# CEO Turnover in a Competitive Assignment Framework

Andrea L. Eisfeldt* Camelia M. Kuhnen‡

September 2010

**Abstract**

There is widespread concern about whether CEOs are appropriately punished for poor performance. While CEOs are more likely to be forced out if their performance is poor relative to the industry average, they are also more likely to be replaced if the industry is doing badly, which seems puzzling if termination is disciplinary. We show that these empirical patterns are natural and efficient outcomes of a competitive assignment model in which CEOs and firms form matches based on multiple characteristics, and where industry conditions affect the outside options of both managers and firms. Our model also has several new predictions about the type of replacement manager, and their pay and performance. We construct a dataset which describes all turnover events during the period 1992-2006 and show that these predictions are also born out empirically.

*Department of Finance, Kellogg School of Management, Northwestern University, 2001 Sheridan Rd., Evanston, IL 60208-2001, a-eisfeldt@northwestern.edu

†Department of Finance, Kellogg School of Management, Northwestern University, 2001 Sheridan Rd., Evanston, IL 60208-2001, c-kuhnen@kellogg.northwestern.edu.

‡We thank Janice Eberly, Alex Edmans, Michael Fishman, Carola Frydman, Dirk Jenter, Robert McDonald, Tyler Muir, Kevin J. Murphy, Dimitris Papanikolaou, Robert Parrino, Luke Taylor and Ajay Subramanian, seminar participants at INSEAD, Ohio State University, Northwestern University, Stockholm University, University of Mannheim and University of Southern California, and participants at the AFA 2009, WFA 2010, SED 2010 and EFA 2010 Annual Meetings for helpful comments. Maggie Tsai, Nicholas Stancu and Kathy Ptouchkina provided excellent research assistance. All remaining errors are ours. A preliminary and significantly different version of this paper previously circulated as "Aggregate Business Conditions and the CEO Labor Market".

# 1 Introduction

There is considerable controversy about whether CEOs are appropriately punished for poor performance. The empirical literature on CEO turnover documents that CEOs are indeed more likely to be forced out of their job if their performance is poor relative to the industry average. However, the empirical evidence also shows that CEOs are more likely to be terminated if overall industry performance is poor, even after accounting for the effect of relative performance. Conversely, they are more likely to be retained even conditional on poor relative performance if the industry is doing well. Jenter and Kanaan (2006) show that this result is puzzling from the perspective of the theoretical literature on relative performance evaluation. These models suggest that exogenous, industry, shocks should be filtered out of the termination decision.[1]

We propose an explanation for the effects of industry shocks on CEO turnover which is based on the simple idea that industry conditions affect the outside options of both the manager and the firm. CEO-firm matches are dissolved when match surplus is negative. Thus, if industry conditions affect outside options, such conditions naturally drive turnover events. Our competitive assignment model pins down precisely how these important outside options change when an industry shock occurs.

Our model has two important implications for the way evidence about managerial turnover is interpreted. First, the presence of valuable firm specific skills acts like a fixed cost of termination and leads to a threshold rule for turnover. Thus, observing that relatively poorly performing managers are more likely to be fired is not direct evidence of relative performance evaluation. In our model, and in fact in any model with fixed firing costs, only the firms with the lowest performance fire their managers even though there are no private information or agency problems. This implies that some managers with inappropriate skill sets, and thus potentially inappropriate strategies, will be efficiently retained. Second, the fact that industry shocks are not filtered out from the termination decision does not mean that boards are not acting efficiently. In our model, industry shocks change the outside options of firms and managers. If we were to include board decisions in our theory, it would be optimal for the model boards to include industry conditions in their decision to terminate, and in their choice of a replacement manager.

Specifically, we develop a competitive assignment model in which CEOs and firms

[1]See Holmstrom (1982) and Gibbons and Murphy (1990) for the development of the theory of relative performance evaluation.

form matches based on multiple characteristics. CEOs are viewed as hedonic goods with multidimensional skill bundles. Likewise, firms' production functions have heterogeneous weights on CEO's firm specific knowledge and on general CEO skills such as the ability to grow sales, and ability to cut costs, for example. Firm productivity is determined by the match between the firm's skill demands and the supply of the skills of their particular manager. There exists a competitive market for CEOs, whose wages are determined analogously to the prices of the hedonic goods in Rosen (1974). We also extend the standard competitive assignment model to include two industries so that both CEOs' and firms' outside options are determined endogenously.

Industry shocks are modeled as shocks to firms' skill demands. For example, consider an industry which is young and focused on sales growth which becomes mature and must focus on cost cutting. Other examples might include industries that are deregulated or industries in which there are significant technological innovations. When such shocks arrive, the quality of firm-CEO matches in that industry deteriorates. The optimal manager for the old environment does not possess the skills necessary for the new state of the industry. As a result, industry level productivity declines. Moreover, the shock implies that firms demand managers with different skills and this drives managerial turnover below a performance threshold. The new equilibrium allocation of managers across firms and industries is determined via competitive assignment, and this equilibrium also pins down the new wage and profit allocations.

Thus, our model employs two basic ideas, namely that industry conditions drive the outside options of firms and managers, and that fixed costs lead to threshold rules for termination.[2] These two simple elements generate both relative and absolute performance driven turnover. Our model also has new predictions about the type of replacement manager, and about their pay and performance. We show that these new predictions are also born out empirically, and help to distinguish our theory from alternative explanations based on learning and/or agency problems which do not have clear predictions about replacement managers.

Our empirical work contributes to the existing literature by studying a large dataset of CEO replacements we construct which describes all turnover events during the period 1992-2006. We document the type of turnover event (force outs, retirements, and potential quits), pay and performance of the incumbent and replacement, and whether the replacement is an industry insider or outsider. In our model, forced turnover events

[2]See Stokey (2009) and the references therein.

are driven by the need for firms to reoptimize over managerial skill sets. Individuals with valuable and hence relatively expensive general skills will come from industries in which such skills have been productively deployed. Thus, forced turnover events lead to replacement by industry outsiders. Performance improves at firms which replace their CEO's with managers possessing the newly desired skill set. Moreover, since for a firm to forgo the valuable firm specific skills of the incumbent, the replacement must have significant levels of desired general skills, these outside replacements will be expensive. Outside replacements command high pay relative to incumbent managers because more of the output produced by these managers comes from priced general skills relative to unpriced firm specific skills. Our empirical work confirms that forced turnover events are more likely to lead to industry outsider replacements, that performance improves under these replacements, and that these replacements earn relatively higher pay than incumbents in the industry.

Empirically, a large fraction of turnover events cannot be unambiguously classified as either firings or quits. We refer to these events as potential quits, since they may include instances where the CEO chose to leave the firm for another job and was not necessarily forced out. Interestingly, in the context of any matching model where separations occur when total surplus becomes negative, this is also the case. In the context of our general model, we show that under most reasonable theoretical definitions of fires vs. quits, a large fraction of separations in data generated by the model would remain unclassified.[3]

Our paper is closely related to recent papers on CEO pay by Gabaix and Landier (2008) and Tervio (2008). These papers show that the observed high levels of CEO pay can be seen as natural outcomes of the joint distribution of talent and firm sizes in a competitive assignment framework.[4] These papers constitute one response to the argument that the observed high level of CEO pay is a result of entrenched managers earning excessive rents (eg. Bebchuk and Fried (2004)). In this paper, we show how the competitive assignment model can also be used to understand the flip side of CEO

[3]See McLaughlin (1991) for an extended matching model with private information in which worker initiated separations can be distinguished from terminations.

[4]For early contributions, see Lucas (1978), the competitive assignment model of the distribution of earnings in Sattinger (1979), the superstars model of Rosen (1981), and the review of the implications of competitive assignment models for earnings in Sattinger (1993). Dicks (2009) studies the implications of the assignment model of CEO pay for corporate governance. Kaplan and Rauh (2010) analyze the pay of top earners across several occupations (i.e., executives, lawyers and athletes) and find evidence consistent with the superstar model. Hermalin and Weisbach (2010) embed a disclosure decision into the competitive assignment model and examine the cross sectional predictions for disclosure policies, firm size, and CEO pay.

pay, namely CEO turnover. We argue along related lines that the observed patterns of CEO turnover and the dynamics of CEO pay around replacement events are the result of efficient match formation and dissolution.

Viewing managers as hedonic goods is useful for considering how industry shocks might drive CEO turnover since weights on particular skills are likely to be correlated within industries. For example, the natural life cycle of industries is one of sales growth followed by increasing competition and then necessary restructuring and cost cutting. In future work, it may also be interesting to use a hedonic pricing model to understand which of the scarce skills general managers possess drives the high pay of talented CEOs. However, in this paper we focus mainly on turnover events, and study the dynamics of CEO pay only around turnover events.

Our theory also incorporates several successful themes from the recent literature on CEO labor markets. The idea that CEO's have specific abilities which firms consider when making their hiring and firing decisions is not only consistent with current executive search processes,[5] but is also in the spirit of Bertrand and Schoar (2003) which documents manager fixed effects in management style. Further support of this idea is presented in Groysberg, McLean, and Nohria (2006), which presents performance evidence for a sample of replacement mangers who are classified via their resumes as either cost cutting, growth, or cyclical managers. The study finds that managers are only successful in their new jobs if the required strategy matches their talent type. The idea that the importance of firm specific skills can influence whether termination occurs is built upon Murphy and Zabojnik (2004) and Murphy and Zabojnik (2007), which develop a theory of the effect of firm specific skill on turnover and on Frydman (2005), which studies the effects of changes in the importance of specific vs. general skills using a long time series of managerial turnover. Taylor (2010) shows quantitatively how replacement costs inhibit CEO replacement using a structural model.

Our paper builds on the results of a large body of empirical work on CEO turnover.[6] One of the most documented facts is that relative performance matters for CEO turnover: the probability of CEO turnover is negatively related to the performance of the firm relative to the industry (Barro and Barro (1990), Gibbons and Murphy (1990)) or to the market (Warner, Watts, and Wruck (1988)).

[5]See Carey and Ogden (2000) who discuss how to tailor firms' executive searches to their desired strategy going forward (e.g., pages 42-43).

[6]See Murphy (1999) for a review of the literature on CEO compensation and turnover.

However, relative performance does not seem to be the only driver of managerial changes. Jenter and Kanaan (2006) document that CEOs are more likely to be dismissed from their job after bad industry and bad market performance, and in light of these findings argue that relative performance evaluation (RPE) cannot be the sole determinant of CEO turnover. They suggest two hypotheses consistent with the empirical results. First, corporate boards may commit systematic attribution errors and credit or blame the CEO for performance caused by factors outside their control. Second, firm performance in bad times may be more revealing about CEO skill than performance in good times. In our model, the relevance of industry conditions for whether or not a CEO is forced out comes from considering the firm and CEO as parties in a match whose actions depend on their respective outside options. The data support our idea since the type of turnover event helps to predict the type and pay of the replacement CEO chosen. Existing models of learning and/or monitoring do not have clear predictions about whether replacements will be industry insiders or outsiders, and about the pay of these replacements. Moreover, the recent findings of Jenter and Lewellen (2010), that relatively poor performance still leads to turnover after six to ten years of tenure, seems inconsistent with a learning explanation.

Several papers have focused on the relationship between corporate governance, compensation and CEO turnover. Huson, Parrino, and Starks (2001) find that the frequency of forced turnover and of outside succession increased over time during 1971 to 1994, and that board characteristics influence the likelihood of these events. Kaplan and Minton (2006) argue that the CEO turnover rate during 1992-2005 is higher than previously found for the prior two decades (11.8% versus 10%) and attribute this to boards becoming increasingly more sensitive to the CEO's performance. Peters and Wagner (2007) suggest that this recent increase in turnover has lead to a significant increase in CEO pay, as executives face a higher risk of losing their jobs.

The role of industry conditions on CEO turnover has not received much attention in the literature. This may be because historically, the literature on CEO turnover has focused on the role of boards as monitors of the firm and has attempted to ascertain their effectiveness in this role.[7] Notable exceptions are Parrino (1997) and Eisfeldt and Rampini (2008). Parrino (1997) argues that intra-industry CEO appointments are less costly and performance measures are more precise in homogeneous industries, and, consistent with this argument, finds that the likelihood of forced turnover and of an intra-

[7]We thank Robert Parrino for this helpful historical perspective on the literature.

industry appointment increase with industry homogeneity. Eisfeldt and Rampini (2008) show how aggregate business cycle conditions can drive CEO turnover and compensation in a principal agent environment where managers have private information about their skill. Their focus, however, is on external turnover due to mergers and acquisitions.

# 2 Model

We develop our model in three steps. In section 2.1 we describe our general framework of firms and CEO's matching based on multiple characteristics. This simple set up illustrates two fundamental results from our framework. First, industry conditions drive the outside options of firms and managers and thus lead to managerial turnover. Second, firm specific skill acts as a fixed termination cost and leads to threshold rules for termination. Thus, these two simple elements generate both relative and absolute performance driven turnover. There is what appears to be relative performance evaluation even though there is no learning or asymmetric information in the model.

In the context of this general model we also show that in a matching framework it is not easy to label separations as quits vs. firings. Thus, viewing turnover in the context of a matching model, one should not be surprised by finding many empirical separations difficult to classify, even with perfect data.

In section 2.2 we develop a two firm competitive assignment example in which shocks to firm's skill weights leads to turnover. We describe how managerial assignments, output, wages, and profits are determined in equilibrium.

Finally, in section 2.3 we construct a two industry competitive assignment economy. Whereas the general framework illustrates how variation in outside options leads to absolute performance effects on turnover, the two industry assignment model pins down all outside options endogenously. The two industry assignment model thus generates our results for turnover and replacement type, pay, and performance based on these endogenous outside options. When industry conditions change, manager-firm match quality deteriorates, and industry performance declines. Firm specific skills lead to a threshold rule for termination, and relatively poorly performing managers are forced out. Expensive outside replacements are brought in to replace fired managers. Replacements are industry outsiders because managers who possess the newly desired general skill will be employed in an industry in which such skills have been previously productively deployed. Otherwise firms would be paying for unused but highly compensated general skills. Moreover, these outside replacements are especially expensive because in order for it to be optimal to replace the incumbent manager, the firm must acquire a manger with general skills which outweigh the loss of firm specific skills. General skills have positive market prices while firm specific skills have no value outside the firm. Thus, if it makes sense to replace the manager, the firm will need to pay the replacement more. Since these new mangers will have the desired general skills optimal for the new industry conditions, performance will improve under these new replacements.

Our model is similar to the competitive assignment models used to explain the rise in, and high levels of CEO compensation, except that in those models skill is one-dimensional and there is only one industry. In fact, we believe we are the first to develop a competitive assignment model with two industries, or markets, although the two market set up might be useful for modeling marriage markets, general labor markets, or real estate markets as well. Thus, our modeling strategy is most closely related to Gabaix and Landier (2008) and Tervio (2008) which use the model from Sattinger (1979) to analytically describe the relationship between CEO talent, firm size, and CEO pay. Gabaix and Landier (2008) employ extreme value theory to show quantitatively that such a model can explain the rise in and level of CEO pay. Our model and solution methods will closely follow Tervio (2008) adapted to our set up with multidimensional heterogeneity and more than one industry.

We also employ the ideas in Murphy and Zabojnik (2004) and Murphy and Zabojnik (2007). Their model incorporates firm-specific vs. general skills by modeling firms as only being able to deploy a fraction of a new CEO's (one dimensional) ability. The remaining fraction represents firm-specific skill which can only be deployed by incumbent managers. Murphy and Zabojnik use their model to explain the rise in CEO pay by an increase in the importance of general managerial skills through comparative statics over this fraction. The Murphy Zabojnik model also accommodates turnover (for example, shocks to firm size would drive reallocation). However, in order to study the effect of industry conditions on turnover, and in order to examine the characteristics, pay, and performance of replacement managers, one needs to define what an "industry" is. In our model, an industry is defined by firms which share similar skill weights. Thus, we can consider insider and outsider replacements, as well as pin down outside options both within and outside the industry.

## 2.1 General Framework

First, we describe our general set up and illustrate how industry conditions might affect managerial and firm outside options. Since CEO-firm matches dissolve when total match surplus becomes negative, such variation in outside options will naturally drive turnover events. Thus, absolute performance will affect turnover. Furthermore, any fixed costs of termination will lead to threshold rules and hence relative performance will also matter. In this general set up, we will allow for managers to retire, or to move to another job. Similarly, firms can choose to liquidate, or to find a new manager in the case that their match dissolves.

We also show how ambiguity in classifying turnover events as firings vs. quits is natural even in the model. This suggests that even with the best data documenting what goes on in board meetings one may not be able to classify turnover events with great precision.

There are two dates, zero and one. At each date, managers will be matched to firms via competitive assignment. To fix ideas, it is useful to first examine the decision problems of a single firm and manager at a single date. For this, we consider the decision problems of a manager and a firm who are currently matched in a competitive assignment economy. Neither the firm, nor the manager can commit to honoring long term contracts, so each must earn at least the value of their outside option in each period in order for the match to continue.[8] The dynamics of optimal managerial compensation induced by agency problems when long term contracts are feasible is the focus of many recent theoretical papers.[9] Although some of these papers do contain results about contract termination, their main focus is on compensation dynamics rather than CEO turnover. For the most part termination in these models is rare, and is largely used as a stick to provide incentives with rather than treated as an object of interest in and of itself. The limited focus on CEO turnover in the dynamic contracting literature is in contrast to the large empirical literature on turnover discussed above.

[8]See Lazear and Oyer (2004) and Oyer (2004) for empirical evidence that firms set wages in accordance with the employees' outside option.

[9]See for example, DeMarzo and Fishman (2007a), DeMarzo and Fishman (2007b), He (2007), DeMarzo, Fishman, He, and Wang (2009), Sannikov (2008), and Lustig, Syverson, and Van Nieuwerburgh (2009). Sannikov (2008) considers the effects of variation in firm and managerial outside options on the agency costs of providing incentives. DeMarzo, Fishman, He, and Wang (2009) consider how exogenous variables affect the degree of agency costs and hence the dynamics of managerial compensation. Lustig, Syverson, and Van Nieuwerburgh (2009) study how managerial outside options affect the division of rents between managers and firm owners over time and study the induced distributions of managerial compensation. He (2007) focuses on the effects of hidden savings on compensation dynamics. Edmans and Gabaix (2009) provide a survey of how these and other recent theories can explain "pay-for-luck".

We consider a firm $i$ which produces output using capital and the managerial input from manager $j$ according to:

$$a_i(m_j)k^\alpha,$$

where $a_i(m_j)$ is the productivity of capital when firm $i$ employs manager $j$, and $\alpha \in [0, 1]$. This productivity is given by (slightly abusing notation):

$$a_i(m_j) = \sum_{s=1}^{S} \theta_{i,s} a_{j,s}$$

where $\theta_{i,s}$ is a weight which describes the importance of skill $s$ in determining the productivity of capital deployed in firm $i$ and $a_{j,s}$ is the level of ability of manager $j$ in skill $s$.[10] Thus the productivity of manager $j$ employed at firm $i$ is the inner product of manager $j$'s skill levels and firm $i$'s skill weights. These weights vary over time and across firms. Moreover, these weights are likely to be correlated within industries, and subject to common shocks. For example, growing firms may have high weights on skills such as building and motivating a sales force, and firms in mature industries may place higher weights on cost cutting. Firms which can fund growth or operating leverage internally may not have a high weight on the ability to raise external finance, whereas firms needing to access capital markets might.[11] Finally, the importance of firm-specific vs. general skills may vary in the spirit of the evidence documented by Frydman (2005) for the time series of all firms.

The abilities of managers may also vary over time. In particular, managers may gain firm-specific abilities through learning by doing during their tenure with the firm. Although it is interesting to consider the decision by the manager to invest in accumulating different skills, for simplicity here we will assume that abilities are fixed and leave a study of that investment decision for future work.[12] Bertrand and Schoar (2003) document managerial fixed effects in management style, consistent with abilities being somewhat rigid. For it to be optimal to replace a manager with a suboptimal skill set,

[10] One can incorporate variation in size if one considers the $\theta$ weights to be weights times capital. In other words, define $\tilde{\theta}_n^j \in \{0, 1\}$ and let $\theta_n^j = \tilde{\theta}_n^j g(k_j)$ where $g'(k_j) > 0$. For simplicity, and to focus on variation in and shocks to skill weights, we hold capital fixed across firms.

[11] Firms may also value particular psychological characteristics or preferences of the CEO. For instance, Graham, Harvey, and Puri (2009) show that CEOs who are more risk tolerant tend to work for high growth firms.

[12] In a recent paper Giannetti (2009) presents a model where compensation is designed to incentivize managers to invest in firm-specific skills.

we need to have that there are at least investment costs, adjustment costs, or time to build for managerial skills, which seems reasonable.

The value or total surplus created by firm $i$ when it is matched with manager $j$ is

$$V \equiv a_i(m_j)k^\alpha.$$

To keep things simple, there is no labor other than the managerial input in our model.

Since we assume that there is no commitment on the part of the manager, the manager will always need to earn a value inside the match equal to the value of their outside option. The manager can quit, or they can retire. We assume that there is a market for managers in which the per period hedonic price of a manager is given by the market value of that manager's ability bundle, which we denote by $w_j$. This market is in the spirit of that formalized in Rosen (1974) and Lancaster (1966). Rosen (1974) contains a description of the technical assumptions which determine the properties of the hedonic price function. If skill bundles are recombinable, and there is no arbitrage, this function will be linear. These assumptions seem strong for the CEO market and so, in general, we expect the price function to be nonlinear. Moreover, because bundles cannot be dismantled, the price of any particular skill will depend on the joint distributions of and demands for all skills. For this reason, when one is interested in the distribution of CEO pay it is convenient to assume that skills are one-dimensional, as in Sattinger (1979) and Tervio (2008). Here, we depart from this assumption but simplify our general model in order to solve for managerial wages in Subsection 2.3.

If the manager can either stay at his current employer, quit for his next best employment option, or retire, then manager $j's$ outside option is:

$$V^{m_j} \equiv \max \left\{ max_i \left\{ w_{ij} \right\}, R \right\}$$

where $i$ denotes possible employers and $R$ is the value of retiring.

The firm's owners will also need to be paid their outside option. The firm can fire the manager and hire a replacement, or it can liquidate. The firm's outside option is given by:

$$V^{f_i} \equiv \max \left\{ \max_j \left\{ a_i(m_j)k^\alpha - (V^{m_j}) \right\}, L \right\}.$$

The left hand argument is the value the firm receives with the optimal replacement manager, where $a_i(m_j)$ and $V^{m_j}$ are the productivity of manager $j$ at firm $i$ and the outside option of manager $j$ defined above. The right hand argument, $L$, is the liquidation value of the firm.

The current match will dissolve if total surplus from the match is negative, in other words if the total value of output created by the current match, minus the manager's outside option, minus the firm's outside option, is negative, i.e. if:

$$\begin{aligned} & (a_i(m_j)k^{\alpha}) - \left( max \left\{ \max_j \{w_j\}, R \right\} \right) \\ - \quad & (max \{max_n \{a_i(m_n)k^{\alpha} - (V^{m_n})\}, L\}) < 0 \end{aligned}$$

or,

$$V - V^{m_j} - V^{f_i} < 0.$$

This condition is analogous to what Murphy and Zabojnik (2004) describe as the "make or buy" tradeoff, except that skills are multidimensional.

Considering this general model, there are several channels through which changes in exogenous variables such as industry conditions might drive total surplus below zero and thereby drive CEO turnover. Throughout the description of this model we used simple notation and suppressed the dependence of skill weights, skill prices, the pool of replacement managers, the value of retirement and liquidation and the productivity of capital on industry conditions. However, we think that such conditions likely affect all of these variables. Consider first the potential effects of a deterioration in industry conditions on the outside option of the firm. As the industry declines, the optimal managerial skill bundle may change, for instance to more heavily weigh cost cutting or the ability to access capital markets. We model this explicitly in sections 2.2 and 2.3. Firms may find it profitable to fire incumbent managers and hire managers with the newly more desirable bundle. Next, consider how industry conditions might change the outside option of the manager and lead to managers quitting for better jobs or retiring. Changes in industry conditions can change skill prices and lead the manager to leave for greener pastures. Finally, industry conditions can change the relative value of retirement through affecting the disutility of work and the value of retirement compensation packages.

Industry conditions affect turnover in the competitive assignment model and in the data. However, firm relative to industry performance is the most important predictor of observing an instance of forced turnover, both in our data and in that of previous studies. The finding that RPE apparently has such a large empirical contribution to turnover seems to suggest that there is quite a bit of private information and/or learning about CEO ability. However, note that even without private information one might observe what would appear to be RPE driven turnover in data generated by a model like the one described. In particular, if there are any fixed costs of managerial replacement (such as the loss of firm specific skills), such fixed costs will lead to a cutoff rule for performance below which managers will be fired.[13] The fixed cost we consider is firm specific skill. In particular, let $a_0$ denote firm specific skill, and let $a_0 > 0$ if and only if the manager is an incumbent. Then, in order to replace an incumbent, the terminating firm must pay the fixed cost of forgone output generated by firm specific skill.

These results imply that finding that RPE drives turnover does not show that boards are effectively dealing with a problem of asymmetric information. The empirical relationship between poor performance and turnover may simply be due to variation in the importance or level of firm or industry specific skills which may lead only the poorest performing firms to seek replacements. Alternatively, there may be other fixed costs of replacement which would also lead to performance thresholds for firing managers. On the other hand, the converse is also true. Even if the data did not find such strong support for RPE, one could still not conclude that boards were not using RPE to gauge talent. Large fixed costs could prevent turnover. We believe that both learning about unobservable managerial skills, and shocks to demands for observable talents, are potentially important contributors to CEO turnover. We focus on the latter to illustrate that these effects alone can generate what appears to be both relative, and absolute, performance evaluation.

Explicitly considering the outside options of both managers and firms in our competitive assignment framework illustrates another, perhaps surprising feature of such a model which is also consistent with the data. In the model, as in the data, it is actually quite difficult to label a separation as a "quit" or "fire". Since empirically separations are typically labeled as quits or fires by utilizing news stories as we do here, one might think that the large fraction of turnovers which can neither be labeled as quits or fires are simply misclassified due to lack of information. One might think that if one had perfect data, that all separations should be able to be labeled one way or the other. However, even in data generated by the model, quite reasonable theoretical definitions

[13] In general, in a dynamic model, such fixed costs will also lead to real option like behavior in the decision to replace managers. For simplicity, we study a two period economy in section 2.3 in which such real option considerations have no role. It would be interesting to consider a longer horizon model with real option effects, but we leave this to future work.

of quits and firings would imply that for a large fraction of separations, the agent who initiated the separation is ambiguous. Separations occur when the total surplus from the current match is negative. As discussed, this can occur for many reasons on the part of the firm and the manager, both of whose outside options vary over time, or it can be that the total value of the match declines. Furthermore, the outside options of the firm and the manager, as well as the value created by the match depend on the same variables, namely, skill weights and prices.

We discuss this ambiguity in the context of one specific definition of "quits" vs. "fires" but note that the model permits others. We introduce time subscripts and suppress individual agent subscripts to define a separation as follows:

**Definition 1** *A* **separation** *occurs in the current period when a match satisfies the following two conditions:*

***Condition 1*** $V_t - V_t^m - V_t^f < 0$

*and*

***Condition 2*** $V_{t-1} - V_{t-1}^m - V_{t-1}^f > 0.$

Now, consider defining a separation as initiated by one agent (either the manager or the firm) if that agent would choose to remain in the match with the current match value and the current outside option of the other agent, but with their own lagged outside option. This separation must satisfy conditions 1 and 2 as well as either

**Condition 3 (Q)** $V_t - V_{t-1}^m - V_t^f > 0$

if the separation is a quit, and

**Condition 4 (F)** $V_t - V_t^m - V_{t-1}^f > 0$

if the separation is a fire. Note that conditions 1 and Q together simply say that $V_t^m > V_{t-1}^m$, while conditions 1 and F together simply say that $V_t^f > V_{t-1}^f$. These two inequalities are not mutually exclusive, so clearly many separations would be unclassified under this definition. We can, however, refine this definition further.

Add to the definition above that the initiating agent would not want to remain in the match even given the current match value, that agent's current outside option, and the other agent's lagged outside option. If conditions Q and F are associated with quits and fires, these new conditions basically state that quits must also not be firings, and likewise firings must also not be quits. In other words, they require that the separation also satisfy

**Condition 5 (¬F)** $V_t - V_t^m - V_{t-1}^f < 0$

if the separation is a quit, and

**Condition 6 (¬Q)** $V_t - V_{t-1}^m - V_t^f < 0$

if the separation is a fire.

Then, a quit can be defined as a separation which satisfies Q and ¬F. Combining these two conditions, and condition 1 with condition Q yields the following definition of a quit:

**Definition 2** *A separation is a* **quit** *if* $V_t^m > V_{t-1}^m$ *and* $V_t^m - V_{t-1}^m > V_t^f - V_{t-1}^f$.

Similarly, a fire can be defined as a separation which satisfies F and ¬Q. Combining these two conditions, and condition 1 with condition F yields the following definition of a firing:

**Definition 3** *A separation is a* **fire** *if* $V_t^f > V_{t-1}^f$ *and* $V_t^f - V_{t-1}^f > V_t^m - V_{t-1}^m$.

Even these very loose definitions permit separations that cannot be classified in cases in which the total value of the match drives the surplus negative and outside options remain unchanged. More strict definitions of quits and fires, such as the one given by conditions Q and F only, or requiring a quit to satisfy $V_t^m > V_{t-1}^m$ and $V_t^f \leq V_{t-1}^f$ and requiring a fire to satisfy $V_t^f > V_{t-1}^f$ and $V_t^m \leq V_{t-1}^m$, would lead to even more ambiguous separations. However, note that in the model, as in the data, the type of replacement manager, and the compensation of that manager, would yield additional information about the type of separation observed.

To summarize, our general framework illustrates how shocks to skill weights can generate turnover with both relative and absolute performance effects. It also shows how in a matching model, classifying turnover as quits vs. fires is likely to be an ambiguous task. Finally, we use the general framework to discuss the effects of variation in outside options such as liquidation and retirement on turnover events since we will hold these outside options fixed in the next two sections, even though they are certainly empirically relevant.

## 2.2 Two-Firm Example

We now consider CEO turnover and pay in a simple stylized equilibrium example of our model. There are two firms (A and B) in a single industry, and four potential managers (w, x, y, and z), each with three skills, namely, industry or firm specific knowledge, sales growth ability, and cost cutting ability. We discuss sales growth and cost cutting as our two general skills because demand for these skills naturally change as an industry matures, or is deregulated, however, they are only two examples of such skills. Others include the ability to raise external finance, conduct mergers, or to adopt new technologies. There are two dates, 0 and 1. Production is linear (i.e., $\alpha = 1$), the interest rate is zero, there is no labor, and capital $k$ is fixed at 1 unit for each firm.[14] Table 1 describes the firm skill weights and managerial skill levels.

At date 0, Firm A has $\theta$ weights (3, 2, 0) on the 3 skills respectively. Firm B has $\theta$ weights (0, 1, 0) on the 3 skills respectively. Thus, both firms weight sales growth ability, and firm A weighs industry specific skills more heavily (it produces a more complex good, for example). Firm A is more productive since all weights are at least as great as those for firm B. Manager w has skill levels (1, 1, 0), manager x has skill levels (0, 1, 0), manager y has skill levels (0, 0, 1), and manager z has skill levels (0, 0, 3), for the 3 skills respectively. Thus, manager w has industry specific skills and sales growth skills, manager x has sales growth skills, and managers y and z have cost cutting skills. Managers who do not get hired may deploy their non-industry specific skills in another industry which has weights equal to one on sales growth and cost cutting and capital equal to $\frac{1}{2}$. Firms in this alternative industry face free entry and earn zero profits, thus, managers' who are not hired have outside options equal to $\frac{1}{2}\sum_{s=2:3} a_s$. Basically, at time zero, firm B pins down the outside option for the manager of firm A, and the alternative industry pins down the outside option for firm B.

An equilibrium at date 0 is an allocation of managers to firms, wages paid to managers, and firm profits, such that no manager and no firm prefers an alternative allocation. One such equilibrium is as follows: Firm B hires manager x, produces 1 unit of output, pays the manager $\frac{1}{2} + \epsilon$ in order to make the manager prefer to work at firm B instead of in the alternative industry, and has profits of $\frac{1}{2} - \epsilon$. Firm A hires manager w, produces 5 units of output, pays the manager $\frac{1}{2} + 2\epsilon$ in order to make the manager prefer to work at firm A instead of firm B, and has profits of $4\frac{1}{2} - 2\epsilon$. Table 2 describes the equilibrium

[14] One can incorporate variation in size if one considers the $\theta$ weights to be weights times capital. In other words, define $\tilde{\theta}_n^j \in \{0, 1\}$ and let $\theta_n^j = \tilde{\theta}_n^j g(k_j)$ where $g'(k_j) > 0$.

allocation at date 0.

At the beginning of time 1, a shock changes the weights on the skill bundles at firm A and B. The formerly young industry is now mature and firms A and B should cut costs instead of growing sales. At date 1, Firm A's $\theta$ weights are shocked to (3, 0, 2) on the 3 skills respectively. Firm B's $\theta$ weights are shocked to (0, 0, 1) on the 3 skills respectively. Due to the shock to the skill weights, output in the industry immediately falls from 6 units to 3 units. Firms may choose to terminate their managers and replace them. First, imagine that only managers (w, x, and y) are available. In this case, one equilibrium is as follows: Firm B hires manager y, produces 1 unit of output, pays the manager $\frac{1}{2} + \epsilon$ in order to make the manager prefer to work at firm B instead of in the alternative industry, and has profits of $\frac{1}{2} - \epsilon$. Firm A decides to retain its manager, w, produces 3 units of output, pays the manager $\frac{1}{2} + \epsilon$ in order to make the manager prefer to work at firm A instead of being employed in the alternative industry for $\frac{1}{2}$, and makes profits of $2\frac{1}{2} - \epsilon$. Thus, in this case, only the relatively poorly performing firm fires its manager. However, if manager z is available, a candidate equilibrium is: Firm B hires manager y, produces 1 unit of output, pays the manager $\frac{1}{2} + \epsilon$ in order to make the manager prefer to work at firm B instead of in the alternative industry, and has profits of $\frac{1}{2} - \epsilon$. Firm A hires manager z, produces 6 units of output, pays the manager $2\frac{1}{2} + 2\epsilon$ in order to make the manager prefer to work at firm A instead of firm B and makes profits of $3\frac{1}{2} - 2\epsilon$. Thus, the industry shock may cause both firms to turn over their CEO's, or there may be a cutoff for firm performance below which mangers are fired and replaced. Table 3 describes the equilibrium allocation at date 1.

Firms will not want to pay for skills they do not find valuable, so when a shock changes skill weights they are likely to look outside the industry, where these new skills have been previously productively deployed, for their replacement. Notice also that if the outside option of deploying general skills in other industries is higher than that of deploying industry specific skills, the outsiders will tend to be more highly paid relative to their contribution to output. In the example, consider firm A's choice of replacement. To dominate the existing manager, the outsider replacement needs to be able to generate considerably higher output since all of that output is generated by skills with positive market prices. As a result, the firm will require much higher output under the new manager in order to be able to pay the manager the higher required wage and still increase profits. Thus, when an outsider is hired, output increases significantly and so does CEO compensation. In our example, output in the industry first decreases from 6 to 3 and then increases to 7 after managerial reallocation. CEO pay increases from $1+3\epsilon$ in the time 0 equilibrium allocation to $3+3\epsilon$ in the time 1 equilibrium allocation.

## 2.3 Two-Industry Economy

The previous example illustrates the general idea of our framework. In this section, we consider CEO turnover in a two industry version of our example economy in order to draw out the empirical implications in a more general setting. The model generates turnover which is consistent with relative performance evaluation. Overall industry performance is also a key predictor of turnover. The model has distinct predictions for quits vs. firings, and also speaks to the type and pay of the replacement manager. For example, one key fact which emerges from our empirical study is that turnovers which occur in industry downturns are more likely to be forced turnovers which result in replacements by industry outsiders at relatively high pay. The intuition for why this occurs in our model is simple: Industry shocks change which managerial skill sets are necessary. When such shocks occur, output declines due to the mismatch between incumbent managerial skill sets and skills needed in the new environment. Despite the mismatch in general skills, high productivity firms retain their managers in order to preserve output from inexpensive firm specific skill. In contrast, the poorest performing firms find it optimal to forego firm specific skills for the newly required general skill. They can attract managers with high levels of general skill from outside the industry where they have been previously deployed at lower levels of productivity. However, these managers will be relatively expensive. Because firms who fire their manager must forego output from unpriced firm specific skills, replacement managers will necessarily have high levels of priced general skills.

We extend the standard competitive assignment model in two ways. First, we consider mangers with multidimensional skills and firms with multidimensional skill weights. Second, we consider the equilibrium in an economy where managers' outside options may be outside their current industry, in a competing industry where matching is also determined via competitive assignment. To our knowledge we are the first to consider a two market competitive assignment model, however the framework would be interesting for other markets as well, such as marriage markets, student markets, real estate markets, or general labor markets.

The basic assignment model of Sattinger (1979), Gabaix and Landier (2008), and

Tervio (2008) is built upon the following three simplifying assumptions: First, skills and firm characteristics are one-dimensional (managers have talent and firms have a size). Second, the distributions of talent and firm size are continuous. Third, firm size and talent are complements. Assuming skills have only one dimension significantly simplifies the analysis because wages do not depend on the joint distributions of managerial skills and firm skill weights. However, considering that managerial skills are multidimensional is more realistic and consistent with the evidence in Bertrand and Schoar (2003) which documents managerial fixed effects in management style, and Kaplan, Klebanov, and Sorensen (2008) who show that multiple personal characteristics matter for the success of a CEO candidate in getting the job. We show that if one chooses the distributions parsimoniously, and retains the assumptions that skill distributions and firm skill weights are continuous and firm skill weights and managerial skill levels are complementary, then the analytical techniques used in Sattinger (1979) can be applied to solve for equilibrium wage and profit profiles.

There are two dates, zero and one. There are two industries, A and B, and two types of managers, x and z. All firms have capital stocks equal to one.[15] There are measure one of firms in each industry, and measure one of each type of manager. Thus, there will be no unemployment. Similarly, to keep things manageable, we will not consider retirement or liquidation here although they would be interesting extensions.[16] As in the example above, skill levels and weights have three components, namely, firm specific skills, sales growth skills, and cost cutting skills, respectively. General skill levels are fixed characteristics of managers. The level of firm specific skill will depend on the industry the manager works in. In industry A, the more productive industry, managers will develop firm specific skill in proportion to their general skill and will have firm specific skill greater than zero if they work at their incumbent firm and zero otherwise. Industry B is a less productive industry, and is a generalist industry. Managers working in this industry do not accumulate firm specific skill. Since few CEO to CEO transitions are observed empirically, one could also think of the managers in industry B as division managers. The fact that skill weights are lower in industry B (i.e. that industry B is less productive) could reflect the fact that division managers have less impact on output relative to CEO's, or that individual divisions are smaller than firms. Note that considering a less productive

[15] Again, one can incorporate variation in size if one considers the $\theta$ weights to be weights times capital. In other words, define $\tilde{\theta}^j_n \in \{0, 1\}$ and let $\theta^j_n = \tilde{\theta}^j_n g(k_j)$ where $g'(k_j) > 0$.

[16] One could consider varying the outside options of the least productive operating firm $\pi_0$ and least talented employed manager $w_0$ in order to generate variation in liquidations and retirements.

industry is without loss of generality since industry A will only be able to attract general skills away from firms at which such skills have been previously deployed at a lower level of productivity. Firms in which such skills are highly productive would be able to increase wages to prevent their CEO's from departing.

Type x managers have sales growth skills distributed uniformly between zero and two, and have zero cost cutting skills. Type x managers have firm specific skills $a_0^x = a_1^x$ iff they work at their incumbent firm in industry A. The opportunity cost of losing firm specific skills acts like a fixed firing cost and leads to what appears to be relative performance evaluation since only the poorest performing managers will be fired. However, note that there is no asymmetric information, and no learning in our model.

Table 4 presents the skill weights and levels for firms and managers. For managers of type $x$, we have firm specific skills

$$a_0^x \sim U(1,3),$$

if type $x$ managers are incumbents at their industry A firms, sales growth skills

$$a_1^x \sim U(1,3),$$

and cost cutting $a_2^x$=0. Type $z$ managers have firm specific skills $a_0^z$ equal to zero even if they work at their incumbent firm in industry B since industry B is a generalist industry. Type z managers have cost cutting skills distributed uniformly between zero and two, and have zero sales growth skills. Thus, for type $z$ managers we have,

$$a_2^z \sim U(0,2),$$

$a_0^z$=0, and $a_1^z$=0.

Again, firm level productivity will be given by the inner product of managerial skill levels and firm skill weights. Firm skill weights can change over time. In particular, we will consider the effects on turnover and managerial compensation of a date 1 shock to the skill weights in industry A. At time zero, firms in industry A have skill weights as follows:

$$\theta_0^A \sim U(1,3), \quad \theta_1^A \sim U(1,3), \text{ and } \quad \theta_2^A = 0.$$

We assume that $\theta_0^A$ and $\theta_1^A$ are perfectly correlated so that the firm with the highest firm specific skill weight also has the highest general skill weights. When ordered between zero and one, the oneth firm has the highest weights and is the most productive. This assumption ensures that our equilibrium will exhibit assortative matching, as in the classic assignment model. Such a distribution would also naturally result, for example, from the assumption that each firm possesses a single level of productivity. Specific skill weights would then determined by this productivity level multiplied by an indicator equal to one if that skill is necessary under current industry conditions. Firms in industry B have skill weights as follows at dates zero and one:

$$\theta_0^B = 0, \quad \theta_1^B \sim U(0, \frac{1}{2}), \text{ and } \quad \theta_2^B \sim U(0, \frac{1}{2}).$$

At date zero, managers are matched with firms via competitive assignment. Given our assumptions, at this date the economy reduces to two distinct competitive assignment markets, and the equilibrium assignment is given by the equilibrium assignments in each of the markets separately. All managers of type $x$ will work in industry $A$, and all managers of type $z$ will work in industry $B$. Industry A only values sales growth skills, which are possessed by type $x$ managers. Since industry A is more productive and will pay more for these skills, type $x$ mangers will choose to work there. We assume that the economy at date $t = -1$ is described by the same parameters as those at time zero, so that all managers in industry A have $a_0^x > 0$ since they will work for their incumbent firms.

We now describe output, managerial compensation, and profits in the two industries. Our analysis closely follows that in Tervio (2008) and it may be useful for the reader to refer to Section I of that paper for additional details. As in Tervio (2008), it will be convenient to consider the inverse distribution functions for skill levels and skill weights. Managers and firms are ordered on the unit interval as described above so that for each manager type $y \in \{x, z\}$, and each skill type $n \in \{0, 1, 2\}$, $a_n^y[i]$ is the skill level of a quantile $i$ type $y$ manager and the derivative of the inverse distribution satisfies $a_n^{y\prime}[i] \geq 0$ for each skill type, with strict inequality for general skills. For each manager and skill type, if $F_{a_n}^y$ is the cumulative distribution of $a_n$ for type $y$, then the profile of $a_n$ is given by

$$a_n^y[i] = a_n^y \quad \text{s.t.} \quad F_{a_n}^y(a_n) = i.$$

Basically, $a_n^y[i]$ gives the ability level of the $i^{th}$ type y manager. The inverse distribution functions for firms' skill weights are defined analogously for industries A and B.

In each industry, the equilibrium assignment must satisfy two types of constraints. First, the sorting constraints state that each firm must prefer hiring its manager at their equilibrium wage to hiring any alternative manager at that replacement manager's equilibrium wage. Second, the participation constraints state that all firms and individuals must earn their outside option for opportunities outside of industries A and B. In our economy, we set these outside options to be equal to zero, and leave the study of variation in liquidation and retirement options to future research. We have the following constraints for firms in industry A which at date zero employs type $x$ managers, where boldface type is used to denote vectors:

$$
\begin{aligned}
V(\mathbf{a}^x[j], \boldsymbol{\theta}^A[i]) - w^x[j] &\geq V(\mathbf{a}^x[k], \boldsymbol{\theta}^A[i]) - w^x[k] \quad \forall i, j, k \in [0,1] \quad SC^x(i,j) && (1)\\
V(\mathbf{a}^x[j], \boldsymbol{\theta}^A[i]) - w^x[j] &\geq V(\mathbf{a}^z[k], \boldsymbol{\theta}^A[i]) - w^z[k] \quad \forall i, j, k \in [0,1] \quad SC^z(i,j) && (2)\\
V(\mathbf{a}^x[i], \boldsymbol{\theta}^A[j]) - w^x[i] &\geq 0 \quad \forall i, j \in [0,1] \quad PC_i && (3)\\
w^x[j] &\geq 0 \quad PC_j && (4)
\end{aligned}
$$

Note also that at date one, analogous constraints must hold if a manager of type $z$ is employed. The second constraint, which is new in our environment, states that with multiple industries and managerial types sorting constraints must hold across industries and managerial types. We ignore these constraints at date 0 since they will not be binding. However, they will bind for some firms and managers at date 1 once there is an incentive for managerial reallocation.[17] Note also that the only binding sorting constraints within an industry are those which consider hiring the next best manager. Since firms in industry A at time zero have $\theta_2^A = 0$, and managers of type $x$ have $a_2^x = 0$, to compute the efficient assignment in industry A one only needs to consider the effects of $a_1^x$ and $\theta_1^A$. Moreover, because firm specific skills are not valued outside the firm, wages in industry A at date zero will be determined solely by the distributions for $a_1^x$ and $\theta_1^A$. As a result, the date zero economy reduces to two economies of the type studied in Tervio (2008). Analogous constraints must be satisfied in industry B which at date zero will employ type $z$ managers. Since managers of type $z$ only have cost cutting skills $a_2^z$, to compute the efficient assignment in industry B one only needs to consider the effects of

[17]In fact, at date one some firms in industry A will prefer type $z$ cost cutting managers and moreover at this date managerial and firm indexes may not match. We modify the sorting constraints accordingly when solving for the equilibrium at date one.

$a_2^z$ and $\theta_2^B$. The participation constraints will bind for the lowest ability manager and the lowest productivity firm.

We now solve for wages and profits at date zero. Regrouping the sorting constraints for types $i$ and $i-\epsilon$ and dividing by $\epsilon$ yields:

$$\frac{V(\mathbf{a}^x[i],\boldsymbol{\theta}^A[i]) - V(\mathbf{a}^x[i-\epsilon],\boldsymbol{\theta}^A[i])}{\epsilon} \geq \frac{w^x[i]-w^x[i-\epsilon]}{\epsilon}.$$

Taking the limit as $\epsilon \to 0$ we get the slope of the wage profile for type $x$ managers:[18]

$$w^{x\prime}[i] = V_{\mathbf{a}}(\mathbf{a}^x[i],\boldsymbol{\theta}^A[i]) \cdot \mathbf{a}^{x\prime}[i].$$

Finally, integrating, and adding the binding participation constraint yields the wage profile:

$$w^x[i] = w^0 + \int_0^i V_{\mathbf{a}}(\mathbf{a}^x[j],\boldsymbol{\theta}^A[j]) \cdot \mathbf{a}^{x\prime}[j]\,dj$$

Again, since firm specific skills are not valued outside the firm, and firms in industry A at time zero have $\theta_2^A = 0$, to compute wages one only needs to consider the effects of $a_1^x$ and $\theta_1^A$. Note that the sorting constraints could have been written from the manager's perspective, and an analogous profile for profits from general skills at date zero can be obtained as follows:

$$\pi^A[i] = \pi^0 + \int_0^i V_\theta(\mathbf{a}^x[j],\boldsymbol{\theta}^A[j]) \cdot \theta^{A\prime}[j]\,dj.$$

Using the distributions for $\boldsymbol{\theta}^A$ and $\mathbf{a}^x$, the definition $V(\mathbf{a}^x[i],\boldsymbol{\theta}^A[i]) = \mathbf{a}^x[i]\cdot\boldsymbol{\theta}^A[i]\,k^\alpha$, and the fact that $k=1$ and $\alpha = 1\ \forall i$, we have that output in industry A is given by:

$$V^A(i,i) = 1 + 6i + 8i^2$$

wages, or managerial outside options are given by,

$$w^x(i) = 2i + 2i^2$$

[18] Firm specific skills are unpriced and have a wage of zero at date zero. One can think of taking the limit only over the part of $V$ which comes from general skills, and then adding the output and profits from general skills separately.

and firm profits are given by

$$\pi^A(i) = 1 + 4i + 6i^2.$$

The appendix provides the details for computing output, wages, and profits at date zero.

To illustrate the allocations in industry A at time 0, take for example, firm $\frac{1}{2}$ who is matched with manager $\frac{1}{2}$. Output is 6. Of this, 1.5 is paid to the manager and 4.5 is retained by the firm. However, note that the manager receives the majority of the portion of output created from general skills, which is 2.

Similarly, for industry B, which in equilibrium employs managers of type $z$, we have:

$$V^B(i, i) = i^2$$

wages, or managerial outside options are given by

$$w^z(i) = \frac{1}{2}i^2$$

and firm profits are given by

$$\pi^B(i) = \frac{1}{2}i^2.$$

We now consider a shock to firm skill weights in industry A, and the resulting effects on managerial assignment and turnover, and wages and profits in industries A and B. Imagine that industry A had been a growing industry but has now matured and firms thus need to focus on cost cutting instead of sales growth. This change in industry conditions induces a change in the skill weights in industry A. In particular, we examine the effects of a switch in which $\theta_1^A$ and $\theta_2^A$ exchange values. Thus, $\theta_1^A$ becomes zero for all firms, and $\theta_2^A$ becomes positive and is distributed uniformly across firms between one and three. Weights in industry B do not change. Output immediately declines in industry A, since firms shift weight to skills which their managers do not possess. Firms' demand for the skill newly valuable in the changed environment drives managerial turnover.

Note that because it has an outside option of zero, firm specific skill produces output much more cheaply than general skill. Thus, in order to make replacement attractive a new manager must possess general skills in greater quantities than what existing managers possess in terms of firm specific skill. Moreover, this replacement can only be drawn from an industry in which the desired general skill was deployed at a lower productivity since otherwise the required compensation would be too high to induce turnover.

We show that the resulting reallocation of managers is as follows: The most talented managers in industry A remain with their firms. The presence of firm specific skill induces a cutoff level of talent below which all managers in industry A are fired and reallocate to industry B. Call the index of this talent level $i^*_A$. Firms below the threshold $i^*_A$ will prefer to fire their sales growth managers and hire cost cutters since they can attract talented cost cutters who can generate output exceeding what incumbents contribute from firm specific skill. Because industry A is more productive, the managers at the top end of industry B will quit and reallocate to replace the fired managers at the bottom of industry A and will earn higher wages there than at their old jobs. Call the index of the talent level above which type $z$ managers quit industry B to work in industry A $i^*_B$ and note that $i^*_B = 1 - i^*_A$. The fired managers from industry A will go to work in industry B, and since they are the low talent sales-growers, they will work at the bottom of industry B.

We solve for the competitive assignment equilibrium at date 1 as follows: First, we use the fact that there is a cutoff rule for managerial turnover as described above. This cutoff rule is implied by the sorting constraints. Conditional on this rule, we compute equilibrium wages and output. We can then solve for the cutoff value, and verify that we have found an equilibrium. The equilibrium must satisfy the sorting constraints described for the date zero assignment. In addition, the date 1 skill weights imply that cross industry sorting constraints will bind for the firms and/or managers at the cutoffs $i^*_A$ and $i^*_B$. In particular, firm $i^*_A$ must be indifferent between hiring their incumbent manager, and firing their manager and replacing them with the oneth manager from industry B. This condition will pin down the cutoff value $i^*_A$. Similarly, manager $i^*_B$ must be indifferent between quitting industry B to work at the bottom of industry A, and staying in industry B. Figure 1 describes the turnover and reallocation of managers in industries A and B.[19]

To compute the equilibrium allocations, we determine which of the sorting constraints will be binding for each firm and manager and derive equilibrium wages from the binding constraints. It is simplest to begin with industry B since managers there will not have outside options in industry A, whereas managers in industry A may have outside options in industry B. Thus, only within industry sorting constraints will bind in industry B and these within industry constraints will pin down wages and profits.

[19]This figure and the wage and profit calculations which follow are conditional on $i^*_A < i^*_B$, which is true in our equilibrium. If distributional choices instead implied that $i^*_B < i^*_A$, similar conditions would hold with mixing in industry B of managers of both types up to the managers with index $i^*_B$.

Industry B will employ the fired sales growers from the bottom of industry A. These are type $x$ managers with indices between zero and $i_A^*$. Industry B will also retain the cost cutting managers who do not quit and move to industry A. These are type $z$ managers with indices below $i_B^*$. These managers will be allocated within industry B as follows: Managers of either type $x$ or $z$ with indices less than $i_A^*$ will be allocated assortatively to the bottom of industry B, and will fulfill employment in industry B up to the firm with index $2i_A^*$. Since industry B firms value both sales growth and cost cutting skills, they are indifferent between hiring type $x$ and type $z$ managers with the same index. Managers of type $z$ with indices between $i_A^*$ and $i_B^*$ will then move up to the top of industry B and will fulfill employment assortatively at the firms with indices from $2i_A^*$ to one. These are the most talented cost cutters left in industry B, and they also have the highest level of any general skill available to firms in industry B.

For all output and wage calculations we use $i$ to denote the firm index, which after reallocation may differ from the index of the manager. For firms with indices less than $2i_A^*$, as one considers firms with higher indexes, skill will not increase as quickly as in the top region of industry B in which there is no mixing. In particular, as one changes the firm index in this region we have that $a'[i] = 1$. Output for firms in industry B with $i < 2i_A^*$ is $\frac{1}{2}i^2$. Wages in this region are determined by the binding within industry sorting constraints. Thus, equilibrium wages are set such that firms are indifferent between their assigned manager and the next best manager within industry B. Wages at firms in industry B with $i < 2i_A^*$ are $\frac{1}{4}i^2$.

Firms in industry B with indexes $i > 2i_A^*$ produce output equal to $i^2 - ii_A^*$. For wages, note that within industry sorting constraints imply that wages must be continuous around firm index $2i_A^*$, but the slope of wages will be higher above $2i_A^*$ since there is no mixing of managerial types and hence ability increases faster with firm index than it does below $2i_A^*$. As in the lower region of industry B, wages at the top of industry B are determined by the binding within industry sorting constraints. Thus, equilibrium wages are set such that firms are indifferent between their assigned manager and the next best manager within industry B. This implies that wages are equal to $\frac{1}{2}i^2 - {i_A^*}^2$.

Talented managers quitting industry B and being replaced by lower ability managers from industry A leads to a decline in output in industry B after the departures. Both wages and profits also decline. Interestingly, profits fall by more than wages even though the average ability of managers in industry B declines and nothing about firm characteristics has changed. This is because the managers have better outside options than industry B firms do.

With the allocations and payments in industry B in hand we can compute allocations and payments in industry A. Firms at the top of industry A, with indexes $i > i^*_A$, retain their managers. Firms at the bottom of industry A, with indexes $i < i^*_A$, fire their managers, and replace them with the managers who quit industry B. Thus, relative performance evaluation is consistent with the pattern of forced turnover in industry A even though there is no private information or learning about ability. Firm specific costs act like fixed firing costs and lead to a threshold rule for terminations. Moreover, absolute performance also matters. Output immediately falls in industry A when the shock to the weights occurs due to the mismatch between firms' skill needs and the supply of those skills by their assigned managers. After reassignment, total output and profits in industry A will remain lower than before the shock until the replacement managers acquire firm specific skill. However, output at firms who fire their managers will be higher after reallocation than both prior to and after the shock, and for the most poorly performing firms the same is true for profits. This is consistent with the pattern we see in the data, as we discuss in section 4.

Firms in industry A with indexes $i < i^*_A$ fire their managers and replace them with managers with indexes $i \in [i^*_B + \epsilon, 1]^z$ from industry B. Output is $(1 + 2i)(2i + 2 - 2i^*_A)$. Wages are determined as follows: Firm zero in industry A employs the cost cutting manager type $z$ with index $i^*_B + \epsilon$. This manager's wage is determined by the cross industry sorting constraint which says that the oneth firm in industry B must not prefer this manager to the manager it employs in equilibrium, namely cost-cutter $i^*_B$. Thus, the wage at firm zero in industry A equals the wage at firm one in industry B. The slope of wages for firms between zero and $i^*_A$ then reflects the contribution of managerial skill to output as ability increases with managerial skill index. For these firms, the binding within industry sorting constraints determine wages. Wages in this region are thus $\frac{1}{2} - {i^*_A}^2 + 2i + 2i^2$. These wages are higher than those paid by these firms at time 0, before the industry productivity shock, since the newly employed CEOs have a general skill that is in demand in both industries, and moreover, being the top cost-cutters, they have higher level of skill relative to the CEOs they replace, who were the bottom sales-growers.

Firms in industry A with indexes $i > i^*_A$ retain their managers and produce output equal to $(1+2i)(1+2i)$. All output at these firms is generated by firm specific skills since there is zero value from sales growth skill in industry A after the shock. Firm specific skills lead to only the poorest performing firms in industry A firing their managers, since doing so entails losing the output and profits from these skills. Since firm specific skills are unpriced, they are cheaper. Even so, managers at these firms do not earn zero wages since they must prefer to stay in industry A rather than quit and go to the top of industry B. Thus, firms no longer earn all the rents from firm specific skills. In equilibrium, the cross industry and managerial type sorting constraints will pin down wages in this region such that managers will have no incentive to try and switch to the other industry. Likewise, firms in industry B will not have an incentive to hire managers of another type.

For sales growing managers who have skill index $j \in [i_A^*, i_B^*]$ and work at firms $i \in [i_A^*, i_B^*]$ in industry A, the cross industry sorting constraints pin down wages. These sales growers must earn the same wage as cost-cutting managers with skill index $j \in [i_A^*, i_B^*]$, who work at the top of industry B (for firms with productivity index between $i_B^*$ and 1) in order for these firms not to prefer them to their assigned cost-cutter. Thus in industry A for firms $i \in [i_A^*, i_B^*]$, wages are $\frac{1}{2}i^2 - \frac{1}{2}{i_A^*}^2 + ii_A^*$. For firms above index $i_B^*$, note that the wage of sales growing type $x$ manager $i_B^*$ at industry A firm $i_B^*$ must equal the wage at the oneth firm in industry B in order to satisfy the cross industry sorting constraint. Wages at firms above $i_B^*$ are determined by cross industry constraints which ensure that the oneth firm in industry B does not prefer these more talented sales-growers to its assigned cost-cutter with index $i_B^*$. The slope of wages in this region reflects the potential contribution to output at the oneth firm in industry B as sales growing skill increases with managerial index. Thus, wages are $\frac{1}{2}i^2 + i_A^* - \frac{3}{2}{i_A^*}^2$ for firms $i > i_B^*$. Wages are lower than before the shock for all firms who retain their incumbent CEO since only firm specific skill produces output and hence managers are only paid their outside option in the less productive industry B.

To close the model and solve for the value of $i_A^*$ we impose the condition that the marginal firm in industry A who is retaining their incumbent CEO is indifferent between doing so and replacing him with a cost-cutting manager from industry B. In other words, in equilibrium firm profits must be smooth around firm index $i_A^*$ in industry A. The resulting value for $i_A^*$ is 0.183. Therefore, the bottom 18% of firms in industry A will replace their CEOs with executives from industry B, who posses high levels of highly productive cost cutting skills. The remaining 82% of firms in industry A will retain their prior CEOs, even though their general skill (sales growing) is no longer useful to those firms. Nonetheless, these retained incumbents are valuable because they have relatively high levels of firm-specific skills, which continue to be productive.

Figure 2 summarizes the equilibrium payoffs and plots output, wages, and profits in industries A and B at dates zero and one. Note in particular the relatively high pay of the managers which are brought in to replace the fired managers at the bottom of industry A. These outside replacements are expensive precisely because in order for replacement to be optimal, such managers must have high enough levels of the more expensive general skill (i.e., cost-cutting) to outweigh the loss of cheap firm specific skill.

The model presented here replicates the results that both absolute and relative performance matter for turnover which we first illustrated using our general framework. Moreover, by solving the two industry economy, we pin down all outside options within the model, and develop our empirical implications for replacement managers. In particular, managers which are fired are replaced by industry outsiders. These replacements exhibit improved performance and are relatively highly paid.

In order to solve the model, we have made some simplifying assumptions for the distributions of skill weights and managerial abilities. Only two are key to our results. Specifically, in order to maintain the assortative matching result from classic assignment models, we have assumed firm specific skills and general skills are perfectly correlated. This is natural if one assumes one dimension of variation in productivity across firms, and then multiplicative effects of this productivity on firms with (homogenous) abilities to deploy firm specific and general skills. In order to generate our result for CEO pay, one also needs that firm specific skills are relatively important, so that foregoing them requires significant expenditures on expensive, general skills. Note that it is without loss of generality that we only consider a less productive alternative industry to industry A. Industry A could not attract talent away from a more productive industry. Depending on the distribution of productivity in the two industries, the model generates no turnover, 100% turnover, or a cutoff talent level below which managers are terminated. As long as the distributions induce a cutoff level for turnover, wages of the replacement will exceed that of the incumbent.

Our model serves to illustrate that the observed empirical outcomes for turnover are consistent with the competitive assignment framework. The model has precise implications for the determinants and types of turnover events, and for the characteristics, pay and performance of replacement managers. Thus, the competitive assignment model, which has been successfully used by Gabaix and Landier (2008) and Tervio (2008) to understand CEO pay as a competitive outcome with no moral hazard, can also be used to understand the observed patterns of CEO turnover as efficient, competitive outcomes of an economy with no private information.

# 3 Data

We use three sources of data: Execucomp for the name and compensation of the CEOs of 2779 publicly traded companies during 1992-2006, CRSP/Compustat for stock returns and accounting data, and Factiva for news stories published in a three-year window around CEO departures. The information in Factiva allows us to determine the reason why a CEO left and where the replacement CEO came from.[20]

We identify 2068 instances where a CEO was replaced, and for which we know both the reason for the incumbent's departure, as well as where the new CEO came from. The replacement event is defined based on whether the same individual has the CEO title (ie., for this individual the Execucomp variable $CEOANN$ takes the value "CEO") during the current and subsequent year. If the name of the CEO in year $t$ is different from the name of the CEO in year $t+1$, we record this as a turnover event in year $t$. Later in the analysis we will refer to the turnover year $t$ as time 0. Of all replacements events, 613 (29.7%) are the result of a planned retirement decision, announced at least six months prior to the actual departure date, or of a health-related reason. Another 323 (15.6%) replacements are instances where the incumbent CEO was forced out, according to newspaper stories related to the departure. The remaining 1132 (54.7%) cases are those that do not clearly fit in any of these two categories and thus we will label them unclassified departures. Since these events include instances where the incumbent voluntarily left the firm, we also refer to them as potential quits.

Our definition of departure type is different from the algorithm described in Parrino (1997) and followed by several other papers, in two significant ways. First, and most important, the extant literature on turnover identifies just two types of departures: forced and unforced (the latter including retirements). However, since in reality, just as in the

[20]We are also grateful to Dirk Jenter for sharing the data from Jenter and Kanaan (2006) regarding whether or not a CEO was forced out or left the firm voluntarily (possibly by retiring). Because our sample is longer, our data set contains 50% more instances of turnover and we classify these as forced, unclassified (potential quits), and retirements. Note that we also collect data on the identity and background of the replacement CEO, and pay and performance subsequent to turnover events. For turnover events which we identified as forced turnover and which also occurred in the Jenter and Kanaan (2006) dataset, our classification schemes agreed for 75% of such events. We were also able to identify 16 cases of forced turnover (5% of observations) which we had previously categorized as unclassified by using the Jenter and Kanaan (2006) data.

model, an employment relationship is the result of a two-sided matching process, we allow for turnover to happen for three reasons: the firm chooses to terminate the match, the CEO chooses to terminate the match but is still active in the executive labor market, or the CEO leaves the executive labor market for exogenous reasons such as age and health. These three types of departure have different theoretical reasons, as the model suggests, and will be predicted by different variables in the empirical analysis. Second, we do not condition on the incumbent CEO's age to define a departure as forced or not. Parrino (1997) classifies as forced departures all cases where the CEO is younger than 60, and (1) related news stories do not report the reason for departure as involving death, poor health or the acceptance of another job, or (2) the firm reports the departure as a retirement, but does so less than six months before succession. We believe that it is possible that in some of these instances managers voluntarily quit the job – they were not fired, nor did they choose to leave the executive labor market (i.e., retire.) Hence, while in prior papers the age of the departing CEO is a significant and negative predictor of forced turnover because of the way they define forced turnovers, in our analysis this mechanical relationship does not exist.

# 4 Empirical Results

The competitive assignment model we present has testable predictions regarding the importance of industry conditions for four classes of outcomes: match dissolution, match formation, firm output and CEO pay. We review these predictions below and show that they are consistent with the empirical evidence.

## 4.1 Match dissolution

In the two-industry economy setting presented in section 2.3 one industry experienced a negative productivity shock at time 1 because of a change in the general skills contributing to output. In the resulting equilibrium, shown in Figure 2, firms with relatively low productivity in that industry fired their incumbent CEOs and replaced them with executives from outside the industry. Hence the competitive assignment model predicts the following with respect to match dissolution: relative performance, as well as industry performance, are negatively correlated with the likelihood of forced CEO turnover.

We first observe that turnover of all types, and forced turnover in particular, are relatively concentrated. Using the Fama French 48 industry classification system, we find that 50% of all instances of forced turnover occur in just seven industries: Business Services, Computers, Retail, Utilities, Chips, Machinery and Drugs. Overall turnover is also concentrated in several industries, although less so than forced turnover. The top 5% of 608 industry-year bins that our observations belong to account for 22% of all turnover events, and for 35% of forced turnover. Since these CEO-firm match dissolution events are not uniformly distributed across industries and over time, we investigate what specific industry conditions may drive turnover.

Figures 3 and 4 show the relationships between the frequency of firings and potential quits, and various industry characteristics measured over 1993-2005.[21] We use the Fama French 48 industry classification throughout this analysis. During thus time period, the average industry-level rates of forced turnover and potential quits are 1.69% and 6.21%, respectively. For each industry and each year, we classify the industry as having below-trend ROA if the industry ROA that year is lower than its three-year average. We then count the number of below-trend years for each industry during 1993-2005. As shown in Figure 3, the frequency of firings is significantly higher in industries with below-trend ROA during more years in the period of 1993-2005 ($p < 0.01$). One additional year of down-trending ROA increases the frequency of forced turnover by 0.2% (from 1.69% to 1.89% in the average industry). We also find that industries with lower average ROA have significantly higher firing rates during 1993-2005 ($p < 0.01$). A one-standard deviation decrease in the ROA from 0% (for the average industry) to -5% increases the firing rate by 0.6%. Industries with lower annual value-weighted stock returns are characterized by higher firing rates ($p < 0.1$), whereas those with higher employment growth have more forced turnover ($p < 0.01$). The latter result is explained by the fact that in our sample there is a strong negative correlation between average employment growth in the industry and industry ROA during 1993-2005 ($p < 0.01$).

An interesting question is whether there is a significant positive relationship between firing rates and the industry homogeneity index, as found by Parrino (1997) for the period 1969-1989. His result implied that it is easier to replace a CEO if there is a larger pool of suitable candidates to pick from. In unreported regressions, we do not find this positive correlation in our data. As suggested by Frydman (2005), however, the

[21] Since our dataset ends in 2006, the last year for which we can compute turnover rates is 2005. Also, a large number of firms do not appear in Execucomp in 1992, and due to this incomplete coverage we drop data from 1992 in our analysis of industry conditions and time trends.

importance of firm (or industry-specific) skill has diminished over time, and nowadays general management skills are most desirable. This would explain why in the recent time period that we study, we no longer find that industry homogeneity (and thus, the availability of candidates with firm or industry-specific skills) is a determinant of forced turnover. Indeed, in a model such as ours, the within industry dispersion in stock returns might be quite small for an industry which is subject to strong common shocks to CEO skill weights. However, these common shocks would lead to turnover and the hiring of outsiders if industry-specific skills were relatively unimportant.[22]

Figure 4 shows that the frequency of unclassified departures (potential quits) is significantly higher in industries with more years of below-trend ROA and with lower value-weighted stock returns ($p < 0.01$). All these effects are economically significant. For instance, decreasing the annual industry-level stock return by one standard deviation (6.09%) from the sample mean of 12.9% increases the annual frequency of quits by 0.73%, a significant effect given that the average quits frequency is 6.21% in our data. We do not find a strong correlation between quits and industry employment growth.

While our theoretical framework is mainly focused on firings and quits, in reality many instances of turnover are retirements due to exogenous reasons such as age or health. In our data, the average annual industry-level rate of retirements is 3.32%.[23] As shown in Figure 5, industry characteristics tend not to be significant drivers of the retirement frequency. The one marginally significant result is that the frequency of retirements is higher in industries with lower employment growth ($p < 0.1$). This indicates that retirement decisions may not be exogenous to the firm or aggregate conditions, as one might think. CEOs have some leeway in when they choose to retire, and may do so where their outside option is better than the payoff from staying with the firm. It is possible that retention payoffs are relatively less attractive in industries with lower employment growth, if empire-building is part of these payoffs.

To illustrate our main results regarding the link between industry conditions and CEO turnover using simple statistics, we split observations based on quartiles of industry conditions. Figure 6 shows the frequency of turnover types as a function of industry conditions during 1993-2005. The firing rate is 0.5% in the top industry ROA quartile and 2.4% in the bottom quartile. The rate of potential quits is 4.8% in industries belonging to

[22]We thank Robert Parrino for sharing with us the industry-level homogeneity index values for the period 1990-2006.

[23]The overall turnover rate for the average industry, which includes firings, potential quits, as well as retirements is 11.98%.

the quartile with the lowest number of ROA down-trending years, and 6.7% in those with the most prolonged ROA down-trend. The firing rate is also higher in industries in the lowest quartile of stock returns (1.7%) than in those in the highest quartile (1.4%), and in industries with higher employment growth. Retirement frequency is highest (3.7%) in industries in the highest ROA quartile and lowest (2.4%) in those in the lowest ROA quartile.

While these univariate results confirm the prediction that CEO-firm match dissolution depends on industry conditions, we further test this hypothesis in a multivariate setting using firm-year level data to control for potential confounds. This analysis reveals the effects of firm and industry conditions on CEO departures, which we document in the multinomial logit model in Table 5. The dependent variable is categorical and can have four values, indicating whether in a particular firm (a) there was no CEO change between years $t$ and $t+1$, (b) the CEO in place in year $t$ was fired and a new CEO took over in year $t+1$, (c) the CEO in place in year $t$ retired and a new CEO took over in year $t+1$ and (d) the CEO in place in year $t$ left for unknown reasons (potentially quit) and in year $t+1$ a new CEO took over.[24]

The results show that firings are more likely relative to there being no turnover, if the firm's stock return or ROA relative to the industry are lower (as in the prior literature on the role of relative performance on turnover), and if the industry has experienced low stock returns relative to the market (as in Jenter and Kanaan (2006)) or a downturn in profitability, measured by an indicator variable equal to 1 if the average ROA in the industry during the preceding three years is below its value during the preceding ten years. We interpret such events as indicating a structural break in the profitability of the industry and as signal that the industry is experiencing bad times. These results are consistent with our hypothesis that when the firm and the industry experience a downturn, a change in strategy may be optimal – hence the firm should dissolve the match with the current CEO by forcing him out. We also replicate the univariate result documented above that a higher employment growth in the industry in year $t$ corresponds to a higher firing likelihood at time $t+1$.

[24]In this analysis we build on the findings of a large empirical literature on CEO turnover which has shown that the firm's stock return and return on assets (ROA) adjusted for industry performance are predictors of CEO turnover (e.g., Gibbons and Murphy (1990), Barro and Barro (1990), Parrino (1997), Murphy (1999), Huson, Parrino, and Starks (2001), Huson, Malatesta, and Parrino (2004), Jenter and Kanaan (2006), and Kaplan and Minton (2006)). The evidence in these papers, and in our own data, indicates that relative performance is an important determinant of whether a CEO is replaced.

Unclassified departures are more likely to happen relative to there being no turnover if the firm's stock return, ROA or employment growth relative to the industry is lower, if the industry ROA is lower, and if the recent three-year industry ROA is below its ten-year trend, consistent with the univariate results documented earlier. As our theoretical framework implies, when the industry's ROA is trending downward, the continuation value for the incumbent to stay with the firm is low – the prospects of the industry are not good and the value of future payments to be received from the firm is lower. Another explanation, outside the competitive assignment model, is that leaving when the industry is going through bad times may allow the CEO to not be inferred as being of as low a type if he left while the industry was experiencing a boom. Similarly, the continuation value for the incumbent is higher when the firm is doing well relative to the industry, in terms of ROA or stock returns.

We find that if the firm's stock return or employment growth relative to the industry are higher, the odds of the CEO retiring decrease. Since CEO compensation increases with firm stock performance and also with firm size, and some managers may also enjoy empire building, we interpret these results as indicating that if the value of staying in the match is higher, the CEO is less likely to retire. Finally, the results in Table 5 show that CEOs younger than 65 years are significantly less likely to either retire or leave for unknown reasons, relative to older individuals. At the same time, the likelihood of being fired relative to continuing as a CEO does not depend on the executive's age.

## 4.2 Match formation

The equilibrium assignment in the two-industry setting in section 2 predicts that match formation, that is, the type of CEO newly hired, is driven by industry conditions. In the industry where the productivity shock occured, low performing firms fire their CEOs and replace them with outsiders, whereas the more productive firms in the industry do not change executives. Hence, the model predicts that outside replacements are more likely when the incumbent CEO is fired, and are especially likely in industries that have undergone a negative productivity shock.

We first document general patterns in the types of replacements hired during 1993-2005. The frequency of replacements by company insiders has decreased over time from 70% in 1993 to 59.5% in 2005, supporting the argument that general management skills are now relatively more valuable than firm-specific skills compared to earlier periods (Frydman (2005)). Also, the frequency of replacements by individuals coming from privately-held firms has increased over time, from 1.75% in 1993 to 5.40% in 2005.

In line with our hypothesis that matches are formed based on the fit of the CEO's skill set with the company's needs, we find evidence suggesting that companies going through difficult times, either because of idiosyncratic reasons or because of industry conditions, are more likely to hire replacement CEOs with a different background than the incumbent executive. We find that company outsiders are more likely to be brought in after a firing or after a voluntary departure of the incumbent, which tend to occur when the firm or the industry experience difficult times, than after a retirement. Moreover, most of these outsiders are from a different industry according to the Fama French 48 industry classification system.[25]

Figure 7 indicates the types of replacement CEOs hired after each type of departure and suggest that the type of replacement CEO hired depends on the reason for the departure of the prior CEO. Replacements by company insiders are significantly more likely if the prior CEO left because of retirement than if he possibly quit or was fired. In the case of retirements, only 20.3% of the new CEOs are from outside the company: 4.2% are from the same industry, 11.6% are from a different industry, and 4.5% come from a non-publicly traded company. In the case of possible quits, 28.3% of the new CEOs are from outside the company: 5.5% are from the same industry, 15.7% are from a different industry, and 7.1% are from a non-publicly traded company. After firings, 37.8% of replacements are company outsiders: 9.1% are from the same industry, 21.2% from another industry, and 7.5% from a non-publicly traded company. We check the robustness of these results by estimating a multinomial logit model of the relative likelihood of various types of replacement CEOs as function of the prior CEO's departure reason. The results are shown in Table 6 and confirm the unconditional findings.

To get more direct evidence that industry conditions matter for the type of replacement CEO hired, we split the firm-year observations into those belonging to industries with below-average and above-average ROA during 1993-2005. To keep the analysis simple, we bundle together all three types of replacement CEOs from outside the company, and refer to these individuals as "outsiders". Replacement CEOs hired from within the firm are referred to as "insiders". Figure 8 shows that the number and frequency of turnover events for low and high ROA industries, and for each departure reason and replacement type. In low ROA industries there are more instances of firings and unclas-

[25]The same is true if we use the 2-digit SIC industry classification code.

sified departures (possible quits) than in high ROA industries, and in such instances it is more likely that an outsider will be brought in, relative to similar instances in high ROA industries. For instance, in high ROA industries there were 122 instances were the incumbent was fired and in 36% of these cases, he was replaced by an outsider. In low ROA industries there were 185 firings, and 39% of these instances led to an outside hire. Similarly, in high ROA industries there were 518 instances of possible quits, and 25% of these were followed by an outside hire. In low ROA industries, there were 619 instances of possible quits, and in 32% of these cases an outsider was brought in.

We interpret these patterns as evidence that the more likely it is that the incumbent CEO-firm match is suboptimal, the more likely it is for the firm to bring in a replacement CEO with a different background and expertise than a company insider. This evidence is consistent with the finding documented by Allgood and Farrell (2003) that longer-lasting firm-CEO matches tend to occur when inside CEOs follow previous CEOs who quit, and when outside CEOs follow previous CEOs who are dismissed.

To see whether these univariate results are robust, we estimate a multivariate probit model for the likelihood that the replacement CEO is an outsider. We allow stock market and real variables that describe firm and industry conditions to influence this likelihood, as we did in our analysis of types of CEO departures in Table 5. The results of this probit model are shown in Table 7. We find that the probability of a replacement by an outsider relative to an insider is higher when the firm's industry-adjusted stock return and ROA are lower, a result very much in the spirit of that of Parrino (1997). Further confirming the predictions of the model, we also find that a succession by a company outsider is more likely relative to an inside succession when the industry ROA is lower (and when the industry employment growth is lower), that is, at times when managerial skills different from those of incumbent CEOs may be valuable.

## 4.3 Firm output

As can be seen in Figure 2, in the competitive equilibrium when the industry experiences a negative productivity shock, the average output in the industry decreases relative to its pre-shock value, but output increases at firms where the incumbent CEO is replaced by an outsider.

Figure 9 presents evidence consistent with these predictions. In the left panel of the figure we show that the median net income before extraordinary items (data item *nibex* in Execucomp)of firms in industries experiencing a negative productivity shock is \$41.6 million, and is lower than that of firms in other industries, which is \$66.4 million. [26] A Wilcoxon ranksum test shows that this difference between the two median output measures is significant at $p < 0.01$. We perform a similar comparison test for the values of the mean *nibex* figures and the difference is slightly higher and also highly significant ($p < 0.01$). Since net income (and wages, as we discuss below) have highly skewed distributions and outliers can drive mean-based results, we choose to present the more conservative, median-based comparisons. Hence the data support the theoretical prediction that average output in the industry falls after the occurrence of a negative productivity shock.

Examining the second output-related theoretical prediction, the right panel of Figure 9 presents evidence that at firms in troubled industries where a new CEO from the outside is brought in, output in fact increases relative to its value before the productivity shock. We find that the median increase in *nibex* in the year when the new outsider replacement is brought in relative to the last year the incumbent was in place is \$6.1 million, which is significantly different from zero ($p < 0.05$ in a Wilcoxon ranksum test). The mean-based output increase at these firms is higher and also highly significant ($p < 0.01$), but as before we focus on the more conservative median-based results.

While this result is in line with the model's prediction, it suffers from an important confound, namely, that it could indicate a general result of bringing new CEOs in, and not one that is specific to output changes in industries hit by productivity shocks. For instance, it could be the case that through accounting manipulations or firm-specific changes in the production process (e.g., "house cleaning" actions such as the firing of unproductive middle management by the new CEO), net income will always increase after a new CEO is brought in from outside the company. To identify the increase in output that is specific to our model from these other means by which a new CEO brings about higher values of net income, we also compute the year-to-year change following the hiring of an outside CEO in firms belonging to industries that did not suffer from a productivity shock. We find that for these firms the value of the median change in annual *nibex* is \$0.5 million, which is significantly lower than the \$6.1 million median

[26] The same result is true if we use the unadjusted net income (data item $NI$ in Execucomp. Nonetheless, it can be argued that this relationship based on net income is mechanical, because it is likely CEOs in troubled industries will engage in divestitures or make one-time accounting changes when their are brought in, without necessarily improving firm productivity per se. If we use the adjusted net income figure given by *nibex* this eliminates this possible confound.)

increase documented for firms in industries with below-trend productivity ($p < 0.07$). As before, the difference between these two types of firms' net income increase is higher when mean values, instead of medians, are used, and the statistical significance is also high ($p < 0.02$). Therefore, this diff-and-diff analysis shows the additional effect (i.e., \$5.6 million in median terms) of annual increases in productivity after an outside CEO is brought in that is driven by industry conditions, which is an effect specific to our competitive assignment model.

## 4.4 CEO pay

The equilibrium wage profiles shown in Figure 2 indicate that, following a negative industry productivity shock, firms where an outsider CEO is brought in will pay a higher wage to the new CEO than the wage of the replaced incumbent, and CEO wages will be highest in firms where an outsider was hired, relative to all other firms in the industry.

These predictions are consistent with the data, as shown in Figure 10. We analyze all firm-year observations for which the recent (three-year) industry-level ROA is below its long term (ten-year) trend. As before, we use the occurence of this event as an indicator of a negative productivity shock in the industry. We then categorize these firm-year observations with respect to whether the incumbent CEO (ie., the executive in charge that year) was replaced by the following year by an outside CEO. We calculate the dollar-value of the change in the CEO wage from the current to the next year, and then obtain the mean and median of this quantity in the subsample of observations where a replacement by an outsider occured, and in the subsample where this did not happen. The left panel in Figure 10 shows that for firms in down-trending industries the median change in CEO total pay (given by variable $tdc1$ in Execucomp) when an outsider is brought in, relative to what the prior CEO earned, is equal to \$976,000. A Wilcoxon ranksum test shows that this increase is significantly different than zero ($p < 0.01$). This change doubles in magnitude if we use means instead of medians, but to be conservative and also to account for the highly skewed distribution of pay, we will focus on median-based comparisons.

It is important to verify that the increase in pay of the firm's new outsider CEO relative to the replaced incumbent is not simply a time-trend in CEO pay, whereby pay in later years is higher than prior year's pay, irrespective of the identity of the CEO. To isolate the effect coming from the competitive assignment model from this potential time trend effect, in the left panel of Figure 10 we also show the median year-to-year change in the pay of CEOs in firms belonging to below-trend ROA industries where the incumbent CEO was not replaced by an outsider. We find that for those firm, the median annual increase in pay is \$100,000, which is significantly lower than the \$976,000 increase we document at firms where a new CEO, from outside the firm, is brought in ($p < 0.01$ in a Wilcoxon ranksum test). Thus, the left panel in Figure 10 shows, using a diff-and-diff approach, that CEOs hired from outside earn more than the incumbents they replaced, and this is not simply due to a general increase of CEO pay over time.

The second prediction of the model regarding CEO pay is that in industries that have suffered a productivity shock, CEO pay levels will be higher at firms where an outsider is brought in, relative to firms where the incumbent stays in place. Note that this second prediction refers to across-firms comparisons after the industry shock occurs, whereas the first prediction discussed above refers to a time-series prediction concerning firms where the CEO was replaced. In the right pabel of Figure 10 we document evidence consistent with this second prediction. We find that if the recent industry ROA is below its long term trend, the median wage of CEOs brought in from the outside is \$2,932,000, whereas that of incumbent CEOs is \$2,243,000. The difference between these medians is significant at $p < 0.01$ in a Wilcoxon ranksum test. If we use mean wages instead of medians, we find that firms employing new CEOs from outside the industry pay these individuals \$2.8 million more on average than firms who retain their incumbents, and this difference is also significant at $p < 0.01$. Nonetheless, due to the skewed distribution of wages and the likely influence of outliers on mean-based results, in the right panel of Figure 10 we continue to report the more conservative median-based results.

# 5 Conclusion

We consider the link between industry conditions and the CEO labor market in the context of a competitive assignment model where both the CEO and firm optimize over the relative value of preserving the match versus pursuing their outside option. In contrast to a principal-agent framework where only relative performance affects CEO turnover, in a matching environment both firm and CEO characteristics as well as broader industry conditions naturally drive turnover events. Although the competitive assignment model has been used by several authors recently to explain empirical facts about CEO pay, we are the first to show that such a model can also be used to successfully understand the dynamics of CEO turnover.

The model has testable implications regarding four types of outcomes: the decision to replace an incumbent CEO, the choice of the replacement CEO, the pay of these executives, as well as the firms' output. Specifically, the predictions are that relative as well as industry performance drive CEO turnover, and outsider replacements are more likely to occur after forced turnovers, particularly during industry downturns. Further, following negative industry productivity shocks, output increases at firms led by newly hired outsiders, but decreases in the rest of the industry, and outsiders get higher pay than prior CEOs and than remaining incumbents in the industry. We find empirical support for these ideas using a large dataset we construct describing turnover events during the period 1992-2006.

# References


Allgood, S. and K. A. Farrell (2003). The match between CEO and firm. *Journal of Business 76*(2), 317–341.

Barro, J. R. and R. J. Barro (1990, October). Pay, performance and turnover of bank CEOs. *Journal of Labor Economics 8*(4), 448–481.

Bebchuk, L. and J. Fried (2004). *Pay without Performance*. Cambridge, MA and London, England: Harvard University Press.

Bertrand, M. and A. Schoar (2003, November). Managing with style: The effect of managers on firm policies. *Quarterly Journal of Economics 118*(4), 1169:1208.

Carey, D. C. and D. Ogden (2000). *CEO Succession*. Oxford University Press.

DeMarzo, P., M. Fishman, Z. He, and N. Wang (2009). Dynamic agency and the q theory of investment. *Working paper*.

DeMarzo, P. M. and M. J. Fishman (2007a, January). Agency and optimal investment dynamics. *Review of Financial Studies* **20**, 151–188.

DeMarzo, P. M. and M. J. Fishman (2007b, November). Optimal long-term financial contracting. *Review of Financial Studies* **20**, 2079–2128.

Dicks, D. (2009). Executive Compensation, Incentives, and the Role for Corporate Governance Regulation. *Working paper, UNC*.

Edmans, A. and X. Gabaix (2009). Is CEO pay really inefficient? A survey of new optimal contracting theories. *European Financial Management 15*(3), 486–496.

Eisfeldt, A. and A. Rampini (2008). Managerial incentives, capital reallocation, and the business cycle. *Journal of Financial Economics*, 177–199.

Frydman, C. (2005). Rising Through the Ranks: The Evolution of the Market for Corporate Executives, 1936-2003. *Harvard University, Working Paper*.

Gabaix, X. and A. Landier (2008). Why Has CEO Pay Increased So Much? *Quarterly Journal of Economics 123*(1), 49–100.

Giannetti, M. (2009). Serial CEO incentives and the structure of managerial contracts. *Working paper*.

Gibbons, R. and K. J. Murphy (1990, February). Relative performance evaluation for Chief Executive Officers. *Industrial and Labor Relations Review 43* (3. Special issue: Do Compensation Policies Matter?), 30S–51S.

Graham, J., C. R. Harvey, and M. Puri (2009). Managerial attitudes and corporate actions. *Working paper*.

He, Z. (2007). Dynamic compensation contracts with private savings. *Working paper*.

Hermalin, B. E. and M. S. Weisbach (2010). Information disclosure and corporate governance. *Working paper*.

Holmstrom, B. (1982). Moral Hazard in Teams. *The Bell Journal of Economics 13* (2), 324–340.

Huson, M. R., P. H. Malatesta, and R. Parrino (2004). Managerial succession and firm performance. *Journal of Financial Economics*, 237–275.

Huson, M. R., R. Parrino, and L. Starks (2001, December). Internal monitoring mechanisms and CEO turnover: A long-term perspective. *Journal of Finance 56* (6).

Jenter, D. and F. Kanaan (2006, February). CEO turnover and relative performance evaluation. *Working paper, MIT*.

Kaplan, S., M. M. Klebanov, and M. Sorensen (2008, August). Which CEO characteristics and abilities matter? *Working paper*.

Kaplan, S. and B. A. Minton (2006, August). How has CEO turnover changed? Increasingly performance sensitive boards and increasingly uneasy CEOs. *NBER Working paper 12465*.

Kaplan, S. N. and J. D. Rauh (2010). Wall Street and Main Street: What Contributes to the Rise in the Highest Incomes? *Review of Financial Studies 23* (3), 1004–1050.

Lancaster, K. J. (1966). A New Approach to Consumer Theory. *Journal of Political Economy* **74**, 132–156.

Lazear, E. P. and P. Oyer (2004). Internal and external labor markets: a personnel economics approach. *Labour Economics* **11**, 527–554.

Lucas, Robert E., J. (1978). On the Size Distribution of Business Firms. *Bell Journal of Economics* **9**, 508–523.

Lustig, H., C. Syverson, and S. Van Nieuwerburgh (2009). Technological change and the growing inequality in managerial compensation. *NBER Working Paper 14661*.

Murphy, K. J. (1999). Executive Compensation. *Handbook of Labor Economics* **3**.

Murphy, K. J. and J. Zabojnik (2004). CEO Pay and Appointments: A Market-based explanation for recent trends. *American Economic Review Papers and Proceedings* **94(2)**, 192–196.

Murphy, K. J. and J. Zabojnik (2007, April). Managerial capital and the market for CEOs. *Working paper*.

Oyer, P. (2004, August). Why Do Firms Use Incentives That Have No Incentive Effects? *Journal of Finance 49*(4), 1619–1649.

Parrino, R. (1997). CEO turnover and outside succession. *Journal of Financial Economics* **46**, 165–197.

Peters, F. S. and A. F. Wagner (2007, December). The executive turnover risk premium. *Working paper*.

Rosen, S. (1974). Hedonic prices and implicit markets. *Journal of Political Economy* **82**, 34–35.

Rosen, S. (1981). The economics of superstars. *American Economic Review* **71**, 845–858.

Sannikov, Y. (2008, July). A continuous-time version of the principal-agent problem. *Review of Economic Studies 75*(3), 957–984.

Sattinger, M. (1979). Differential rents and the distribution of earnings. *Oxford Economics Papers 31*(1), 60–71.

Sattinger, M. (1993). Assignment Models of the Distribution of Earnings. *Journal of Economic Literature* **31**, 831–880.

Stokey, N. L. (2009). *The economics of inaction: Stochastic control models with fixed costs*. Princeton University Press.

Taylor, L. (2010). Why Are CEOs Rarely Fired? Evidence from Structural Estimation. *Working paper*.

Tervio, M. (2008). The Difference That CEOs Make: An Assignment Model Approach. *American Economic Review 98*(3), 642–668.

Warner, J., R. Watts, and K. Wruck (1988). Stock prices and top management changes. *Journal of Financial Economics* **20**, 461–492.

# Appendices

## A Output, Wages, and Profits: Two-Industry Economy Date 0

We begin with payoffs in Industry A. To compute output, note that output equals $\theta_0(i)a_0(i)+\theta_1(i)a_1(i)+\theta_2(i)a_2(i)$ and use the distributions for skills and skill weights to compute output as a function of $i$. In particular, note that $\theta_0^A = 1+2i$, $a_0^x = 1+2i$, $\theta_1^A = 1+2i$, $a_1^x = 2i$, $\theta_2^A = 0$, and $a_2^x = 0$. Thus, output in industry A is given by:

$$V^A(i,i) = 1 + 6i + 8i^2.$$

For wages, note that $a_1^x[j] = 2j$ so that $a_1^{x\prime}[j] = 2$, and $\theta_1^A(j) = 1+2j$ so $\int_0^i \theta_1^A(j)a_1^{x\prime}[j]\,dj$. Wages are then:

$$w^x(i) = 2i + 2i^2.$$

For profits from general skills, note that $\theta_1^A[j] = 1+2j$ so $\theta_1^{A\prime}[j] = 2$ and $a_1^x(j) = 2j$ so $\int_0^i a_1^x(j)\theta_1^{A\prime}[j]\,dj = 2i^2$. Total profits also include the payoff $(1+2i)^2$ from firm specific skills. Thus, profits are:

$$\pi^A(i) = 1 + 4i + 6i^2.$$

To compute output in industry B, note that output is $\theta_0(i)a_0(i) + \theta_1(i)a_1(i) + \theta_2(i)a_2(i)$, and in industry B $\theta_0^B = 0$, $a_0^z = 0$, $\theta_1^B = \frac{1}{2}i$, $a_1^z = 0$, $\theta_2^B = \frac{1}{2}i$, and $a_2^z = 2i$. Thus we have:

$$V^B(i,i) = i^2.$$

For wages, note that $a_2^z[j] = 2j$ so that $a_2^{z\prime}[j] = 2$, and $\theta_2^B(j) = \frac{j}{2}$ so $\int_0^i \theta_2^B(j)a_2^{z\prime}[j]\,dj$. Thus,

$$w^z(i) = \frac{1}{2}i^2.$$

For profits from general skills, note that $\theta_2^B[j] = \frac{j}{2}$ so $\theta_2^{B\prime}[j] = \frac{1}{2}$ and $a_2^z(j) = 2j$ so $\int_0^i a_2^z(j)\theta_2^{B\prime}[j]\,dj = \frac{1}{2}i^2$. Thus, since there is no weight on or accumulation of firm specific skill in industry B, profits are given by

$$\pi^B(i) = \frac{1}{2}i^2.$$

## B Output, Wages, and Profits: Two-Industry Economy Date 1

We describe the calculations for output and wages, and compute profits as a residual. Unlike at date zero, output from firm specific skills is not fully captured by firms. Part of this output is paid out to managers in order to retain their firm specific skills by compensating them for the outside option of their general skills. We begin with payoffs in industry B, starting with firms with indices between zero and $2i_A^*$. Output is $\theta_0(i)a_0(j) + \theta_1(i)a_1(j) + \theta_2(i)a_2(j)$. Note that firm and managerial indices may not coincide after managerial reallocation across industries even though there is still assortative matching overall. Firms with $i \in [0, 2i_A^*]$ employ managers with $j \in [0, i_A^*]$ of types $x$ and $z$. From the distributions for skill weights and ability levels we have that $\theta^B_{\{1,2\}} = \frac{1}{2}i$, $a_1^x(i) = i$, and $a_2^z(i) = i$ (due to mixing). Output for firms in industry B with $i < 2i_A^*$ is thus $\frac{1}{2}i^2$ for firms with either type of manager. Wages in this region are determined by the binding within industry sorting constraints which imply that for firms employing type $z$ managers,

$$w^z(i) = \int_0^i \theta_2^B(j) a_2^{z\prime}[j]\, dj = \int_0^i \frac{1}{2} j\, dj,$$

and an analogous computation determines wages for firms employing type $x$ managers. Wages at firms in industry B with $i < 2i_A^*$ are thus $\frac{1}{4}i^2$.

Firms in industry B with indexes $i > 2i_A^*$ employ type $z$ managers with $j \in [i_A^*, i_B^*]$. Using the fact that $\theta_2^B = \frac{1}{2}i$ and $a_2^z(j) = 2j$ where $j = i - i_A^*$ we have that output equals $i^2 - ii_A^*$. For wages, note that within industry sorting constraints imply that wages must be continuous around firm index $2i_A^*$ and so the intercept of wages for firms above $2i_A^*$ is $w(i_A^*)$, or ${i_A^*}^2$. As in the lower region of industry B, wages at the top of industry B are determined by the binding within industry sorting constraints which imply that:

$$w^z(i) = w(i_A^*) + \int_{2i_A^*}^i \theta_2^B(j) a_2^{z\prime}[j]\, dj = \int_{2i_A^*}^i j\, dj,$$

since $a_2^{z\prime}[j] = 2$ at the top of industry B. Adding the intercept to the integrated slope for wages implies that wages are equal to $\frac{1}{2}i^2 - {i_A^*}^2$.

We will use industry B wages to determine wages in industry A, since the cross industry constraints will bind for agents at the boundaries and at the top of industry A. Firms in industry A with indexes $i < i_A^*$ fire their managers and replace them with managers with indexes $i \in [i_B^* + \epsilon, 1]^z$ from industry B. Output is $\theta_0(i)a_0(j) + \theta_1(i)a_1(j) + \theta_2(i)a_2(j)$. Since these firms hire cost cutters with no firm specific skill this simplifies to $\theta_2(i)a_2(j) = (1 + 2i)(1 + 2j)$ with $j = i + 1 - i_A^*$. Thus output is given by $(1 + 2i)(2i + 2 - 2i_A^*)$. The intercept for wages at the bottom of industry A is $w(i_B^{*z}) = \frac{1}{2} - {i_A^*}^2$ since for manager $i_B^{*z} + \epsilon$ the cross industry sorting constraint implies that they must not prefer to work at the oneth firm in industry B. The slope of wages is then determined by the binding within industry sorting constraints and integrating we get:

$$w^z(i) = w(i_B^{*z}) + \int_0^i \theta_2^A(j) a_2^{z\prime}[j]\, dj = \int_0^i (1 + 2j)2\, dj.$$

Adding the intercept to this integral, wages are then $\frac{1}{2} - {i_A^*}^2 + 2i + 2i^2$.

Firms in industry A with indexes $i > i_A^*$ retain their type $x$ managers. Output comes from firm specific skill only and is equal to $(1 + 2i)(1 + 2i)$. Even though all output is from unpriced managerial skill, managers at these firms do not earn zero wages due to binding cross industry sorting constraints. These managers have outside options at the top of industry B. When computing wages, it is useful to consider two regions for the top of industry A. Consider first sales growing managers who have skill index $j \in (i_A^*, i_B^*)$ and work at firms $i \in (i_A^*, i_B^*)$ in industry A. These sales growers must earn the same wage as cost-cutting managers with skill index $j \in (i_A^*, i_B^*)$, who work at the top of industry B (for firms with productivity index between $i_B^*$ and 1) in order for these industry B firms not to prefer them to their assigned cost-cutter. The intercept for wages in this region is $w(i_A^*) = {i_A^*}^2$. The binding cross industry sorting constraints yield the additional wages for firms with higher indices

$$w^x(i) = w(i_A^*) + \int_{2i_A^*}^{i+i_A^*} \theta_1^B(j) a_1^{x\prime}[j]\, dj = \int_{2i_A^*}^{i+i_A^*} j\, dj.$$

Because these managers' outside option is in industry B, one must translate the industry A firm index to the appropriate firm B index and use the skill weights of the firm B firms as well as how ability increases with index for the relevant region of industry B. The industry A firm index $i$ translates to industry B firm index $i+i_A^*$. Skill weights $\theta_1^B(i) = \frac{1}{2}i$ and ability is $2i$ since there is no mixing at the top of industry B. Adding the intercept to the integrated slope, we have that wages are $\frac{1}{2}(i^2 - {i_A^*}^2) + ii_A^*$.

Finally, we compute wages at industry A firms with indices in $[i_B^*, 1]$ who retain type $x$ managers with corresponding indices. First, note that the intercept of wages in this region must be $w(i_B^*) = \frac{1}{2} - {i_A^*}^2$. Again, the binding cross industry sorting constraints yield the additional wages for firms with higher indices. Essentially, wages must increase with the potential contribution of managerial ability to output at the oneth firm in industry B in order to ensure that this firm does not prefer these higher ability sales growers to its assigned cost cutter $i_B^{*z}$. We have:

$$w^x(i) = w(i_B^*) + \int_{i_B*}^{i} \theta_1^B(j) a_1^{x\prime}[j]\, dj = \int_{i_B^*}^{i} j\, dj.$$

Using the fact that $i_B^* = 1 - i_A^*$ and adding the intercept to the integrated slope, we have that wages are $\frac{1}{2}i^2 + i_A^* - \frac{3}{2}{i_A^*}^2$.

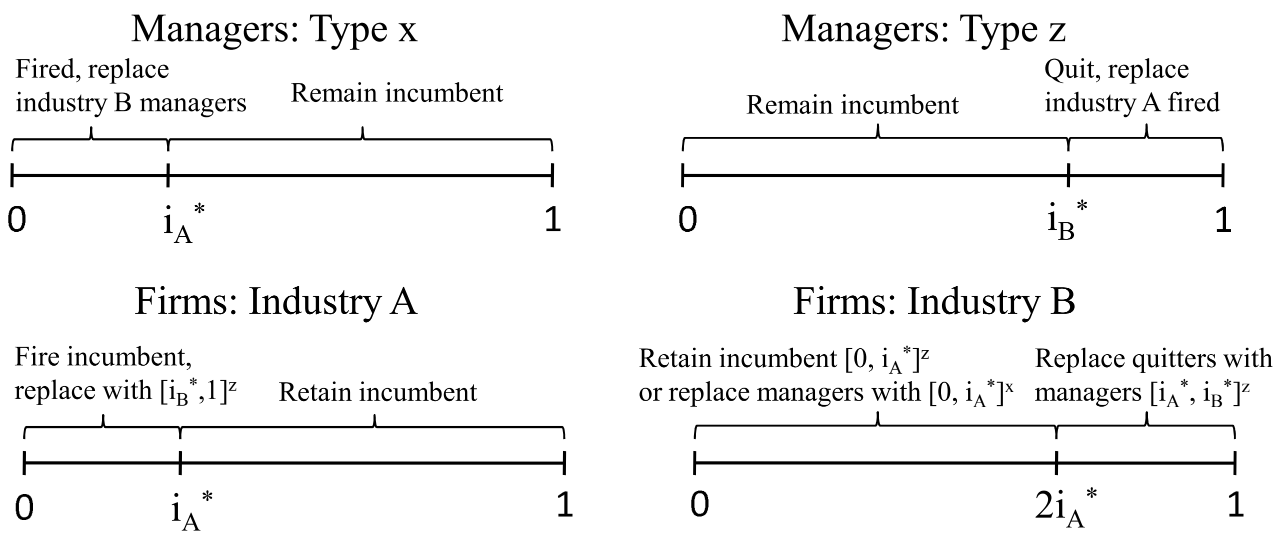


Figure 1: Two-industry economy: Turnover and reallocation in industries A and B.

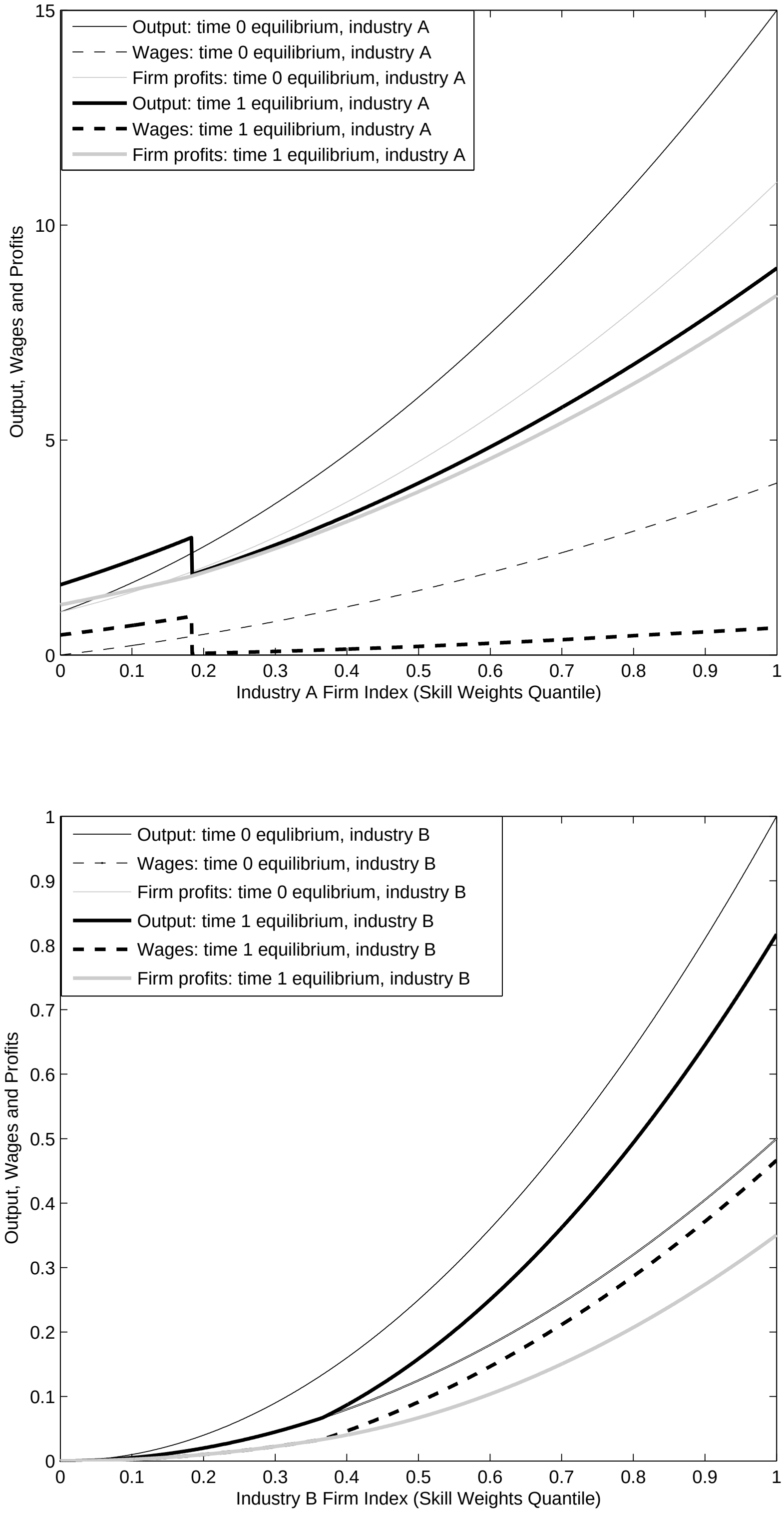


Figure 2: Two-industry economy: Output, wages, and profits in industries A and B.

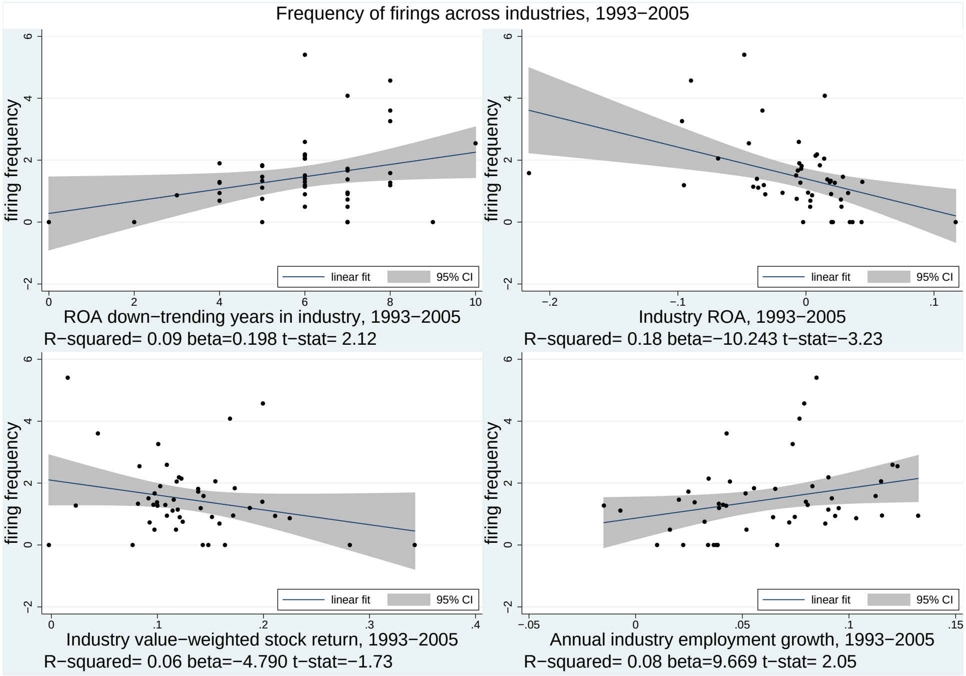


Figure 3: Frequency of firings and industry conditions during 1993-2005.

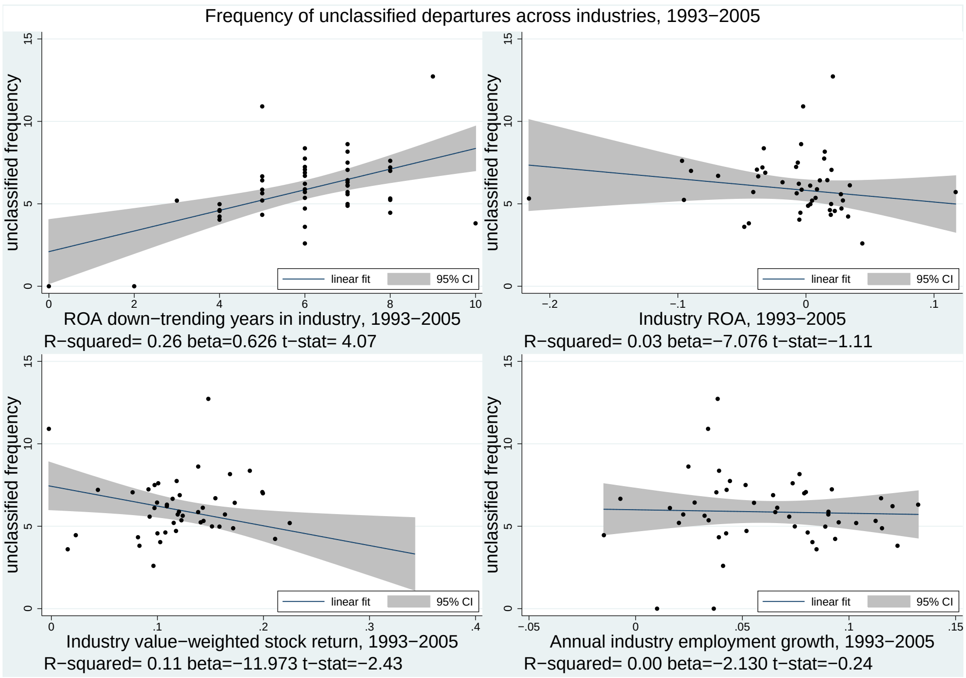


Figure 4: Frequency of unclassified departures and industry conditions during 1993-2005.

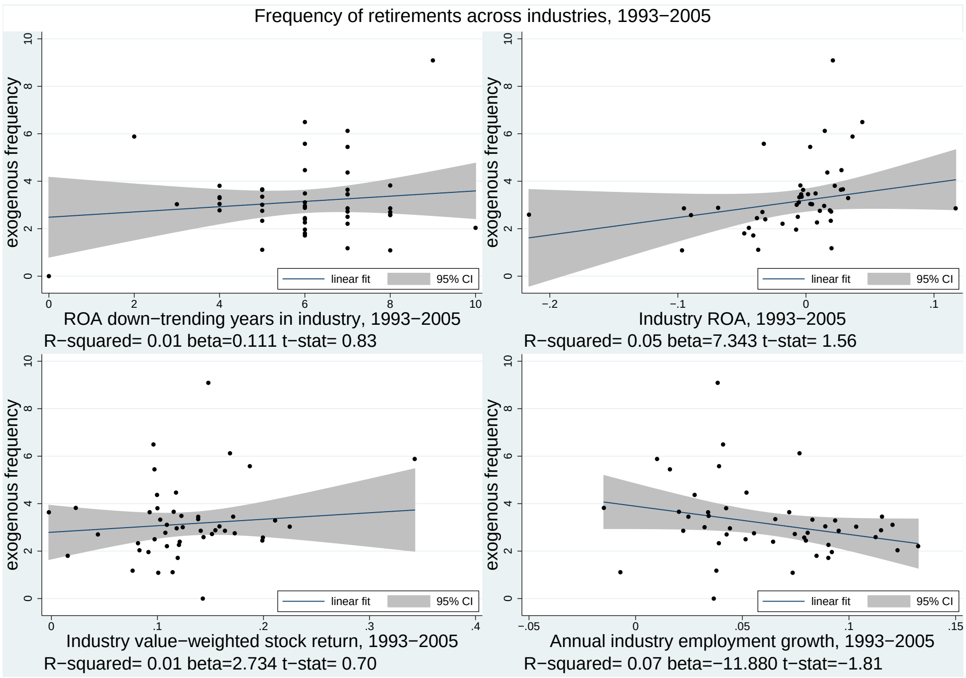


Figure 5: Frequency of retirements and industry conditions during 1993-2005.

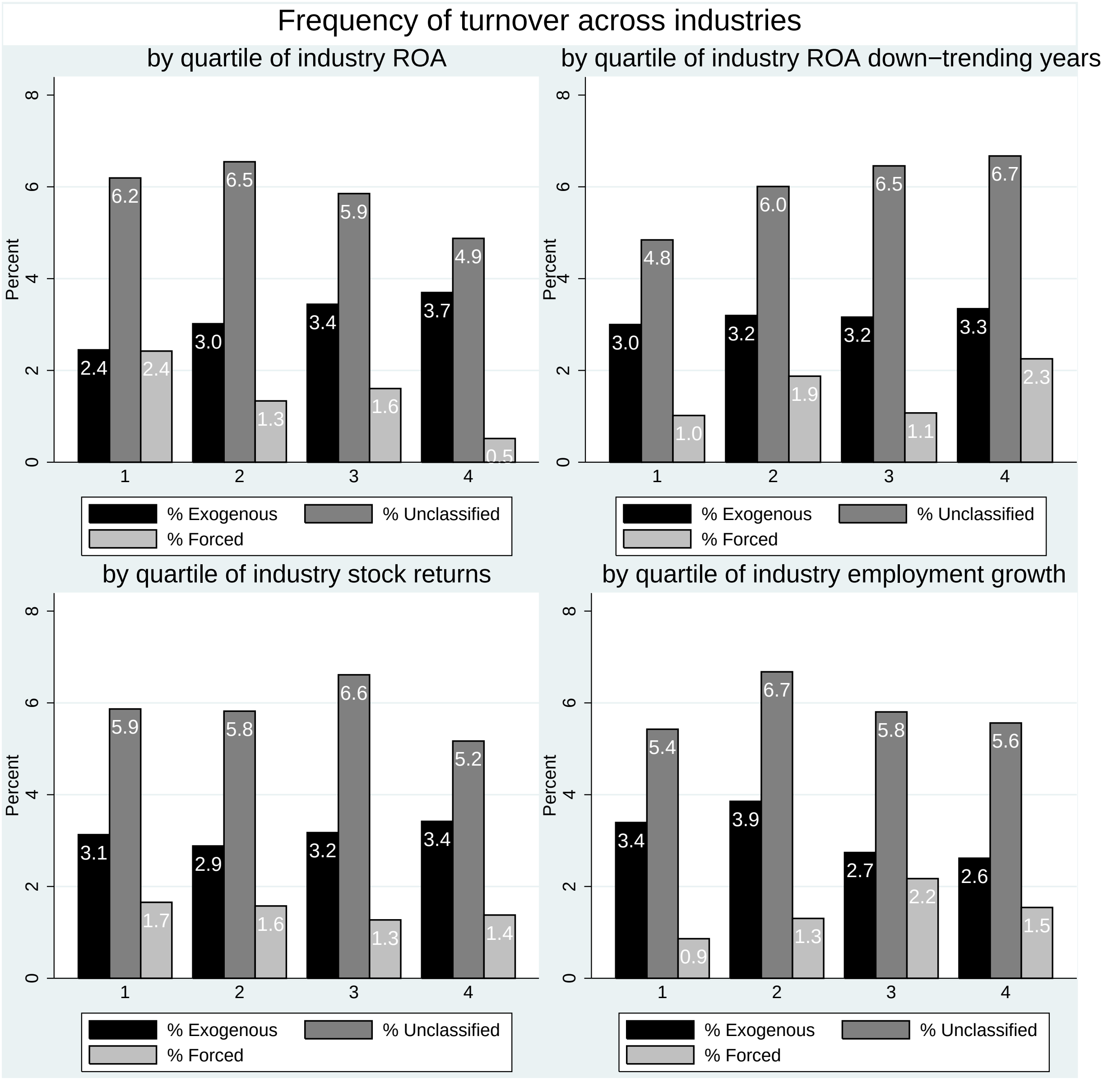


Figure 6: Frequency of turnover types as a function of industry conditions, 1993-2005.

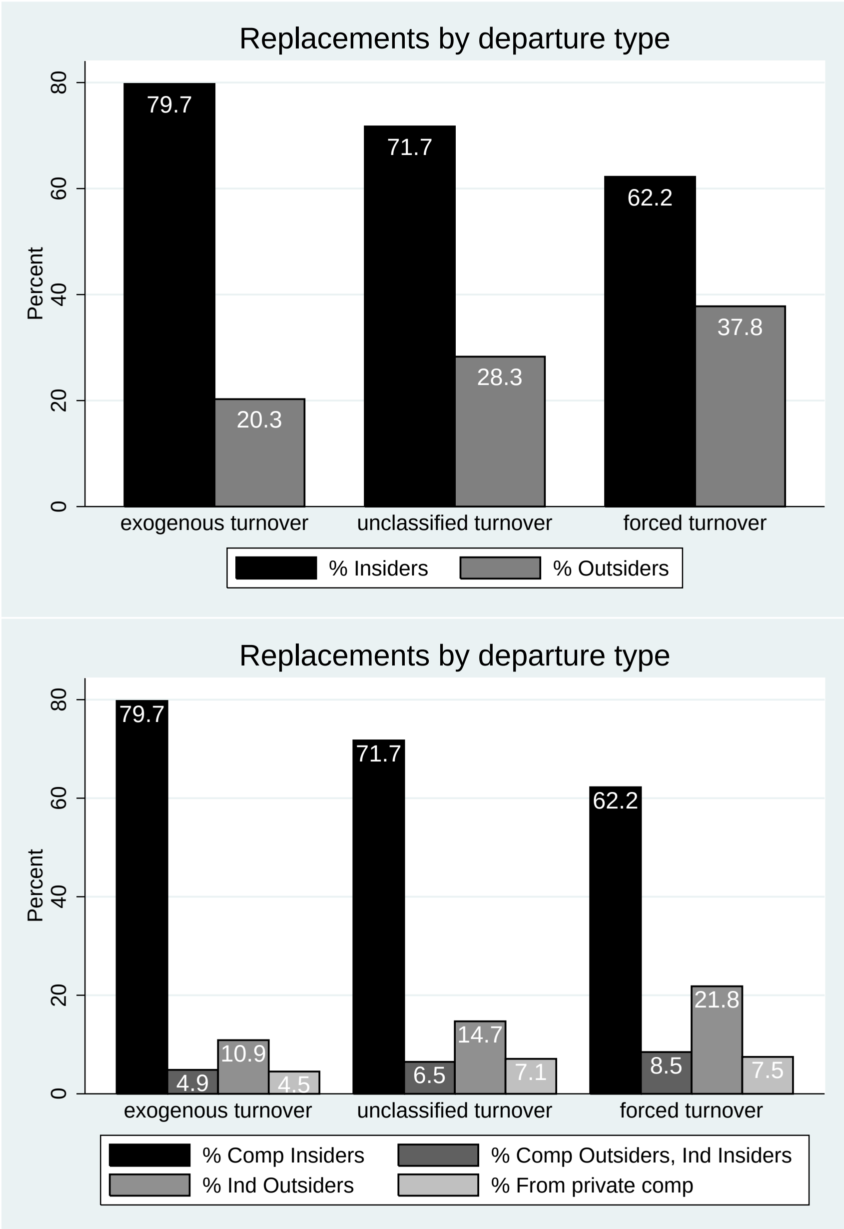


Figure 7: Replacement types and departure reasons.

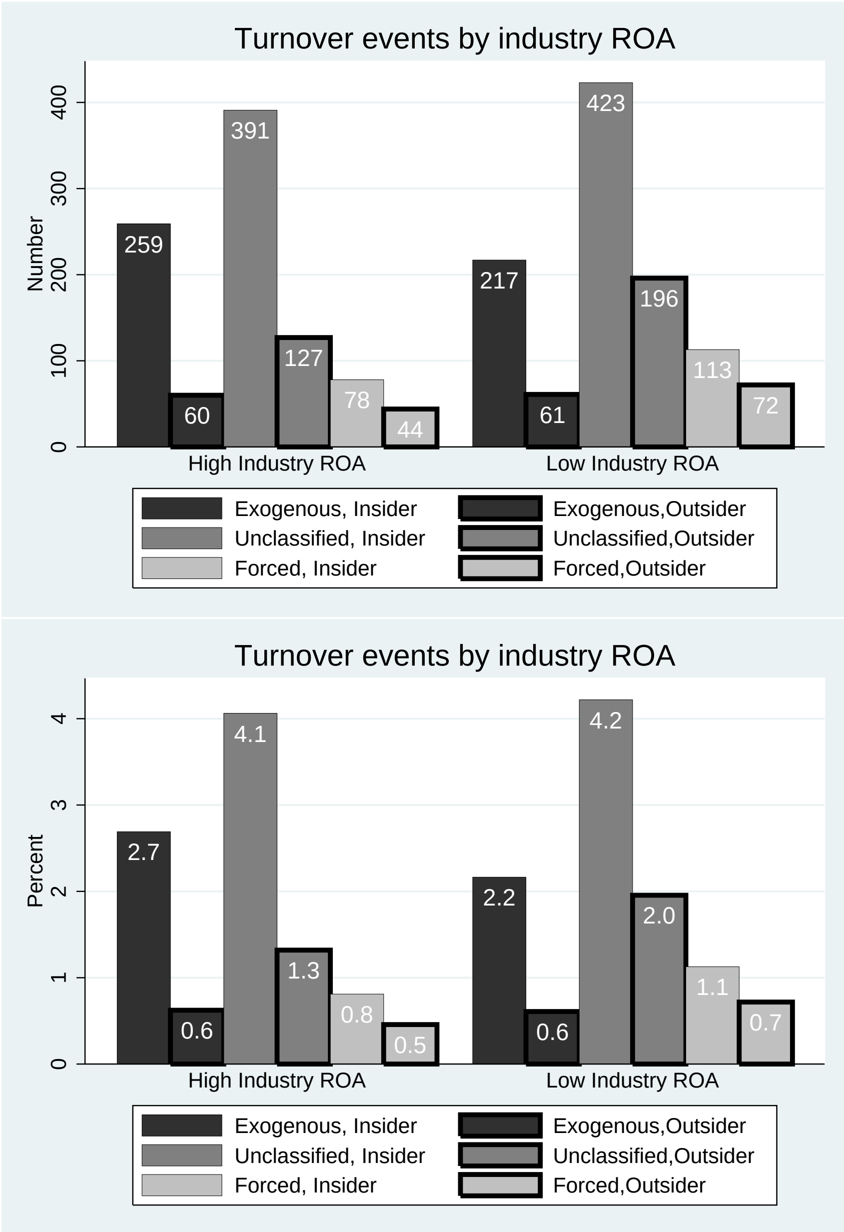


Figure 8: Turnover events (number and frequency) by industry ROA.

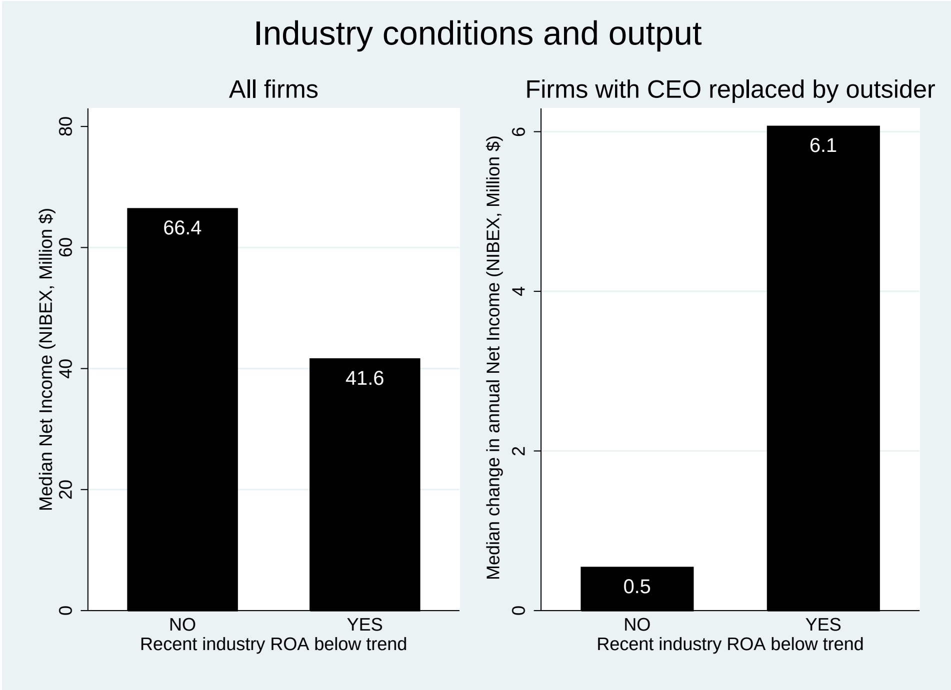


Figure 9: Industry conditions and output.

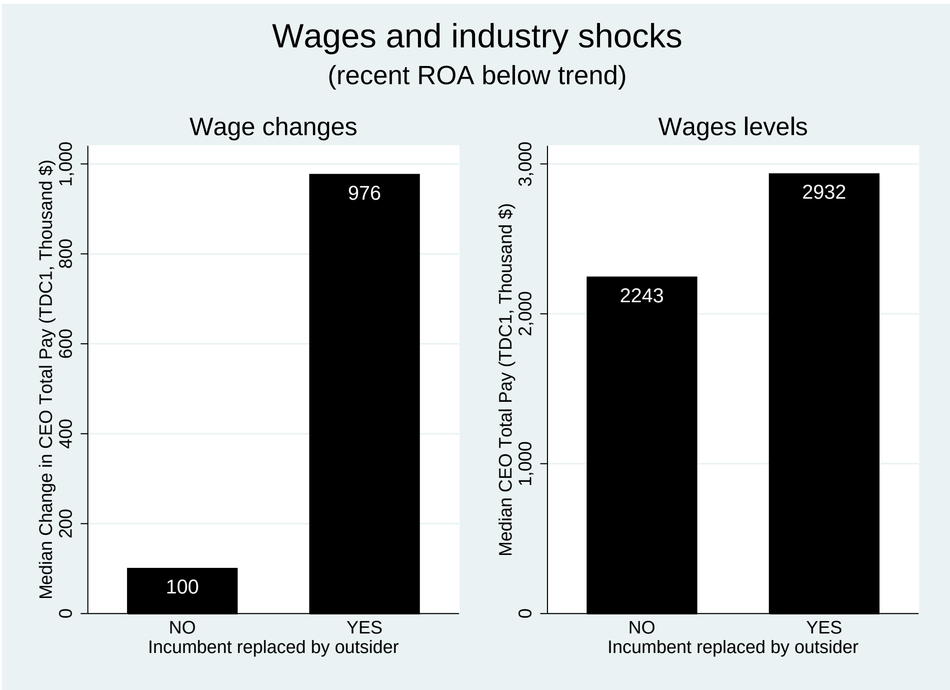


Figure 10: Industry conditions and wages.

Table 1: Firm skill weights and managerial skill levels for two-firm example.

| Time 0 Firm skill weights | | Time 1 Firm skill weights | | Managerial Skill Levels | | | |
|---|---|---|---|---|---|---|---|
| $\theta_A$ | $\theta_B$ | $\theta_A$ | $\theta_B$ | $a_w$ | $a_x$ | $a_y$ | $a_z$ |
| 3 | 0 | 3 | 0 | 1 | 0 | 0 | 0 |
| 2 | 1 | 0 | 0 | 1 | 1 | 0 | 0 |
| 0 | 0 | 2 | 1 | 0 | 0 | 1 | 3 |

Table 2: Equilibrium allocations at date 0 for two-firm example.

| | Managers | | | |
|---|---|---|---|---|
| | w | x | y | z |
| Firm A output | 5 | 2 | 0 | 0 |
| Firm A pay | $\frac{1}{2} + 2\epsilon$ | | | |
| Firm A profits | $4\frac{1}{2} - 2\epsilon$ | | | |
| Firm B output | 1 | 1 | 0 | 0 |
| Firm B pay | | $\frac{1}{2} + \epsilon$ | | |
| Firm B profits | | $\frac{1}{2} - \epsilon$ | | |

Table 3: Equilibrium allocations at date 1 for two-firm example.

| | Managers | | | |
|---|---|---|---|---|
| | w | x | y | z |
| Firm A output | 3 | 0 | 2 | 6 |
| Firm A pay | $\frac{1}{2}+\epsilon$ | 0 | $\frac{1}{2}+\epsilon$ | $2\frac{1}{2}+2\epsilon$ |
| Firm A profits | $2\frac{1}{2}-\epsilon$ | | $1\frac{1}{2}-\epsilon$ | $3\frac{1}{2}-2\epsilon$ |
| Firm B output | 0 | 0 | 1 | 3 |
| Firm B pay | | | $\frac{1}{2}+\epsilon$ | $2\frac{1}{2}+\epsilon$ |
| Firm B profits | 0 | 0 | $\frac{1}{2}-\epsilon$ | $\frac{1}{2}-\epsilon$ |

Table 4: Time 0 firm skill weights and manager skill levels in two-industry economy

| Firm Skill Weights | |
|---|---|
| Industry A | Industry B |
| $\theta_0^A \sim U(1,3)$ | $\theta_0^B = 0$ |
| $\theta_1^A \sim U(1,3)$ | $\theta_1^B \sim U(0,\frac{1}{2})$ |
| $\theta_2^A = 0$ | $\theta_2^B \sim U(0,\frac{1}{2})$ |

| Manager Skill Levels | |
|---|---|
| Type x | Type z |
| $a_0^x \sim U(1,3)$ | $a_0^z = 0$ |
| $a_1^x \sim U(0,2)$ | $a_1^z = 0$ |
| $a_2^x = 0$ | $a_2^z \sim U(0,2)$ |

Table 5: Multinomial logit model for CEO departure reasons. The reference category is "no turnover". Exogenous turnover indicates instances where the CEO left the company because of age or health reasons. Forced turnover indicates instances where the CEO was forced out. Unclassified turnover refers to the CEO departures that were not exogenous, nor forced. Standard errors are clustered by Fama French 48 industry codes.

| Dependent variable | *CEO departure type* | | |
|---|---|---|---|
| | exogenous turnover | unclassified turnover | forced turnover |
| $Firm - IndustryReturn_t$ | –0.32 | –0.35 | –1.87 |
| | (–2.90)*** | (–3.86)*** | (–6.90)*** |
| $Industry - MarketReturn_t$ | 0.07 | 0.17 | –1.10 |
| | (0.30) | (0.95) | (–3.22)*** |
| $VWMarketReturn_t$ | 0.45 | –0.48 | –0.49 |
| | (1.42) | (–2.01)** | (–0.98) |
| $Firm - IndustryReturn_{t-1}$ | –0.14 | –0.08 | –0.73 |
| | (–1.80)* | (–1.16) | (–4.62)*** |
| $Industry - MarketReturn_{t-1}$ | –0.29 | 0.20 | –0.32 |
| | (–0.96) | (0.74) | (–0.85) |
| $VWMarketReturn_{t-1}$ | 0.99 | 0.18 | 0.81 |
| | (3.94)*** | (0.72) | (2.01)** |
| $Firm - IndustryROA_t$ | 0.02 | –1.26 | –1.89 |
| | (0.04) | (–4.39)*** | (–4.28)*** |
| $IndustryROA_t$ | 0.85 | –2.31 | –0.95 |
| | (1.49) | (–2.16)** | (–0.73) |
| $IndustryROABelowTrend_t$ | 0.08 | 0.23 | 0.29 |
| | (0.85) | (3.62)*** | (2.18)** |
| $Firm - IndustryEmploymentGrowth_t$ | –0.65 | –0.69 | –0.30 |
| | (–2.64)*** | (–3.40)*** | (–1.14) |
| $IndustryEmploymentGrowth_t$ | –1.21 | –0.63 | 1.97 |
| | (–1.37) | (–0.85) | (1.91)* |
| $IsUnder65_t$ | –1.79 | –1.27 | 0.09 |
| | (–21.50)*** | (–13.57)*** | (0.39) |
| Pseudo $R^2$ | | 0.07 | |
| No. of obs | | 18804 | |

Table 6: Multinomial logit model for CEO replacement types. The reference replacement category is "company insider". The missing departure type consists of exogenous (i.e., age or health-related) retirements. Fama French 48 industry code fixed effects are included. Standard errors clustered by Fama French 48 industry code.

| Dependent variable | *CEO replacement type* | | |
|---|---|---|---|
| | company outsider, industry insider | industry outsider from public co. | from private firms |
| $UnclassifiedDeparture_t$ | 0.42 | 0.34 | 0.33 |
| | (1.95)* | (1.77)* | (1.33) |
| $ForcedDeparture_t$ | 0.84 | 0.83 | 0.49 |
| | (3.19)*** | (4.08)*** | (1.27) |
| Industry FEs | | YES | |
| Pseudo $R^2$ | | 0.07 | |
| No. of obs | | 2068 | |

Table 7: Probit models for the likelihood that the replacement CEO is a company outsider. Reference category is "company insider". Standard errors clustered by Fama French 48 industry code.

| Dependent variable | *Replacement is outsider* |
|---|---|
| $Firm - IndustryReturn_t$ | –0.32 |
| | (–4.73)*** |
| $Industry - MarketReturn_t$ | –0.01 |
| | (–0.07) |
| $VWMarketReturn_t$ | 0.38 |
| | (1.89)* |
| $Firm - IndustryReturn_{t-1}$ | –0.04 |
| | (–0.67) |
| $Industry - MarketReturn_{t-1}$ | 0.20 |
| | (1.58) |
| $VWMarketReturn_{t-1}$ | 0.04 |
| | (0.21) |
| $Firm - IndustryROA_t$ | –1.22 |
| | (–5.12)*** |
| $IndustryROA_t$ | –2.52 |
| | (–3.79)*** |
| $IndustryROABelowTrend_t$ | –0.06 |
| | (–0.94) |
| $Firm - IndustryEmploymentGrowth_t$ | 0.06 |
| | (0.58) |
| $IndustryEmploymentGrowth_t$ | –1.20 |
| | (–2.23)** |
| $IsUnder65_t$ | 0.18 |
| | (2.57)** |
| Pseudo $R^2$ | 0.04 |
| No. of obs | 1933 |