$

This equation implies that compensation of each executive in the firm is a function of his own skill level and an aggregate skill level of all his co-workers. The latter will be captured as a firm-specific effect in the empirical setup, which I will discuss below in Section 3.2.

# 3 Data and Empirical Methodology

## 3.1 Data

I use four different databases to construct our final sample. Executive and director compensation data is taken from ExecuComp database. It covers firms in S&P 500, the Midcap 400, and Smallcap 600 firms. These data are matched to firms' accounting data, which is obtained from Compustat. Director appointments are identified through Risk Metrics database (former IRRC). Stock returns information is taken from CRSP files. Definition of variables is given in the Appendix. The final sample is an unbalanced panel of director and executive level data. Table 1 provides summary statistics for the final sample.

In the main part of the paper that does not use director compensation data, I restrict my analysis to 1992-2009. The year 1992 is when ExecuComp's coverage starts. For the part of the paper where I analyze the matchup between executives and directors, I restrict my analysis to 2006-2009. In 2006 SEC issued a new disclosure requirement that mandated all public companies to disclose director compensation at the individual level. Firm must report the total compensation awarded (not necessarily realized) in a given year to each director. This is the number ExecuComp reports. For executive compensation, I take the total compensation awarded to top-5 executives of the firm each year. ExecuComp distinguishes between awarded (variable TDC1) and realized (variable TDC2) compensation. In this paper I work with the awarded compensation.

### 3.2 Empirical Methodology

Compensation equation (3) calls for identification of a person-specific effect $q_i$ and a firm-specific effect (that captures aggregate skill level of $i$'s colleagues) $Q_k$ from observations $w_{ik}$. This means we have to identify two fixed effects, person-specific and firm-specific, in a compensation regression. This cannot be done in a single cross-section; hence we need a time-series dimension to be able to identify both effects. There are several ways of doing this. First, we can use the sample of executives who move from one firm to another during our sample period.[9] This method, however, is very restrictive because executive mobility is very scarce in the data. To avoid using the sample of "movers" only, I use Abowd, Kramarz, and Margolis (1999) technique that constructs exactly identifiable systems of connected individuals. Below I discuss the empirical setup and identification technique.

Let $y_{iJ(i,t)t}$ be the compensation of executive $i \in \{1, ..., I\}$ received in year $t \in \{1, ..., T\}$ if he was retained by firm $J(i,t) \in \{1, ..., J\}$. Here $J(i,t)$ is a correspondence that gives us a subset of firms that retained executive $i$ in year $t$. The direct empirical counterpart of compensation

[9]This method is used in Bertrand and Schoar (2003), among others.

equation (3) is

$$y_{iJ(i,t)t} = \delta_i + \phi_{J(i,t)} + z_{it}\beta_1 + x_{J(i,t)}\beta_2 + \gamma_t + \epsilon_{iJ(i,t)t}. \tag{4}$$

The above specification suggests that executive compensation is the sum of market valuation of his personal characteristics $z_{it}\beta_1 + \delta_i$, firm-specific compensation practices $x_{J(i,t)t}\beta_2 + \phi_J(i,t)$, and time effects in compensation $\gamma_t$. Components $\delta_i$ and $\phi_J(i,t)$ are unobservable executive and firm characteristics. This specification assumes that for director $i$, $\delta_i$ is constant over time and across firms.[10] Executives may also have firm-specific skills that cannot be transferred across firms and will be captured by $\phi_J(i,t)$.

We assume that residual $\epsilon_{iJ(i,t)t}$ is centered around zero, $\mathbb{E}[\epsilon_{iJ(i,t)t}|i,t,z,x] = 0$, has finite variance, $\text{var}[\epsilon_{iJ(i,t)t}|i,t,z,x] < \infty$, and is orthogonal to other effects in the model. Further details regarding these assumptions can be found in Abowd, Kramarz, and Margolis (1999). I re-write the above equation in the matrix form

$$y = P\Delta + Q\Phi + X\beta + \epsilon, \tag{5}$$

where $\Delta = (\delta_1, \ldots, \delta_I)'$ is the vector of director fixed effects, $\Phi = (\phi_1, \ldots, \phi_J)'$ is the vector of firm fixed effects, matrix $X$ contains both $z_{it}$ and $x_{J(i,t)}$, i.e. executive and firm observable characteristics, and $\beta$ is the vector of corresponding coefficients. Matrices $P$ and $Q$ are design matrices that reflect the matching structure that is observed in the market. Let $N_{it}$ be the number of observations with respect to director $i$ at year $t$. Then $\sum_t N_{it}$ is the number of observations for director $i$ we have in our sample, and hence $N = \sum_i \sum_t N_{it}$ is the total number of observations.

[10] One may interpret $\delta_i$ as a skill or ability that is transferable between companies, and hence priced in the labor market, in the sense of Murphy and Zábojník (2004).

### 3.3 Identification of manager and firm fixed effects

Since in this paper I make use of the estimated person and firm effects, I am interested in not only controlling for unobserved heterogeneity, but also in estimating the magnitudes of each effect separately. Estimation requires a method for identifying these effects. The identification problem for director and firm effects can be solved by constructing a sample of *connected* individuals and firms. Intuitively, if two firms have executive teams composed of different executives and none of them ever worked for another firm, firm and person effects cannot be separately identified since they are perfectly collinear. Hence separation of executive fixed effects from firm fixed effects requires at least one executive who worked for both firms. Once such executive is identified, person-specific effects for every member of executive team will be identified through this individual who connects everybody else. In other words, a group of executives and firms is connected when it contains all the managers who ever worked for any of the firms in the group and all the firms at which any of the executives were ever employed. In contrast, when a group of executives and firms is not connected to a second group, no firm in the first group ever employed an executive in the second group, nor has any executive in the first group ever been employed by a firm in the second group. A simple example is shown in Figure 1.

The following algorithm constructs $G$ mutually-exclusive groups of connected observations from $I$ managers in $J$ firms observed over the sample period. Start with an arbitrary manager. Include all firms in which he was ever employed. Next, add all executives who currently work or who have ever worked for these firms. Continue adding all additional firms for which any of these managers has ever worked (or currently works) and all additional managers in any of those firms until no more managers or firms can be added to the current group. Repeat for the next group and continue until no more observations left. At the conclusion of the algorithm, the persons and firms in the sample have been divided into $G$ groups. The number of managers in each group is

$I_g$. The number of firms in each group is $J_g$. Within each group $g$, $I_g - 1 + J_g - 1$ person and firm effects are identified. Overall in all $G$ groups, exactly $I + J - G$ effects are estimable. This assertion can be formally proved.

The above implies that within each group manager and firm fixed effects are identified relative to a benchmark. Hence the estimated firm and manager effects are directly comparable to each other only within each group, but not across groups. This issue however can be solved by applying a normalization procedure, which follows Abowd, Kramarz, and Margolis (1999). I normalize all manager fixed effects in each group so that within-group mean of fixed-effects is zero. Then I normalize the grand mean of firm fixed effects to zero. Note that this procedure implicitly assumes that each group has the same average manager fixed effect. In practice, it is unlikely that the average managerial skill between groups in the same. Since groups are based on mobility and executive mobility is likely to be segregated by skill level, it is natural to assume that some groups will have larger average person-specific effect. By equating the average effects between groups, I effectively assume that there is less sorting between groups than there likely is. Therefore this biases my results down, and working against me finding significant degree of sorting in this market. Note that this procedure has no effect on estimated degree of sorting within connected groups.

In practice, there is a substantial amount of connectedness between executive-firm pairs in our sample. Panel A of Table 2 shows the distribution of executives and firms across groups. The largest group contains 2,079 firms and 29,346 executives. The second largest group contains only 7 firms and 82 executives. The remaining 1,169 groups contain 11.0 executives per group on average.

For the remaining analysis, I remove all observations from groups that contain only one firm. As discussed above, person and firm specific effects are identified within groups up to a constant.

This would not allow me to compare ability of executives who work in these groups to executives from other groups. After I remove these groups, I have 118 groups left. The largest group contains 2,079 firms, two groups contain 7 firms, one group contains 5 firms, seven groups contain 4 firms, thirteen groups contain 3 firms, and the remaining 94 groups contain two firms. Since the largest group contains the bulk of firms and executives and since normalization procedure might mislocate the true skill across the groups, I re-run the analysis using only observations from the largest group. I find that the estimated degree of sorting is marginally stronger. The results in the paper are reported using all observations from all groups that contain at least two firms.

I implement the same grouping procedure for board members to estimate complementarities between managers and directors. Table 3 shows distribution of the number of boards individual directors sit during the sample period. Each year more than 30% of directors serve on two or more boards at the same time. This results in a much larger degree of connectivity in the sample of directors. Panel B of Table 2 shows that most of the firms and directors fall into one connected group, with only 4 firms falling outside of the largest group. For estimation purposes, I take the largest group only and discard 4 firms and their directors who fall outside of this group.

# 4 Results

Below I discuss major results. I start by estimating the degree of sorting among top executives and its impact on the distribution of pay. Next, I augment firm's production function with director skill, assuming the same compensation setting process for directors, and test for sorting between executives and directors at the firm level. I conclude with analysis of correlation between executive and director pay.

### 4.1 Degree of Sorting in the Executive Labor Market

To estimate the degree of sorting among top executives, I run regression (4) and estimate person-specific fixed effects $\delta_i$ for every manager. The results are reported in Table 4. For comparison purposes, I report regression results of CEO compensation on firm and executive observable characteristics, which is reported in the first column. The second regression is a pooled regression for all executives in the firm. The third regression contains executive fixed effects, but it does not contain firm fixed effects. Finally, regression in column (4) is the AKM regression that contains both person and firm fixed effects. This regression has the best explanatory power. The fixed effects I use in the subsequent analysis are from this regression.

Next, I asses the degree of sorting in this market. For most firms I have $n = 5$ as Execucomp reports compensation of top 5 employees in the firm. For each executive $\delta_i$, I calculate $\bar{\bar{\delta}}_{J(i,t)}$, which is the average person-specific effect of all $i$'s co-workers. Recall that $J(i,t)$ is an empirical map that gives the index of the firm that employed executive $i$ at time $t$. I take all co-workers of $i$ at time $t$ and calculate their average person-specific fixed effect. My empirical measure of the degree of sorting among executives is $\mathrm{corr}(\delta_i, \bar{\bar{\delta}}_{J(i,t)})$, which measure the correlation between manager-specific fixed effect and fixed effects of his colleagues.

I find that person-specific fixed effects explain more than 56% of observed variation in executive pay. Results are reported in Table 5. This is consistent with what is found in a general population of workers (see, for example, Abowd, Kramarz, and Margolis (1999) and Postel-Vinay and Robin (2002)) as well as in the population of top managers (see Graham, Li, and Qiu (2012)). Interestingly, firm-specific effects account for a significant share in pay dispersion as well. In particular, the variation in estimated firm-specific effects as a fraction of variation captured by person-specific plus firm-specific effects is about 30%:

$$\frac{\mathrm{var}(\phi_{J(i,t)})}{\mathrm{var}(\delta_i + \phi_{J(i,t)})} = 0.29 \tag{6}$$

Since the firm fixed effect masks the aggregate effect of co-workers, this suggest we may expect to see significant degree of sorting at the firm level. To verify this, I estimate the main measure of manager/co-manager sorting: the correlation between manager-specific fixed effect and fixed effects of his colleagues. I find

$$\mathrm{corr}(\delta_i, \bar{\delta}_{J(i,t)}) = 0.62, \tag{7}$$

which suggests that there is a very substantial degree of clustering of executives at the firm level based on their skill level.

To interpret this estimate, recall that the estimates of $\delta_i$ from (4) deliver structural estimates of managers' skills as discussed in Section 2. Since the resulting correlation is very large and positive, the structure of the model implies that this correlation captures the degree of sorting, implying that this labor market is characterized by positive assortative matching. Interestingly, this degree of sorting is much larger that is typically found in other labor markets.[11]

This high degree of sorting feeds into compensation. A manager working with more productive colleagues gets higher pay because his productivity is higher at a firm that has higher aggregate skill level. Because we observe clustering of managers by skill at the firm level, this exacerbates the differences in pay between the managers who are part of more productive teams and managers who are part of less productive teams. This contributes to the inequality of pay among top executives. In unreported preliminary results, I quantify how much within firm sorting contributes to the total skewness of observed distribution of executive compensation. My preliminary estimates are in the range of 36%, i.e., more than third of the inequality in pay is

[11] See, for example, Rogerson, Shimer, and Wright (2005).

due to the positive assortative matching within firms.

#### 4.1.1 The relation between estimated fixed effects and executive observable characteristics

The previous section shows that there is a high degree of sorting in the managerial labor market. This inference is based on the estimated person specific fixed effect from AKM regression. Although this measure is widely interpreted as a measure of unobservable skill in the labor economics literature, this assertion has been taken for granted.[12] In this paper, I analyze whether the estimated fixed effects are correlated with executive observable characteristics.

In Table 6, I regress estimated person fixed effects on the selectivity of undergraduate institution executive attended, the age at which they obtained their first CEO job, number of directorships by age 65, highest degree obtained, and the gender. These observable characteristics are typically thought to proxy for executive skill. It has also been shown that under certain circumstances some of these measures are correlated with firm performance. The measure of college selectivity I use is from Perez-Gonzalez (2006). The first row defines colleges that fall into "most competitive", "highly competitive", and "very competitive" categories based on Barron's (1980) definition. The second raw defines colleges that fall into "most competitive" category only.

The results show that there is positive association between the first three measures and estimated fixed effect.

[12] It is typically hard to obtain data on observable characteristics of regular workers. For executives, these data is usually easier to obtain.

### 4.1.2 The relation between estimated fixed effects and firm performance

Next, I look at the firm performance around executive turnover. Each executive turnover event changes the composition of the executive team and hence it changes the average team skill.[13] I separate all turnover-induced changes in the team skill into two groups. The first group contains firms that has increased the skill of their team, and the second group contains firms where the team skill decreases.

Table 7 shows that there is a very significant difference in performance changes between two groups. The first group outperforms the second group during the three year period around turnover event by 3.66% in return on assets. This is economically a very significant number.

Finally, I run predictive regressions of a firm's growth rates on team skill. We would expect that firms that were able to assemble better executive teams will outperform other firms. I measure firm's growth rate by log growth rates in firm's total assets and market value. Table 8 shows that firms with better teams grow faster. Economically these results are very significant. A firm that has a team that is one standard deviation better will outgrow its peers by 28% in assets and by 24% in market value over the 5 year period.

These results contributes to the literature on the firm size distribution (FSD). In particular, it uncovers one channel – strong degree of sorting in managerial labor market – that strongly contributes to different growth rates of firms in the economy. This in turn may lead to the skewness of FSD that we observe in the data. To the best of my knowledge, this is the first paper that directly links firms' growth rates to the quality of their management teams.

[13] The team skill is defined as an average fixed effect of a member of the executive team.

## 4.2 Degree of Sorting Between Executives and Directors

### 4.2.1 Director Compensation

I start by estimating (4) for the sample of directors from 2006-2009. For the estimation purposes, I need individual level director compensation, which is not available prior to 2006. I follow prior literature in selecting the observable characteristics that determine the level of director compensation (see for example Ryan and Wiggins (2004), Adams, Hermalin, and Weisbach (2010), among others). Specifically, I regress the logarithm of total director compensation on the firm-level variables that potentially capture the difficulty of director's job and firm's need for monitoring. These include the firm size (captured by total value of assets), growth opportunities (captured by book-to-market, by research and development expenses, which is not significant in any specifications, and by stock return volatility), performance measures (ROA, lagged ROA, stock returns, and lagged returns). Other control variables include governance proxies and board characteristics. In particular, I expect director compensation to increase with CEO tenure. The main rationale for this follows from Hermalin and Weisbach (1998). The longer CEO spends in the office, the more entrenched he becomes, hence he has more ways to influence the director selection process as well as compensation for them. It is reasonable to expect that CEO may choose higher levels of director compensation so that he gets less scrutiny from them.

Results are reported in Table 9. The first regression is a pooled regression without director or firm fixed effects. The overall results are in line with previous literature. The adjusted $R^2$ from pooled regression is 0.225, which is slightly higher than what was found in the previous literature.[14] This is likely because of the different samples used in this and prior literature. I include year fixed effects in all specifications to control for any possible year differences in director pay. The second regression includes director fixed effects. The adjusted $R^2$ increases

[14] See for example Ryan and Wiggins (2004), Adams and Ferreira (2008).

more than twice. This is the first indication that unobservable director heterogeneity plays substantial role in explaining observed levels of director pay. In the third specification I add firm fixed effects to control for any possible heterogeneity on the firm side. Adding firm fixed effects improves the overall fit from 54.2% to 76.2%. Table 5 uses coefficient estimates from specification that includes both firm and director fixed effects to decompose the model's R-squared in order to quantify relative importance of each class of variables in determining the portion of total director compensation explained. I find that director fixed effects explain more than 60% in observed levels of variation in director pay. This is in line with what is usually found in other labor markets, including managerial labor market.[15]

Finally, I report the distribution of estimated director fixed effects. If estimated fixed effects proxy for director skill (which I address in the next section), the variance of this distribution can be interpreted as a measure of skill dispersion in the population of directors. Figure 2 shows histogram and smoothed density of estimated director fixed effects. This empirical distribution has standard deviation of 0.83. Mechanically, as we mentioned above this distribution is centered around 0. This suggests that there is a significant amount of unobservable skill in the population of directors. Economically, these differences in abilities are also sizable. Consider, for example, two directors such that the first one is one standard deviation above the second one in his measure of skill. The log compensation of the first director will be higher by 0.83, i.e., it would increase from the average level of 5.143 to 5.973, which constitutes an increase of around $220,000.

Table 9 shows correlation between estimated director fixed effects and independent variables in the regression analysis. A few results are of interest here. First, there is a large positive correlation between firm size and director skill. This suggests that better directors are matched with bigger firms. Second, skill is positively associated with the number of directorships and board independence. Finally, there is a significant positive correlation between CEO ownership

[15]See, for example, Graham, Li, and Qiu (2012) and Iranzo, Schivardi, and Tosetti (2008).

and director skill.

Given the importance of unobserved director heterogeneity in determining director pay, I try to understand in the next section whether person-specific director fixed effects are associated with firm performance and other measures of director skill.

#### 4.2.2 Director Skill and Estimated Fixed Effects

Similar to the analysis of the executive fixed effects, in this section I test whether director fixed effects are related to director observable characteristics. Perez-Gonzalez (2006) shows that CEO successions in family firms where incoming CEO attended selective colleague are associated with better firm performance. It points to the fact that selectivity of undergraduate institution attended by a CEO picks up executive skill, at least within sample of family firms. Falato, Li, and Milbourn (2014) show that the earlier in his life CEO gets his first CEO job, the higher his pay is and the more value he brings to the firm. I run preliminary analysis using both of these measures to see whether they are correlated with estimated director fixed effects. If these measures capture director skill, we may expect to see positive correlation with person-specific fixed effects from compensation regressions. This may provide further evidence that estimated fixed effects capture some dimension of director skill.

I report results in Table 10. The dependent variable is the estimated director fixed effect from regression (2) in Table 9. First measure of talent is a dummy variable that equals to one if director attended selective college (top three categories in Barron's ranking, see Perez-Gonzalez (2006) for details). The second regression looks only at the top tier of selective colleges. The top tier, called "most competitive" by Barron's, contains 33 colleges. This group contains most of the colleges in the US that are thought of as elite institutions. On the contrary, the top 3 category contains 33 institutions in "most competitive" bin, 52 institutions in "highly competitive" bin, and 104 institutions in "very competitive" bin. One may argue that the second and third bin dilute the definition of a true selective college. I expect to see more correlation between fixed effects and the "top 1" bin, similar to what we saw with the executives.

The second measure of director talent is a dummy variable that equals 1 if director is in the top quintile of the distribution of age at which he was given his first director job. I follow authors and call this variable *fast track career*. There is a positive correlation between estimated fixed effects and both college selectivity and fast-track career measures.

The results are similar to what is reported in Table 5 for executives, albeit they are economically weaker. Overall, we can conclude that like executive skill, director skill is also captured by the estimated fixed effects from the compensation regressions.

#### 4.2.3 Sorting

My main goal in this section is to understand whether the market is characterized by the positive assortative matching between executives and directors at the firm level. For each firm $j$ in year $t$, I construct a measure of aggregate executive skill by taking the average of estimated executive fixed effects:

$$\bar{\delta}_{jt}^{E} = \sum_{i \in J^{E}(i,t)} \delta_{i}^{E}. \tag{8}$$

In the above equation, $J^{E}(i,t)$ is an empirical map that gives me firm $j$ where executive $i$ worked in year $t$. I construct an equivalent measure of director talent in firm $j$ in year $t$:

$$\bar{\delta}_{jt}^{D} = \sum_{i \in J^{D}(i,t)} \delta_{i}^{D}. \tag{9}$$

My empirical measure of sorting between executives and directors is the correlation of aggregate effects. I find that

$$\text{corr}(\bar{\delta}_{jt}^{E}, \bar{\delta}_{jt}^{D}) = 0.41, \tag{10}$$

which is highly statistically significant. Figure 4 visualizes this sorting by plotting $\bar{\delta}^D$ against $\bar{\delta}^E$ for every firm-year.

To interpret this result, recall that the structure of the model allows us to interpret this result as evidence of complementarities in production between executives and directors. These complementarities exhibit themselves in compensation regressions through positive correlation of estimated person-specific effects.

This result may potentially point to the importance of the advisory role of the board. If the advisory role of the boards was minimal and their main function was to monitor management, we would be unlikely to find evidence of positive sorting between management and directors. Although it is still possible to think of a world where directors, whose only task is to monitor management, are positively matched with executives in equilibrium, this alternative would likely be less intuitive. In reality, it is easier to justify this PAM as evidence of some productive value that boards contribute to firms, which is likely to materialize through advice and strategic decisions, rather than through purely monitoring role.

#### 4.2.4 The Relationship Between Director and Executive Compensation

To examine the relationship between executive and director compensation, I take residuals from director compensation regressions and add them as an independent variable ti the executive compensation regression. To be consistent with the prior literature, I first take residuals from pooled director compensation regression. These residuals include individual and firm unobserved heterogeneity that affects director compensation. I find that executive compensation is significantly associated with residuals from pooled director compensation regression. A 10% increase in director compensation is associated with 8.16% increase in CEO compensation. This confirms results documented in Brick, Palmon, and Wald (2006). This correlation is potentially driven either by the positive assortative matching (PAM) or by other factors that are not controlled for, for example, "cronyism" between executives and directors.

To determine whether PAM explains observed association, I control for unobserved firm and director heterogeneity in the first stage regression. Then I take residuals from the regression and add them as an independent variable to the second stage regression where I regress CEO pay on observables. Results are shown in regression (3) in Table 11. The degree of association between excess director compensation and CEO compensation is significantly reduced. Finally, in Table 12 I control for both firm and person fixed effects in executive compensation regressions. These regressions include top-5 executives in each firm. Results show that when I control for unobserved firm and person heterogeneity in both first and second stage regressions, there is no significant positive association between executive and director compensation.

Taken together, results in this section show that the observed high correlation in executive and director pay is driven by positive assortative matching between executives and directors.

## 5 Conclusion

The existence of heterogeneous skill in the population of top executives implies that there are possible gains from sorting of managers across firms. In particular, if managers' abilities are complements in production, then optimal assignment theory would suggest that managers are matched together. This matching will occur at the firm level if it takes more than one manager to produce final output. Therefore, we expect to see sorting of managers into executive teams at the firm level, provided that search frictions in the labor market are not significant enough.

I empirically test this theory. I set up a very simple structural model of production and executive compensation. Firm's productivity features complementary production technology, where output depends on skills of every member of the executive team (the extension of the model also adds the skill of directors to the firm's production function). Manager (and director) compensation is set through the Nash bargaining mechanism. Structural model implies that executive compensation is a function of productive characteristics of all members of the executive team. I use the framework of Abowd, Kramarz, and Margolis (1999) to estimate person-specific skill parameters, which are captured by person-specific fixed effects from compensation regressions. The model implies that we will see positive correlation between estimated skill parameters within executive teams.

I find that manager/co-manager correlation of skill parameters at the firm level is 0.62, which implies that managerial labor market is characterized by very a strong degree of sorting. Interpreting this result within the structure of the model suggests that there are strong complementarities in production within executive teams. Interestingly, the degree of sorting in managerial labor market is much stronger that what is typically found in other markets. There are several possible explanations for this empirical regularity. First, and the most obvious one, complementarities may matter the most at the top end of skill distribution. Another explanation is that the labor markets for top-end talent are less frictionless. Since executives matter more for firm outcomes than other workers, firms may spend more time identifying talented executives. Human resource consulting market is also more active for higher end jobs, which also potentially lessens search frictions.

Strong complementarities in production in managerial labor markets have significant economic implications. First, if the talent is scarce, we will significant differences in aggregate talent accumulated across firms. Firms that were able to assemble better management teams will significantly outperform firms that were less successful in attracting talent. Over time this will result in a right skewed distribution of firm sizes, which we observe in the data. Second, this will translate into executive compensation. If executive compensation is positively linked to their output, complementarities will result in skewed to the right executive compensation. This is consistent with stylized facts about executive compensation. I find that about a third of the skewness of observed executive compensation can be attributed to the sorting.

Finally, I test whether director skill is an important contributor to firm's production and whether there are complementarities in production between managers and directors within firms. I extend the model to include director as a productive input and test for the correlation between aggregate director and executive skill measures within firms. I find that this correlation is 0.41, which implies that managers and directors are sorted within firms based on their abilities. This indirectly points to the importance of the advisory role of the corporate boards. Indeed, if directors' role within firms was limited to monitoring, it would be unlikely to see any evidence of sorting. I also show that sorting between directors and executives is a very significant determinant of correlation in observed director and executive compensation at the firm level. Once accounted for, I find no abnormal level of correlation between director and executive pay.

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Table 1: Descriptive Statistics for the final sample

This table provides summary statistics for the full sample. Refer to the Appendix for variable definitions.

| | Mean | Median | 25% | 75% | St. Dev. |
|---|---|---|---|---|---|
| Director Characteristics | | | | | |
| Director Total Compensation (thousands) | 171.37 | 145.18 | 89.98 | 207.59 | 252.95 |
| Director Equity-Based Compensation | 97.38 | 76.90 | 35.53 | 133.48 | 158.32 |
| Executive Characteristics | | | | | |
| CEO Total Compensation (thousands) | 5,178.13 | 3,054.27 | 1,134.78 | 6,448.04 | 7,761.90 |
| CEO Option Compensation (thousands) | 2,123.40 | 956.66 | 479.40 | 2,059.58 | 5,374.88 |
| Tenure as CEO | 9.12 | 7.33 | 4.25 | 11.58 | 6.21 |
| Male Indicator | 0.948 | 1 | 1 | 1 | 0.107 |
| CEO Equity Ownership | 0.047 | 0.012 | 0.008 | 0.042 | 0.094 |
| Firm Characteristics | | | | | |
| Assets (millions) | 13,361 | 3,008 | 905 | 10,567 | 92,492 |
| Return on Assets | 0.118 | 0.113 | 0.062 | 0.169 | 0.110 |
| Return on Equity | 0.298 | 0.282 | 0.175 | 0.406 | 4.241 |
| Stock Return | 0.09 | -0.02 | -0.28 | 0.23 | 1.31 |
| Stock Return Volatility | 0.52 | 0.33 | 0.23 | 0.48 | 1.60 |
| Market to Book | 1.71 | 1.37 | 1.08 | 1.95 | 1.09 |
| R&D/Assets | 0.022 | 0.000 | 0.000 | 0.020 | 0.053 |
| PP&E/Assets | 0.510 | 0.411 | 0.187 | 0.780 | 0.393 |
| CEO-Chair Indicator | 0.71 | 1 | 0 | 1 | 0.39 |
| Proportion of Independent Directors | 0.64 | 0.75 | 0.42 | 0.83 | 0.18 |
| Number of Directors | 8.49 | 7 | 6 | 9 | 2.75 |

Table 2: Results of applying grouping algorithm

Groups are ordered from largest to the smallest by the number of individuals in every group. For example, "Group 1" has the largest number of executives identified by procedure described in the text. Data for executives spans years 1992 through 2013, while data for directors spans 2006 through 2009. In subsequent analysis, I remove all groups that contain only one firm.

| | Group 1 | Group 2 | Avg of other groups | Total |
|---|---|---|---|---|
| Panel A: Executives | | | | |
| Number of groups | 1 | 1 | 1,169 | 1,171 |
| Firms | 2,079 | 7 | 1.13 | 3,406 |
| Executives | 29,346 | 82 | 10.93 | 42,200 |
| Total observations | 144,343 | 482 | 56.54 | 210,919 |
| Estimable effects | 31,424 | 188 | | 44,435 |
| Panel B: Directors | | | | |
| Number of groups | 1 | 1 | 3 | 5 |
| Firms | 1,927 | 1 | 1 | 1,931 |
| Directors | 9,125 | 9 | 3.67 | 9,145 |
| Total observations | 55,048 | 20 | 13 | 55,107 |
| Estimable effects | 11,051 | 9 | | 11,071 |

Table 3: Number of Directorships

The table shows distribution of the number of position held by directors. Numbers in square brackets are percentages.

| No. positions held | 2006 | | 2007 | | 2008 | | 2009 | |
|---|---|---|---|---|---|---|---|---|
| 1 | 4609 | [ 69.8] | 5021 | [ 67.7] | 4831 | [ 68.3] | 4754 | [ 68.3] |
| 2 | 1071 | [ 16.2] | 1276 | [ 17.2] | 1212 | [ 17.1] | 1202 | [ 17.3] |
| 3 | 412 | [ 6.2] | 519 | [ 7.0] | 473 | [ 6.7] | 473 | [ 6.8] |
| 4 | 193 | [ 2.9] | 234 | [ 3.2] | 210 | [ 3.0] | 206 | [ 3.0] |
| 5 | 98 | [ 1.5] | 134 | [ 1.8] | 115 | [ 1.6] | 106 | [ 1.5] |
| 6 | 67 | [ 1.0] | 67 | [ 0.9] | 71 | [ 1.0] | 55 | [ 0.8] |
| 7 | 40 | [ 0.6] | 56 | [ 0.8] | 53 | [ 0.7] | 51 | [ 0.7] |
| 8 | 22 | [ 0.3] | 35 | [ 0.5] | 41 | [ 0.6] | 41 | [ 0.6] |
| 9 | 31 | [ 0.5] | 24 | [ 0.3] | 23 | [ 0.3] | 35 | [ 0.5] |
| 10 | 26 | [ 0.4] | 26 | [ 0.4] | 25 | [ 0.4] | 17 | [ 0.2] |
| $> 10$ | 32 | [ 0.5] | 28 | [ 0.4] | 17 | [ 0.2] | 22 | [ 0.3] |
| Total | 6601 | [ 100.0] | 7420 | [ 100.0] | 7071 | [ 100.0] | 6962 | [ 100.0] |

Table 4: Executive compensation

The dependent variable is the logarithm of total executive compensation (Execucomp's TDC1 variable). The first column reports results from a model that includes CEOs only. The second, third, and fourth columns includes all executives. Year fixed effects are included in all specifications. Standard errors are adjusted for heteroskedasticity. I cluster standard errors at the executive level in regressions two through four. T-statistics are reported in parenthesis. One, two, and three stars denote significance at ten, five, and one percent level, respectively.

| | CEOs only | All execs | All execs | All execs |
|---|---|---|---|---|
| $\log(AT_t)$ | 0.344 | 0.339 | 0.260 | 0.245 |
| | (68.52) | (107.89) | (33.26) | (15.54) |
| $q_t$ | 0.115 | 0.112 | 0.051 | 0.065 |
| | (13.81) | (21.30) | (10.82) | (8.80) |
| $ROA_t$ | 0.421 | 0.265 | 0.438 | 0.208 |
| | (3.56) | (6.11) | (9.17) | (5.10) |
| $ROA_{t-1}$ | 0.120 | 0.118 | 0.210 | 0.188 |
| | (1.18) | (4.84) | (5.25) | (4.23) |
| $RET_t$ | 0.064 | 0.021 | 0.044 | 0.058 |
| | (4.87) | (4.03) | (8.53) | (9.50) |
| $RET_{t-1}$ | 0.082 | 0.069 | 0.065 | 0.749 |
| | (5.74) | (15.40) | (14.53) | (10.28) |
| Investment$_t$ | -0.000 | -0.000 | 0.000 | -0.000 |
| | (-0.28) | (-0.40) | (0.89) | (0.41) |
| Leverage$_t$ | -0.003 | -0.042 | -0.010 | -0.013 |
| | (-0.39) | (-5.87) | (-3.04) | (-4.54) |
| Board member | 0.658 | 0.692 | 0.424 | 0.351 |
| | (32.64) | (52.68) | (26.90) | (11.21) |
| log(Tenure) | 0.048 | 0.032 | 0.024 | 0.019 |
| | (3.58) | (6.25) | (3.22) | (1.75) |
| Female | -0.070 | -0.085 | NA | NA |
| | (-2.34) | (-5.20) | NA | NA |
| CEO | NA | 0.301 | 0.165 | NA |
| | NA | (13.58) | (2.66) | NA |
| CFO | NA | 0.014 | 0.099 | NA |
| | NA | (0.88) | (2.36) | NA |
| Year fixed effects | Yes | Yes | Yes | Yes |
| Manager fixed effects | No | No | Yes | Yes |
| Firm fixed effects | No | No | No | Yes |
| Number of Observations | 21,554 | 133,772 | 133,772 | 133,772 |
| Adjusted $R^2$ | 0.360 | 0.473 | 0.701 | 0.860 |

Table 5: RELATIVE IMPORTANCE OF COMPONENTS IN EXPLAINING EXECUTIVE COMPENSATION

This table reports the relative importance of different components in explaining executive compensation. The first component includes firm observable characteristics from regressions in Table 3: firm size, (average) Tobin's q, ROA, ROA in the previous year, total stock return over the fiscal year, total stock return over the previous fiscal year, firm's investment, and leverage. The second component includes executive's observables: tenure and whether he or she is a board member. The third, fourth, and fifth components contain executive, firm, and year fixed effects, respectively. The second column in the table shows the percentage contribution of each of the components in explaining observed variation in director compensation.

$$R^2 = \frac{\mathrm{cov}(x_{it}\hat{\beta}, y_{it})}{\mathrm{var}(y_{it})} + \frac{\mathrm{cov}(\hat{\phi}_{j(i,t)}, y_{it})}{\mathrm{var}(y_{it})} + \frac{\mathrm{cov}(\hat{\delta}_i, y_{it})}{\mathrm{var}(y_{it})} + \frac{\mathrm{cov}(\hat{\gamma}_t, y_{it})}{\mathrm{var}(y_{it})}$$

| Component | $\frac{\mathrm{cov}(\mathrm{Component}, y_{it})}{\mathrm{var}(y_{it})}$ | Percentage contribution to $R^2$ |
|---|---|---|
| Firm observables | 0.18 | 21.7% |
| Executive observables | 0.05 | 6.0% |
| Firm fixed effects, $\delta$ | 0.08 | 9.7% |
| Executive fixed effects, $\phi$ | 0.47 | 56.6% |
| Year fixed effects | 0.05 | 6.0% |
| Residual | 0.17 | |
| $\frac{\mathrm{var}(\phi)}{\mathrm{var}(\delta+\phi)}$ | 0.29 | |

Table 6: Correlation between estimated manager fixed effects and his/her observable characteristics

This table reports correlation between estimated manager fixed effects and observable characteristics. The measure of college selectivity I use is from Perez-Gonzalez (2006). The first row defines colleges that fall into "most competitive", "highly competitive", and "very competitive" categories based on Barron's (1980) definition. The second raw defines colleges that fall into "most competitive" category only. Variable "First top-5 job, top quintile" is defined as top 20% of executives sorted by age at which they obtained their first CEO job. Standard errors are reported in parenthesis. Significance at 0.10, 0.05, 0.01 level indicated by *, **, and ***, respectively.

| Observable characteristic | (1) | (2) |
|---|---|---|
| College selectivity, top 3 | 0.054* | |
| | (0.032) | |
| College selectivity, top 1 | | 0.101** |
| | | (0.044) |
| First top-5 job, top quintile | 0.013* | 0.013 |
| | (0.007) | (0.008) |
| Number of directorships at age 65 | 0.019* | 0.019* |
| | (0.011) | (0.010) |
| Highest degree | 0.042 | 0.042 |
| | (0.031) | (0.037) |
| Gender | -0.003 | -0.003 |
| | (0.010) | (0.010) |
| $R^2$ | 0.045 | 0.045 |

Table 7: Firm performance around turnover-induced changes in team skill

The table reports mean and median ROA changes between year +2 and year -1. Year 0 is the year of executive turnover that changes the composition of executive team. Group 1 contains firms where the turnover led to higher executive team skill defined as the average fixed effect of team members. Group 2 contains firms where executive turnover led to lower average skill in the team. Industry-adjusted ROA is the difference between firm's ROA and the median industry ROA. The median industry ROA calculated based on all firms in the same two-digit SIC industry. Second measure is size- and performance-adjusted ROA, which is defined as the difference between the unadjusted ROA and ROA of a control firm. The control firm is a firm from the same four digit SIC industry, with ROA within $(-10\%, 10\%)$ of the appointing firm and that is closest in size. Mean is tested if it equals zero using $t$-test, for median we use Mann-Whitney-Wilcoxon test. Significance at 0.10, 0.05, 0.01 level indicated by *, **, and ***, respectively.

| | Team skill change | | |
|---|---|---|---|
| | Group 1 | Group 2 | Difference |
| Unadjusted ROA | | | |
| Mean | -0.0473 | -0.0892 | 0.0419*** |
| Median | -0.0251 | -0.0461 | 0.0210*** |
| Industry-adjusted ROA | | | |
| Mean | -0.0134 | -0.0288 | 0.0154* |
| Median | 0.0025 | -0.0043 | 0.0068*** |
| Match-adjusted ROA | | | |
| Mean | -0.0326 | -0.0692 | 0.0366*** |
| Median | -0.0011 | -0.0108 | 0.0097*** |

Table 8: Firm growth rates

The table reports predictive regressions of log growth rates on the skill of executive team and firm observable characteristics. The dependent variable in the first regression is $\log(AT_{t+1}) - \log(AT_t)$, where AT is the firm's total assets. The dependent variable in the second regression is $\log(MV_{t+1}) - \log(MV_t)$, where MV is the firm's market value. Standard errors are in parenthesis. Significance at 0.10, 0.05, 0.01 level indicated by *, **, and ***, respectively.

| | AT growth $t$ to $t+1$ | MV growth $t$ to $t+1$ |
|---|---|---|
| Team skill at $t$ | 0.022*** | 0.018*** |
| | (0.005) | (0.006) |
| $\text{ROA}_t$ | 0.063 | 0.048 |
| | (0.024) | (0.015) |
| $\text{Return}_t$ | 0.009 | 0.016 |
| | (0.005) | (0.006) |
| $\text{Return}_{t-1}$ | 0.004 | 0.010 |
| | (0.008) | (0.007) |
| $\text{Investment}_t$ | 0.034 | 0.045 |
| | (0.017) | (0.019) |
| $\text{Investment}_{t-1}$ | 0.020 | 0.051 |
| | (0.015) | (0.025) |
| Year fixed effects | Yes | Yes |
| Industry fixed effects | Yes | Yes |
| Number of Observations | 68,526 | 62,738 |
| Adjusted $R^2$ | 0.6802 | 0.577 |

Table 9: Director Compensation

The dependent variable is logarithm of total director compensation. Year fixed effects are included in all regressions. The first regression does not contain person or firm fixed effects. Second regression contains person fixed effects, and the third regression contains both person and firm fixed effects. Standard errors are heteroskedasticity-adjusted and clustered within firms. T-statistics are in parenthesis. One, two, and three stars denote significance at ten, five, and one percent level, respectively.

| | (1) | (2) | (3) |
|---|---|---|---|
| $MB_{t-1}$ | 0.062*** | 0.058*** | 0.048** |
| | (3.075) | (3.120) | (2.212) |
| $ROA_t$ | 0.776*** | 0.961*** | 0.811*** |
| | (4.046) | (5.419) | (4.490) |
| $ROA_{t-1}$ | 0.518** | 0.651*** | 0.359*** |
| | (2.191) | (3.291) | (3.103) |
| $RET_t$ | −0.037** | 0.124*** | 0.072*** |
| | (−2.033) | (2.897) | (2.613) |
| $RET_{t-1}$ | −0.014 | 0.061** | 0.054* |
| | (−1.230) | (1.853) | (1.688) |
| $VOL_t$ | 0.544*** | 0.181 | 0.303 |
| | (2.984) | (1.337) | (1.582) |
| $\log(AT_t)$ | 0.434*** | 0.381*** | 0.320*** |
| | (17.925) | (11.812) | (8.174) |
| $R\&D_t/AT_t$ | 1.218 | 0.384 | 0.435 |
| | (0.785) | (0.448) | (0.561) |
| CEO-Chair | 0.043 | 0.023 | −0.036 |
| | (1.371) | (0.893) | (−1.009) |
| log(CEO Tenure) | 0.062*** | 0.063*** | 0.059*** |
| | (5.629) | (5.131) | (3.554) |
| Board Independence | 0.471* | 0.557 | 0.269 |
| | (1.869) | (1.239) | (1.128) |
| CEO ownership | −0.215*** | 0.128 | −0.086 |
| | (−2.698) | (1.201) | (−0.617) |
| No. of directorships | 0.242*** | 0.096** | 0.058*** |
| | (4.101) | (2.369) | (2.677) |
| Year Fixed Effects | Yes | Yes | Yes |
| Director Fixed Effects | No | Yes | Yes |
| Firm Fixed Effects | No | No | Yes |
| Number of Observations | 55,048 | 55,048 | 55,048 |
| Adjusted $R^2$ | 0.225 | 0.542 | 0.762 |

Table 10: Correlation between estimated director fixed effects and his/her observable characteristics

The dependent variable is the estimated director fixed effect. The measure of college selectivity I use is from Perez-Gonzalez (2006). The first row defines colleges that fall into "most competitive", "highly competitive", and "very competitive" categories based on Barron's (1980) definition. The second raw defines colleges that fall into "most competitive" category only. The second measure of director talent is a dummy variable that equals 1 if director is in the top quintile of the distribution of age at which he was given his first director job. Standard errors are in parenthesis.

| | (1) | (2) |
|---|---|---|
| College selectivity, top 3 | 0.002 | |
| | (0.005) | |
| College selectivity, top 1 | | 0.008 |
| | | (0.004) |
| Age at first director job, top quintile | 0.003 | 0.004 |
| | (0.001) | (0.001) |
| Number of directorships at age 65 | 0.020 | 0.023 |
| | (0.008) | (0.006) |
| Highest degree | 0.012 | 0.011 |
| | (0.010) | (0.010) |
| Gender (female) | 0.006 | 0.006 |
| | (0.025) | (0.023) |
| Adjusted $R^2$ | 0.037 | 0.080 |
| Number of Observations | 8,485 | 8,485 |

Table 11: THE IMPACT OF EXCESS DIRECTOR COMPENSATION ON CEO COMPENSATION
Pooled and firm fixed effects regression of total CEO compensation on control variables and excess director compensation. Excess director compensation is defined as a residual from director pay regression. The first residual (first row in the table) is the residual from the pooled regression. The second row is the residual from regression that includes both director and firm FE. In both cases excess compensation variable is defined as a sum of excess compensation of all board members in the firm.

| | Pooled Regression | | | Firm Fixed Effects Regression | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (1) | (2) | (3) |
| Dir Excess Comp (no FE) | | 0.8157*** | | | 0.4944** | |
| | | (6.2767) | | | (2.2739) | |
| Dir Excess Comp (FE) | | | 0.4739*** | | | 0.2848 |
| | | | (4.2769) | | | (1.4450) |
| log(CEO Tenure) | 0.0824*** | 0.0975*** | 0.0744*** | 0.0662*** | 0.0763*** | 0.0712*** |
| | (2.8013) | (2.6448) | (3.0821) | (3.4118) | (3.1021) | (2.8175) |
| $ROA_t$ | 0.8628*** | 0.7395*** | 0.7637*** | 1.0578*** | 0.8992*** | 0.7609*** |
| | (5.6490) | (4.4764) | (5.0106) | (3.6740) | (2.5874) | 2.6737 |
| $ROA_{t-1}$ | 0.9711*** | 0.8237*** | 1.0293*** | 0.9237** | 0.6118** | 0.6747** |
| | (4.8019) | (4.1269) | (4.6860) | (2.2360) | (2.0076) | (2.2795) |
| $RET_t$ | 0.0345*** | 0.0412*** | 0.0299*** | 0.0116*** | 0.0185*** | 0.0173*** |
| | (5.1046) | (5.7009) | (2.7839) | (2.5773) | (2.7127) | (2.4735) |
| $RET_{t-1}$ | 0.0232*** | 0.0285*** | 0.0224** | 0.0246* | 0.0208** | 0.0268** |
| | (4.1520) | (3.2902) | (2.4626) | (1.9216) | (2.1388) | (2.0966) |
| $VOL_t$ | 0.0032 | 0.0030 | 0.0032 | 0.0062 | 0.0149 | 0.0158 |
| | (1.0975) | (1.2264) | (1.1353) | (1.2357) | (1.4511) | (1.5421) |
| $\log(AT_t)$ | 0.3401*** | 0.3537*** | 0.3457*** | 0.2414*** | 0.2665*** | 0.2876*** |
| | (42.7643) | (43.3966) | (41.6672) | (3.9155) | (4.3071) | (3.7063) |
| $MB_{t-1}$ | 0.0981*** | 0.1008*** | 0.0996*** | 0.0108 | 0.0160 | 0.0328 |
| | (5.3630) | (5.3465) | (5.4882) | (0.3407) | (0.3672) | (1.0113) |
| $R\&D_t/AT_t$ | 1.7088 | 1.6309 | 1.7105 | −0.8422 | −0.3230 | −0.3171 |
| | (1.1192) | (0.7541) | (0.8218) | (−0.7791) | (−0.8931) | (−1.0831) |
| CEO-Chair | 0.0078** | 0.0085* | 0.0110** | 0.0214 | −0.0133 | 0.0161 |
| | (2.0371) | (1.7762) | (2.1349) | (1.4701) | (−0.9373) | (1.1820) |
| Per Ind Dir | 0.6935 | 0.6882 | 0.6823 | 0.3935 | 0.3850 | 0.3981 |
| | (1.2428) | (1.0406) | (1.1549) | (1.4766) | (1.3639) | (1.4310) |
| Year Fixed Effects included | Yes | Yes | Yes | Yes | Yes | Yes |
| Number of Observations | 4291 | 4291 | 4291 | 4291 | 4291 | 4291 |
| Adjusted $R^2$ | 0.3122 | 0.3726 | 0.3671 | 0.5330 | 0.5635 | 0.5427 |

* Significant at 0.10 level
** Significant at 0.05 level
*** Significant at 0.01 level

Table 12: The impact of excess director compensation on total executive compensation

This table presents person, and both firm and person fixed effects regressions of total executive pay on its determinants and excess director compensation. Excess director compensation is defined as in the previous table.

| | Pooled | Exec FE | Exec and Firm FE |
|---|---|---|---|
| Dir Excess Comp (FE) | 0.3830*** | 0.2619 | 0.3086 |
| | (3.8608) | (1.3530) | (1.1355) |
| CEO Indicator | 1.1022*** | 0.7537*** | 0.6588*** |
| | (46.9094) | (15.8339) | (13.8622) |
| log(CEO Tenure) | 0.0417*** | 0.0207** | 0.0136 |
| | (3.2587) | (2.2769) | (0.8341) |
| $ROA_t$ | 0.8240*** | 0.6499*** | 0.7254*** |
| | (5.6302) | (4.0349) | (5.0631) |
| $ROA_{t-1}$ | 0.9262*** | 0.7147*** | 0.4897*** |
| | (6.5103) | (5.2050) | (4.1241) |
| $RET_t$ | 0.0152** | 0.0149** | 0.0136** |
| | (1.9946) | (2.4390) | 2.1941 |
| $RET_{t-1}$ | 0.0409* | 0.0597** | 0.0651* |
| | (1.6811) | (2.0384) | (1.8367) |
| $VOL_t$ | 0.0008 | 0.0016 | 0.0015 |
| | (0.3754) | (0.5442) | (0.6156) |
| $\log(AT_t)$ | 0.3580*** | 0.2075*** | 0.2334*** |
| | (42.4105) | (20.6715) | (16.7172) |
| $MB_{t-1}$ | 0.1331*** | 0.1113*** | 0.1384*** |
| | (6.7590) | (7.1471) | (6.8095) |
| $R\&D_t/AT_t$ | 1.3625 | −0.2102 | −0.1649 |
| | (0.7678) | (−0.8649) | (−0.6277) |
| CEO-Chair | 0.0358*** | 0.0137 | −0.0068 |
| | (3.3018) | (0.5326) | (−0.7697) |
| Per Ind Dir | 0.4623 | 0.1299 | 0.1542 |
| | (1.1906) | (0.7982) | (0.5890) |
| Year Fixed Effects included | Yes | Yes | Yes |
| Number of Observations | 21482 | 21482 | 21482 |
| Adjusted $R^2$ | 0.3317 | 0.6872 | 0.7090 |

* Significant at 0.10 level

** Significant at 0.05 level

*** Significant at 0.01 level

Table 13: Variable Definitions

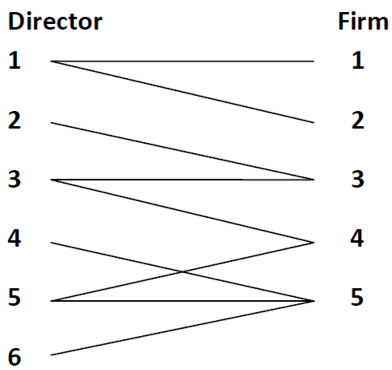
| Name | Definition and Corresponding Item |
|---|---|
| *Director Variables* | |
| Total Compensation | Total compensation as reported in SEC filings. This is the sum of the fees that were earned or paid in cash (CASH FEES), value of stock-related awards that do not have option-like features (STOCK AWARDS), value of option-related awards (OPTION AWARDS), value of non-equity incentive plans (NONEQ INCENT), change in pension value (PENSION CHG), and other compensation received by the director including perquisites and other personal benefits (OTHCOMP). In thousands of dollars. |
| Total Equity-Based Compensation | Value of stock-related awards that do not have option-like features (STOCK AWARDS) plus value of option-related awards (OPTION AWARDS). In thousands of dollars. |
| Director Excess Compensation | Measured as the residual from corresponding regression which includes both firm and director fixed effects |
| Director Tenure | A number of years director has been employed by the company |
| Male Director Indicator | A dummy variable that equals 1 if director is male |
| *Executive Variables* | |
| Total Compensation | Total compensation comprised of the following: Salary, Bonus, Other Annual, Total Value of Restricted Stock Granted, Total Value of Stock Options Granted (using Black-Scholes), Long-Term Incentive Payouts, and All Other Total. TDC1. In thousands of dollars. |
| Total Equity-Based Compensation | |
| Executive Excess Compensation | Measured as the residual from corresponding regression which includes both firm and executive fixed effects |
| CEO Age | The age of the CEO |
| CEO Indicator | A dummy variable that equals 1 if executive holds CEO position |
| Male Indicator | A dummy variable that equals 1 if executive is male |
| Executive Tenure | Number of years executive has been with the firm |
| CEO Equity Ownership | Percentage of total shares outstanding held by the executive |
| *Firm Variables* | |
| Stock Returns (RET) | Stock returns from CRSP, annual |
| Volatility of Stock Returns (VOL) | Standard deviation of daily stock returns over the past three years, annualized |

*Continued ...*

Table 13: (continued)

| Name | Definition and Corresponding Item |
|---|---|
| Assets (AT) | Total assets, in millions of dollars |
| Return on Assets (ROA) | The earnings before interest, taxes, depreciation, and amortization (EBITDA) divided by total assets. |
| Return on Equity (ROE) | The earnings before interest, taxes, depreciation, and amortization (EBITDA) divided by total book value of common equity. |
| Market-to-Book (MB) | The market value of common stock plus the book value of total debt divided by the book value of total assets. |
| Capital Expenditure (CAPEX) | Capital expenditures divided by the lagged one year PP&E. |
| Research and Development Expenses (R&D) | Research and development expenses divided by the lagged one year PP&E. |
| Number of Directors | Total number of independent directors on corporate board |
| CEO-Chair Indicator | A dummy variable that equals 1 if CEO is chairman of the board |

Figure 1: Example of the grouping procedure




| Director | Firm | Group |
|---|---|---|
| 1 | 1 | 1 |
| 1 | 2 | 1 |
| 2 | 3 | 2 |
| 3 | 3 | 2 |
| 3 | 4 | 2 |
| 4 | 5 | 2 |
| 5 | 4 | 2 |
| 5 | 5 | 2 |
| 6 | 5 | 2 |

Figure 2: Distribution of Executive Fixed Effects, obtained from regression (4) in Table 4.

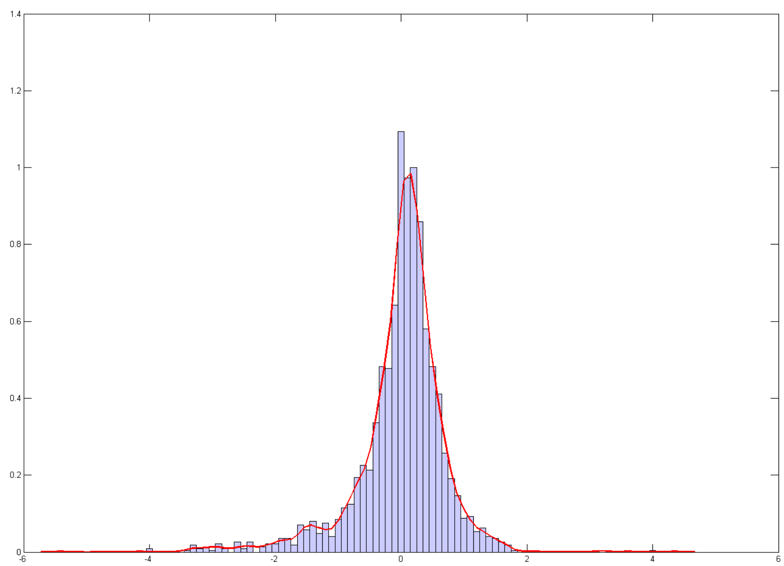


Figure 3: Distribution of Firm Fixed Effects, obtained from regression (4) in Table 4.

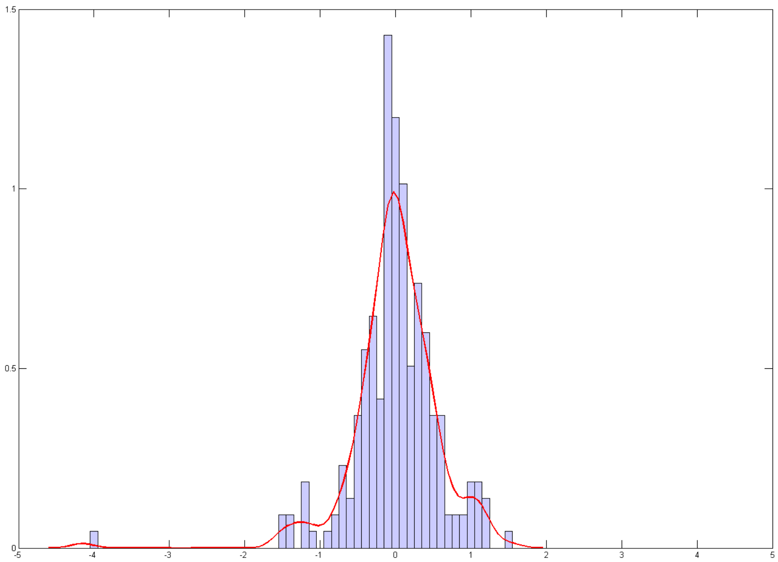
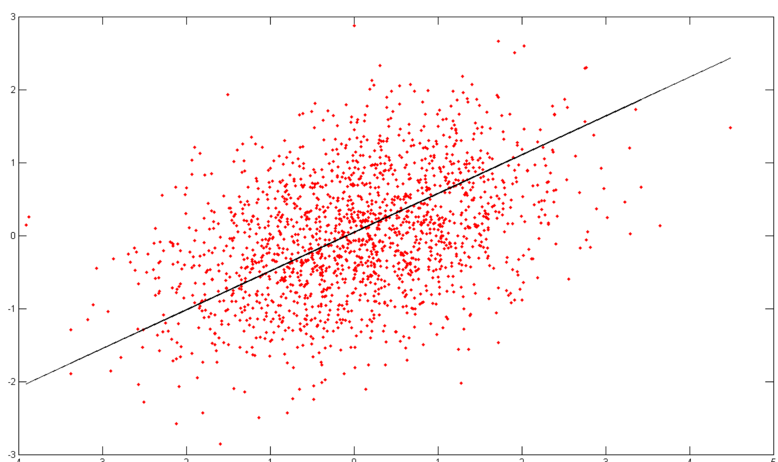


Figure 4: Estimated sorting between executives and directors



This figure plots within-firm average director fixed effect against the firm-average executive fixed effect. Firm average executive and director fixed effects for each year $t$ are calculated as $\bar{\delta}^E_{jt} = \sum_{i \in J^E(i,t)} \delta^E_i$ and $\bar{\delta}^D_{jt} = \sum_{i \in J^D(i,t)} \delta^D_i$. See text for details.