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. Using data on top managers in large U.S. firms, I find that the managerial labor market is characterized by the high degree of within-firm positive sorting, which implies that better managers are matched with better co-workers. Sorting significantly contributes to the evolution of firm productivity and distribution of top incomes in the economy. Firms with better executive teams outgrow their competitors by 30 percent over the five year period. Further, more than a third of observed pay inequality among top executives is directly attributable to within-firm sorting. 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 board of directors' advisory role in the U.S.

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 do 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 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

[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.

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

[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.

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, 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 a 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

[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.

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

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 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 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.

[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.

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,

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

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 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.

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

Finally, this paper is related to organizational economics literature that focuses on production in teams. Early papers, (e.g., Alchian and Demsetz, 1972) laid out basic foundations for thinking about output as a joint product of a team, while later papers focus on issues such as how complementarities affect executive turnover (e.g., Hayes, Oyer and Schaefer, 2006).

2 Framework

The starting point of my setup is 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 an executive team of n members.[8] The production process features complementarities between the members of the team. I assume that a firm cannot substitute one good manager with a few mediocre ones.

Each member of the executive team is endowed with a productive quality q_i, which I interpret as managerial skill. The output produced by firm j in year t is a function of skill level of all members of the executive team and takes the form $y_{jt} = k_{jt}^{\alpha} Q_{jt}^{\beta}$, where Q_{jt} is the aggregate skill of the executive team at firm j in year t. I assume that the team skill is a product of individual skill of each team member: $Q_{jt} = \frac{1}{N_j} \prod_{i=1}^{N_j} q_{it}$, where N_j is the number of managers assigned to firm j and q_{it} is the individual skill of manager i assigned to firm j in year t. The overall production function is

$$y_{jt} = k_{jt}^{\alpha} \Big(\frac{1}{N_j} \prod_{i=1}^{N_j} q_{it} \Big)^{\beta}. \tag{1}$$

Note that this production function is increasing in all of its arguments and is strictly supermodular.

I consider a set of competitive equilibria that is defined by the assignment of managers into firms, a set of wage functions $w(q_{it})$ paid to every manager i in year t, and a price of the capital good. Firms maximize their profits by choosing workers of a particular skill q_{it} and the amount

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

of capital k they use in the production:

$$\max_{\{q_{it}\},k}\left(k_{jt}^{\alpha}\left(\frac{1}{N_j}\prod_{i=1}^{N_j}q_{it}\right)^{\beta}-\sum_{j=1}^{N_j}w(q_{it})-r_t k_{jt}\right) \tag{2}$$

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. This means that the correlation between a manager's skill and skill of his co-workers across all firms should be equal to 1: $\text{corr}(q_{i \text{ in } j}, q_{i\text{'s co-workers in } j}) = 1$.

Integrating the first order conditions of (2) with respect to q_{it} gives me the log wage equation for each manager i:

$$\log w_{it} = \phi_j + \alpha_i \log k_{jt} + \underbrace{\log q_{it}}_{\text{own skill}} + \underbrace{\log \widetilde{Q}_{jt}}_{\text{aggregate co-worker skill}}, \tag{3}$$

where ϕ_j the firm-specific component of wages and aggregate co-worker skill $\widetilde{Q}_{jt}$ is defined as

$$\widetilde{Q}_{jt} = \frac{1}{N_j}\prod_{k=1,k\neq i}^{N_j} q_{kt} \tag{4}$$

This equation implies that compensation of each executive in the firm is a function of firm-specific components, his or her own skill, and an aggregate skill level of all his co-workers. The goal is to use the observable data on executive compensation and use the structural wage equation (3), to recover measures of executive skill q_i for each manager and each firm. Once they are estimated, I can use the empirical counterpart of $\text{corr}(q_{i \text{ in } j}, q_{i\text{'s co-workers in } j})$ to measure the degree of sorting in the market.

In Section 3.2 I discuss empirical methodology that allows me to identify q_i separately from the rest of the components of equation (3).

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 an identification of three separate components of the wage structure: a person-specific component q_i, a firm-specific component ϕ_j, and a co-worker component $\widetilde{Q}_{jt}$. This is a very restrictive specification and it requires a significant mobility of executives across jobs to be able to identify all three components separately. First, it is impossible to identify all three effects in a single cross section; hence we need a sufficiently long time-series to identify these components. 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 will restrict my analysis to the sample where each firm contains executives who change jobs at least twice during the sample period. In practice, this requirement is too restrictive because executive mobility is scarce in the data. To avoid this, I use a technique developed by Abowd, Kramarz and Margolis (1999) that puts less stringent identification requirements on mobility. 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 equation (3) is

$$y_{iJ(i,t)t} = \delta_i + \phi_{J(i,t)} + z_{it}\beta_1 + x_{J(i,t)}\beta_2 + \gamma_t + \varepsilon_{iJ(i,t)t}. \tag{5}$$

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 γ_t. Components δ_i and $\phi_J(i,t)$ are unobservable executive and firm characteristics. This specification assumes that for director i, δ_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 $\varepsilon_{iJ(i,t)t}$ is centered around zero, $\mathbb{E}[\varepsilon_{iJ(i,t)t}|i,t,z,x] = 0$, has finite variance, $\text{var}[\varepsilon_{iJ(i,t)t}|i,t,z,x] < \infty$, 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

$$y = P\Delta + Q\Phi + X\beta + \varepsilon, \tag{6}$$

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

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

[10] One may interpret δ_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).

characteristics, and β 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.

3.3 Iterative procedure to identify co-worker components of wages

The discuss on AKM method in the previous section does not take into account the co-worker component of wages. In particular, if we compare equation (5) to equation (3), we can notice that the former does not contain the co-worker components $\widetilde{Q}_{jt}$. There are two ways to add co-worker components to the estimated wage equation. First, one could derive the mobility requirements on each individual worker and his co-workers similar to the original Abowd, Kramarz and Margolis (1999). These identification requirements will considerably reduce the sample of observations that can be used in estimation. Instead, I develop an iterative procedure that directly uses AKM methodology but accounts for co-worker effects. Below I discuss this procedure.

First, I start by estimating equation

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

ignoring the co-worker effects. This gives me a set of initial estimates of δ_i, which I denote as $\widehat{\delta}_i^0$. At the next step, for each manager i, I calculate co-worker effects as an average fixed effect of i's colleagues:

$$\widehat{\delta}_{J(i,t)}^0 = \frac{1}{N_{J(i,t)}} \prod_{k=1,k\neq i}^{N_{J(i,t)}} \widehat{\delta}_k^0.$$

I plug this measure of co-worker skill into compensation equation and estimate it again using the AKM method:

$$y_{iJ(i,t)t} = \delta_i + \widehat{\delta}_{J(i,t)}^0 + \phi_{J(i,t)} + z_{it}\beta_1 + x_{J(i,t)}\beta_2 + \gamma_t + \varepsilon_{iJ(i,t)t}.$$

This gives me a second set of estimated fixed effects δ_i, which I denote as $\widehat{\delta}_i^1$. I use these estimates to construct co-worker effects $\widehat{\delta}^1_{J(i,t)}$. Then I use them again in the AKM regression, which gives me $\widehat{\delta}^2_i$. I continue doing this until estimated effects converge: $||\widehat{\delta}^{n+1}_i - \widehat{\delta}^n_i|| < 10^{-6}$. In practice, it take 7 (i.e., $n = 7$) steps to reach this convergence criterion.

3.4 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 4 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 (5) and estimate person-specific fixed effects δ_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. Table 3 shows the empirical distribution of the number of executives per firm. For each executive δ_i, I calculate $\widetilde{\delta}_{J(i,t)}$, which is the average person-specific effect of all i's co-workers:

$$\widetilde{\delta}_{J(i,t)} = \frac{\sum_{k \in \bar{J}(i,t)} \hat{\delta}_k}{N_{\bar{J}(i,t)}}, \tag{7}$$

where $\bar{J}(i,t)$ is the set of co-workers who worked with i at firm j in year t. This set excludes the manager i himself. The empirical measure of sorting I use is $\text{corr}(\hat{\delta}_i, \widetilde{\delta}_{J(i,t)})$, which is the director counterpart of the theoretical sorting measure discussed in Section 2.

I find that co-worker components of executive pay explain 36% of observed variation in executive pay. Results are reported in Table 6. The individual executive skill contributes 26% to the variation. Together, these two components account for 62% of variation, which is consistent with the results for a general population of workers.[11] This is also consistent with the results in Graham, Li and Qiu (2012) who decompose the variation in pay into the AKM components. My results show that person-specific components mask the co-worker components, and that the within-firm sorting accounts for 36% of the total variation, which is the largest observable component that explains variation in executive pay.

Next, I report the main sorting results of the paper. I estimate both Spearman (rank) and Pearson correlations defined by (7). The table below shows the results:

The rank correlation is a more informative measure of the overall sorting for two reasons. First, Section 2 suggests that the direct empirical counterpart of the within-firm sorting measure is the rank correlation. Second, is the empirical AKM model is mis-specified, it will produce estimates of executive skill that contain the measurement error. This measurement error will likely affect Pearson correlation and unlikely to affect rank correlation.

The results above indicate that the executive labor market is highly sorted. The full sample estimate suggest that the empirical measure of sorting is 0.58. The degree of sorting has been

[11] See, for example, Abowd, Kramarz and Margolis (1999) and Postel-Vinay and Robin (2002).

Years	Rank correlation	Pearson Correlation
Full sample	0.58	0.52
1992-1996	0.55	0.46
1997-2000	0.57	0.50
2001-2004	0.54	0.51
2005-2008	0.61	0.59
2009-2013	0.60	0.57

going up in the recent years. This result suggests that there is a very substantial degree of complementarities within executive teams. Interestingly, this degree of sorting is much larger that is typically found in other labor markets.[12] It is likely that information and other labor market frictions that preclude sorting are much lower in the labor market for top talents.

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. Table 6 shows that it accounts for 36% of total variation in executive pay, i.e., more than third of the inequality in pay is due to the positive assortative matching within firms.

Finally, this result provides a foundation for assignment models of executive pay, such as Gabaix and Landier (2008) and Terviö (2008). These models assume that the CEO labor market is perfectly sorted. Since these models produce important quantitative implications, it is important to understand whether the CEO labor markets are indeed perfectly sorted. This paper provides support for this assumption by showing that the executive labor markets are highly sorted.

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

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.[13] 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.

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.[14] 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

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

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

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.

4.2 Degree of Sorting Between Executives and Directors

4.2.1 Director Compensation

I start by estimating (5) 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 10. 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.[15] 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 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 6 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.[16]

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

[15]See for example Ryan and Wiggins (2004), Adams and Ferreira (2008).
[16]See, for example, Graham, Li and Qiu (2012) and Iranzo, Schivardi and Tosetti (2008).

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 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 11. 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:

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

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:

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

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

$$\text{corr}(\bar{\delta}^E_{jt}, \bar{\delta}^D_{jt}) = 0.41, \tag{10}$$

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 12. The degree of association between excess director compensation and CEO compensation is significantly reduced. Finally, in Table 13 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 EXECUTIVES PER FIRM BY YEAR

The table shows the distribution of the number of executives per firm reported in Execucomp. The second and third columns show the number of unique firms and executives each year. Columns (4) and (5) shows the minimum and the maximum executives per firm, and columns (6) and (7) report means and medians, respectively.

(1) Year	(2) Firms	(3) Executives	(4) Min	(5) Max	(6) Average	(7) Median
1992	1571	8023	1	11	5.12	5
1993	1682	9757	1	12	5.84	6
1994	1749	10609	1	12	6.11	6
1995	1849	11044	1	15	6.02	6
1996	1977	11555	1	15	5.91	6
1997	2037	11942	1	15	5.92	6
1998	2071	12505	1	14	6.10	6
1999	1954	12083	1	12	6.24	6
2000	1846	11456	1	13	6.25	6
2001	1848	11315	1	13	6.16	6
2002	1886	11487	1	14	6.12	6
2003	1936	11747	1	13	6.10	6
2004	1878	10859	1	12	5.80	6
2005	1762	9349	1	12	5.32	5
2006	1893	9875	1	10	5.24	5
2007	2125	11405	1	11	5.41	5
2008	2044	11011	1	13	5.42	5
2009	1997	10580	1	13	5.33	5
2010	1951	10037	1	13	5.17	5
2011	1891	9749	1	11	5.19	5
2012	1830	9473	1	10	5.21	5
2013	1683	8818	1	12	5.27	5

Table 4: 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 5: 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 6: 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 firm, manager, co-manager, 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.

$$R^2 = \frac{\mathrm{cov}(x_{it}\hat{\beta}, y_{it})}{\mathrm{var}(y_{it})} + \frac{\mathrm{cov}(\phi_{j(i,t)}, y_{it})}{\mathrm{var}(y_{it})} + \frac{\mathrm{cov}(\delta_i, y_{it})}{\mathrm{var}(y_{it})} + \frac{\mathrm{cov}(\widetilde{\delta}_i, y_{it})}{\mathrm{var}(y_{it})} + \frac{\mathrm{cov}(\gamma_t, y_{it})}{\mathrm{var}(y_{it})}$$

Component	$\frac{\mathrm{cov}(Y,\mathrm{Component})}{\mathrm{var}(Y)}$	Percentage contribution to R^2
Firm observables	0.16	19.5%
Executive observables	0.05	6.1%
Firm fixed effects, ϕ	0.05	6.6%
Executive fixed effects, δ	0.21	26.0%
Co-worker fixed effects, $\widetilde{\delta}$	0.30	35.8%
Year fixed effects	0.05	6.1%
Residual	0.18	

Table 7: 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 8: 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 9: 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)
ROA_t	0.063	0.048
	(0.024)	(0.015)
Return_t	0.009	0.016
	(0.005)	(0.006)
Return_{t-1}	0.004	0.010
	(0.008)	(0.007)
Investment_t	0.034	0.045
	(0.017)	(0.019)
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 10: 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 11: 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 12: 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 13: 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 14: VARIABLE DEFINITIONS

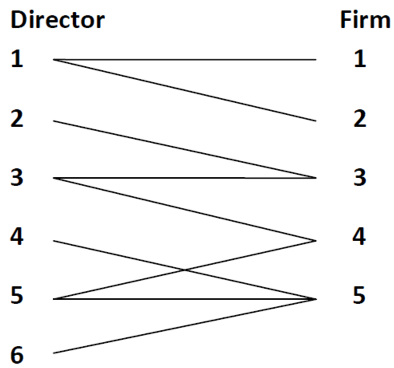
Name	Definition and Corresponding Item
Director Variables	
Total Compensation	Total compensation as reported in SEC filings. This is the sum of the fees that were earned or paid in cash (CASH FEES), value of stock-related awards that do not have option-like features (STOCK AWARDS), value of option-related 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

Continued ...

Table 14: (continued)

Name	Definition and Corresponding Item
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
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.

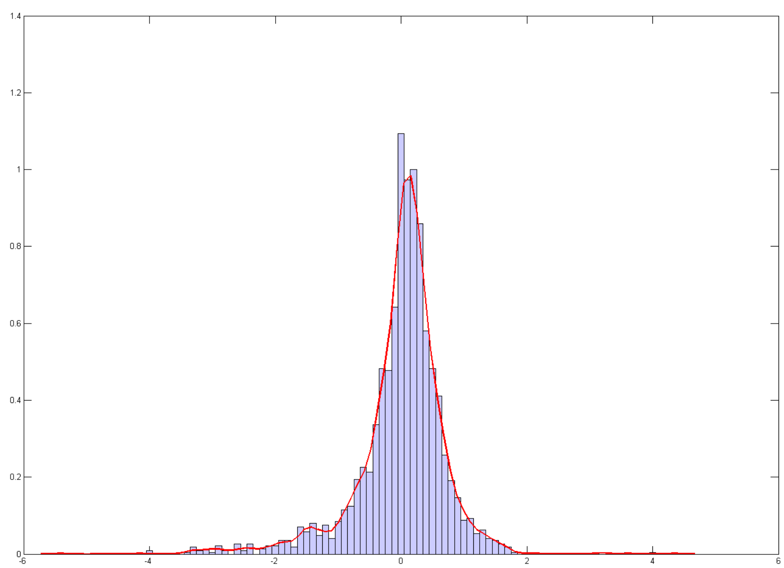


Figure 3: Distribution of Firm Fixed Effects, obtained from regression (4) in Table 4.

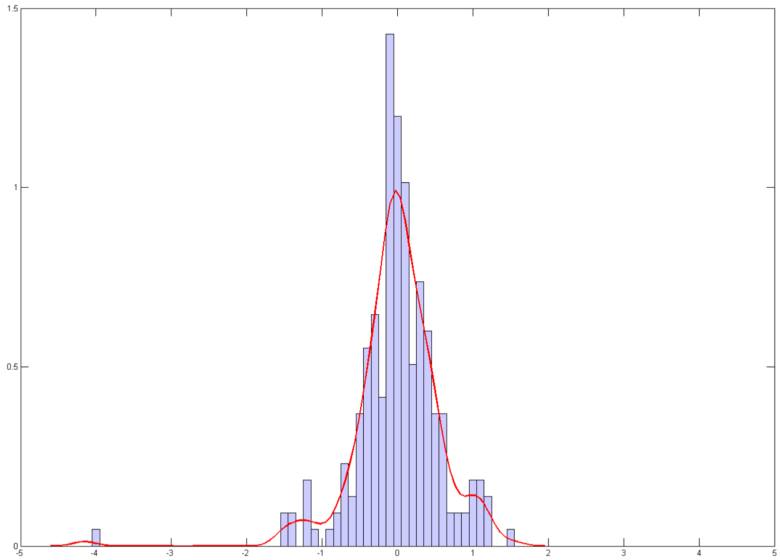
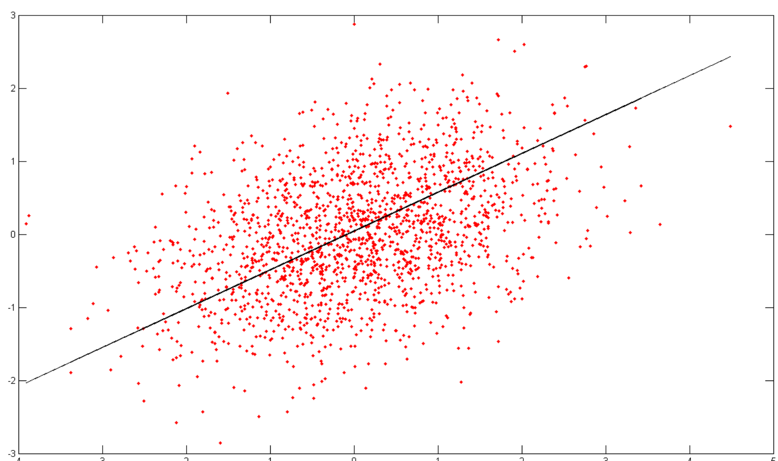


Figure 4: Estimated sorting between executives and directors



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.