CEO turnover in a competitive assignment framework

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A B S T R A C T

There is widespread concern about whether Chief Executive Officers (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, overall industry performance also matters. This seems puzzling if termination is disciplinary, however, we show that both absolute and relative performance-driven turnover can be natural and efficient outcomes in a competitive assignment model in which CEOs and firms form matches based on multiple characteristics. The model also has new predictions about replacement managers' equilibrium pay and performance. We document CEO turnover events during 1992–2006 and provide empirical support for our model.

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 (Kaplan and Minton, 2006; Jenter and Kanaan, forthcoming). This result is puzzling from the perspective of the theoretical literature on relative performance evaluation (RPE), which suggests that exogenous industry shocks should be filtered out of the termination decision (e.g., Holmstrom, 1982; Gibbons and Murphy, 1990).

We propose an explanation for the effects of both relative and absolute performance on turnover based on two simple ideas, and develop a competitive assignment model which illustrates these effects. First, if industry conditions impact the outside options of matched firms and managers, industry shocks will also drive turnover. The competitive assignment model that we develop pins down precisely one way in which these outside options might change when an industry shock occurs. In our model, CEOs and firms form matches based on multiple characteristics. Industry conditions determine the most desirable managerial skill set and thus naturally drive
managerial turnover. Second, any fixed firing cost leads to a threshold rule for termination at the firm level. Firms will only replace their managers if the benefits of replacement exceed the replacement cost. If these fixed costs inhibit CEO turnover at better performing firms, while the worst performers find it optimal to pay the replacement cost and fire their manager, then the industry will exhibit what looks like relative performance evaluation. In our model, the fixed costs of managerial replacement come from the loss of firm-specific managerial skill.

Our model can be thought of as a counter example with two important implications for the way evidence about managerial turnover is interpreted. First, observing that relatively poorly performing managers are more likely to be fired is not direct evidence of relative performance evaluation. In our model, 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 acting inefficiently. In our model, industry shocks change the outside options of firms and managers. If boards made the efficient hiring and firing decisions in our model, it would be optimal for them to include industry conditions in their decision to terminate the incumbent CEO, and in their choice of a replacement manager.

Specifically, we develop a competitive assignment model in which CEOs are viewed as hedonic goods with multidimensional skill bundles. Likewise, firms' production functions have heterogeneous weights on CEOs' firm-specific knowledge and on general CEO skills such as the ability to grow sales, and the 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 of the match-quality shock, industry-level productivity and output decline. Moreover, the shock implies that firms demand managers with different skills and this leads to 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.

Our equilibrium model is very stylized, however, we argue that the ideas motivating our model, and the results it generates, are useful for understanding the observed empirical patterns of CEO turnover. In our simple setup, we are able to study turnover in a two-industry setting in which managers have multidimensional skill bundles and in which managerial allocations and CEO pay are determined in equilibrium. Thus, we study managerial reallocation as opposed to the standard focus on CEO turnover at the firm level. Moreover, our analysis includes equilibrium implications for managerial compensation and firm profits.

We generate the following five main empirical implications: First, absolute performance affects CEO turnover. Second, relative performance affects turnover despite the fact that there are no information asymmetries or agency problems in our model. Third, industry outsiders are chosen as replacement managers after poor relative and absolute performance leads to terminations. Fourth, performance improves at firms that terminate and replace their managers in an industry downturn. Fifth and finally, these industry outsiders receive higher pay than the CEOs they replaced and the remaining incumbent managers.

Our empirical work contributes to the existing literature by studying a large data-set of CEO replacements we construct which describes turnover events during 1992–2006. We examine the type of turnover event (firings, retirements, and potential quits), the pay and performance of the incumbent and replacement, and whether the replacement is an industry insider or outsider. We document relative and absolute performance effects on turnover. We also show that our model's new predictions concerning the type, pay, and performance of replacement managers are borne out empirically. These predictions help to distinguish our theory from alternative explanations based on learning and/or agency problems which do not have clear implications about the type and pay of replacement managers.

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. They constitute one response to the argument that the observed high level of CEO pay is a result of entrenched managers earning excessive rents (e.g., Bebchuk and Fried, 2004). In this paper, we show how the competitive assignment model can be used to understand the flip side of CEO pay, namely CEO turnover. Our model serves to illustrate that the observed empirical outcomes for turnover can be 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.
Viewing managers as hedonic goods is useful for considering how industry shocks might drive CEO turnover since weights on, and hence demand for, 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 that 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 CEOs have specific abilities which firms consider when making their hiring and firing decisions is consistent with current executive search procedures. A recent book (Carey and Ogden, 2000) by executives from leading executive search firm Spencer Stuart, discusses how firms should tailor their executive searches to their desired strategy going forward. Further evidence that using CEO characteristics to appoint replacements is empirically relevant is provided in Groysberg, McLean and Nohria (2006), who document the performance of a sample of 20 replacement managers, all former General Electric executives, classified via their resumes as either cost cutting, growth, or cyclical managers. Their study finds that managers are only successful in their new jobs if the required strategy matches their talent type. Focusing on one particular manager type and firm strategy, Canella, Parrino, and Srinivasan (2012) find that firms which pursue a product differentiation strategy are more likely to appoint a CEO with a marketing background. They note that there is a large and growing literature in management which emphasizes the importance of matching CEO skill sets to industry conditions, such as Wiersema and Bantel (1993) and the cites therein. Firms may also value particular psychological characteristics or preferences of the CEO. For instance, Graham, Harvey, and Puri (2009) show that risk-tolerant CEOs tend to work for high growth firms. Finally, using interview data on a large array of personality characteristics, recent work by Kaplan, Klebanov, and Sorensen (2011) shows that using information on specific CEO characteristics can help predict performance conditional on whether the CEO operates in a private equity or venture capital-funded firm.

The idea that specific managerial abilities matter is also in the spirit of Bertrand and Schoar (2003) who identify manager fixed effects in management style. Fahlenbrach, Low and Stulz (2010) study director appointments and, consistent with the style hypothesis, find that CEOs are more likely to join boards of firms that pursue similar financial and investment policies. Our theory also reconciles the evidence in these papers with the results in Fee, Hadlock, and Pierce (2011), who find no evidence of changes in managerial style (e.g., policies regarding financing and investment decisions) around CEO turnover events driven by exogenous shocks. In our matching framework, it is natural that the turnover event type determines the replacement CEO’s style, as well as whether that style differs from the incumbent’s style. In particular, one would only expect endogenous turnover events driven by match-quality shocks to result in replacement managers with a new style.

The idea that the importance of firm-specific skills can influence whether termination occurs is built upon Murphy and Zabojnik (2004, 2007), which develop a theory of the effect of firm-specific skill on turnover. Taylor (2010) quantifies the inaction effect of fixed costs on the CEO turnover rate using a structural model.

The role industry conditions play in CEO turnover has not received much attention in the literature until recently. 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. 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-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, which, as shown empirically in Harford (2005), occur in response to industry shocks that require large-scale asset reallocations.

Our paper also builds on the results of a large body of empirical work on CEO turnover. One of the most well-documented facts is that 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). However, relative performance does not seem to be the only reason CEOs turn over.

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3 This idea is consistent with the finding by Allgood and Farrell (2003) that longer-lasting firm-CEO matches tend to occur when company insiders follow previous CEOs who quit, and when company outsiders follow previous CEOs who are dismissed.

4 Frydman (2005) implements these ideas empirically to study the effects of changes in the importance of specific vs. general skills using a long time series of managerial turnover.

5 We thank Robert Parrino for this helpful historical perspective on the literature. Among papers studying the link between corporate governance and CEO pay and 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. Parrino, Sias, and Starks (2003) show the dependence of forced turnovers and outside CEO replacements on institutional ownership. 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 CEOs’ performance.

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

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2 Similar ideas were communicated to us in private phone conversations with one of the book’s authors, Dayton Ogden, who was kind enough to provide us with an insider’s perspective on the executive search process at the start of our project.
driver of managerial replacement. Kaplan and Minton (2006) and Jenter and Kanaan (forthcoming) find that CEOs are more likely to be dismissed from their job after bad industry performance.

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 to 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, pay, and performance 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, about the pay of these replacements, or their impact on firm output.\(^7\)

2. Model

We develop our model in two steps. In Section 2.1 we describe a general framework of firms and CEOs matching based on multiple characteristics. We do not fully specify or solve the general model. Instead, we use it to illustrate our conceptual framework and to build the general intuition behind our two most fundamental results regarding the role of absolute and relative performance for CEO turnover. This intuition applies beyond the specific framework, we also show that in any matching model, labeling separations as quits vs. firings is likely to involve some ambiguity.\(^8\) Then, in Section 2.2 we construct a stylized two-industry competitive assignment model. In order to solve for equilibrium pay in our model with two industries and multidimensional skill sets, we make stark simplifying assumptions. As a result, we are able to pin down all outside options endogenously and to generate results for turnover and replacement type, CEO pay, and firm performance.

2.1. General framework

Consider an economy with two dates, zero and one. We assume that at each date, managers are matched to firms via competitive assignment. We examine the decision problems of a matched manager and firm at the initial date. 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.\(^9\) The dynamics of optimal managerial compensation induced by agency problems when long-term contracts are feasible is the focus of many recent theoretical papers.\(^10\) 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.\(^11\) The limited focus on CEO turnover in the dynamic contracting literature is in contrast to the large empirical literature on turnover discussed above.

The output created by firm \(i\) when it is matched with manager \(j\) is

\[
V = a_i(m_j)k, \tag{1}
\]

where \(a_i(m_j)\) is the productivity of capital when firm \(i\) employs manager \(j\). Thus, we use a standard linear production function and for simplicity, in what follows we set \(k = 1\) for all firms and consider only the managerial labor input. The corresponding empirical measure of output is then operating profits gross of managerial compensation, relative to the firm’s capital stock. Firm productivity is given by (slightly abusing notation):

\[
a_i(m_j) = \sum_{s=1}^{S} \theta_{ij}q_{js},
\]

where \(\theta_{ij}\) is a weight which describes the importance of skill \(s\) in determining the productivity of capital deployed in firm \(i\) and \(q_{js}\) is the level of ability of manager \(j\) in skill \(s\).\(^12\) The productivity of manager \(j\) employed at firm \(i\) is then the inner product of manager \(j\)’s skill levels and firm \(i\)’s skill weights. These weights vary over time and across firms.\(^13\) 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

\(^7\) The recent finding of Jenter and Lewellen (2010) that relatively poor performance still leads to turnover after six to ten years of tenure also seems to counter learning-based explanations for CEO replacement decisions.

\(^8\) See McLaughlin (1991) for an extended matching model with private information in which worker-initiated separations can be distinguished from terminations.

\(^9\) See Lazear and Oyer (2004) for empirical evidence that firms set wages in accordance with the employees’ outside option.


\(^11\) Notable exceptions are Inderst and Mueller (2010), who derive optimal CEO compensation and replacement policy in a moral hazard setting where CEOs are also privately informed about their ability to create value for the firm, and Garrett and Pavan (2010), who consider changes in retention and compensation policies as a function of CEO tenure in an environment with asymmetric information.

\(^12\) One can easily incorporate variation in size if one considers the \(\theta\) weights to be weights times capital. In other words, define \(\theta_i^g \in [0,1]\) and let \(\theta_i^g = \theta_i^g g(k_i)\) where \(g(k_i) > 0\). For simplicity, and to focus on variation in and shocks to skill weights, we hold capital fixed across firms.

\(^13\) See Lazear (2009) for a related model in which the precise weights on various general skills effectively act as firm-specific skill.
high weight on the ability to raise external finance, whereas firms needing to access capital markets might.

The abilities of managers may also vary over time. 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. For it to be optimal to replace a manager with a suboptimal skill set, we need to have that there are at least investment costs, adjustment costs, or time to build for managerial skills, which seems reasonable.

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 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 $w_l$. 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), Gabaix and Landier (2008), and Tervio (2008). We depart from this assumption but specify a greatly simplified model in Section 2.2 in order to solve for managerial wages.

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

$$V^{m_j} \equiv \max \left\{ \max_l [w_l, R], f \right\},$$

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

The firm’s owners will also need to be paid their outside option of firing the manager and hiring the profit-maximizing replacement. The firm’s outside option is given by

$$V^{f_l} \equiv \max_k [a_i(m_k) - V^{m_k} - d].$$

This is the value the firm receives with the optimal replacement manager, where $a_i(m_k)$ is the productivity of manager $k$ at firm $i$, $V^{m_k}$ is the outside option of manager $k$ defined above, and $d$ is a deadweight cost which the firm must pay if it replaces its manager.

The current match will dissolve if total surplus from the match is negative, i.e., if:

$$a_i(m_j) - \max_l \left\{ \max [w_l, R], \max_k [a_i(m_k) - V^{m_k} - d] \right\} < 0 \quad (4)$$

or

$$V - V^{m_j} - V^{f_j} < 0. \quad (5)$$

First, we discuss how absolute performance might affect CEO turnover in our framework. Considering the condition in (4), there are several channels through which changes in industry conditions might drive total surplus below zero and thereby drive CEO turnover. In practice, skill weights, skill prices, the pool of replacement managers, the value of retirement, and the productivity of capital are all likely to depend on industry conditions. 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. Firms may find it profitable to fire incumbent managers and hire managers with the newly more desirable bundle. Industry conditions might also change the outside option of the manager and lead to managers quitting for better jobs or retiring. For example, changes in industry conditions can change relative skill prices and lead the manager to leave for greener pastures. Finally, industry conditions can change the relative value of retirement by affecting the disutility of work and the value of retirement compensation packages. For all of these reasons, there is a natural relationship between absolute performance and turnover in a matching framework.

Explicitly considering the outside options of both managers and firms in this matching 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. However, even in data generated by the model, quite reasonable theoretical definitions of quits and firings would imply that for a significant 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 document this ambiguity in the context of two specific definitions of quits vs. fires in Appendix A. We also note that in our model, characteristics of and outcomes under the replacement manager contain information about the cause of the separation with the incumbent, and may be used to better classify these separations.

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14 Giannetti (2011) presents a model where compensation is designed to incentivize managers to invest in firm-specific skills.
Next, we examine the role of fixed costs such as the loss of firm-specific skills in generating what appears to be RPE. Consider the termination decision of a single firm in Eq. (3). If the firm chooses any manager besides the incumbent, it must pay a fixed deadweight cost \( d \). Thus, the firm’s profits under a new CEO must exceed profits under the incumbent by at least \( d \) in order for the firm to find it optimal to replace them. The fixed cost leads to a threshold for performance by the incumbent below which they will be terminated.\(^{15}\) Thus, fixed costs will imply that each firm’s decision rule will exhibit a threshold rule. To generate the empirically relevant industry-level termination rule (namely, firing below a performance threshold) by aggregating the effects of firm-level threshold rules, it must be that the poorest performing firms’ gains from firing their manager exceed their threshold, while the better performing firms display inaction. If this is the case, the industry will display what appears to be relative performance evaluation even though there are no agency or private information problems.

In a competitive assignment model, the payoff to replacement depends both on firm and manager characteristics as well as equilibrium prices. In the next section we develop an economy which displays firings at the bottom, and we show the role of equilibrium wage effects on turnover decisions.

2.2. Two-industry economy

In this section, we consider CEO turnover in a two-industry competitive assignment equilibrium economy in order to pin down managerial and firm outside options within the model.

We extend the standard competitive assignment model in two ways.\(^{16}\) First, we consider managers with multidimensional skills and firms with multidimensional skill weights. Second, we consider the equilibrium in an economy in which managers’ outside options may be outside their current industry, in a competing industry where matching is also determined via competitive assignment. In fact, we believe we are the first to develop a competitive assignment model with two industries, or markets, although the two-market setup might be useful for modeling marriage markets, general labor markets, or real estate markets as well. Although we will assume that firm-specific skill and general skills (and skill weights) are perfectly correlated, the presence of two distinct general skills will be key to our model and results. The additional dimension to general skills is essential both to defining an industry and to defining the shock that drives reallocation across industries. We make stark stylized assumptions, in particular for the distributions of skill levels and weights. By doing so, we are able to generate equilibrium results for the effects of absolute and relative performance, and for the type, pay, and performance of incumbent and replacement managers.

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. 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 Tervio (2008) 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. All firms have capital stocks equal to one. There are measure one of firms in each industry, and measure one of each type of manager. There will be no unemployment or unfilled vacancies. Skill levels and weights have three components, namely, firm-specific skills, sales-growth skills, and cost-cutting skills, respectively. As in Section 2.1, there are sales-growth and cost-cutting managers, \( x \) and \( z \), respectively. We discuss sales growth and cost cutting as our two general skills because demand for these skills naturally changes 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.

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. Similarly, since a majority of transitions are internal promotions, one might alternatively consider managers in industry B to be other officers of the firm and the firm-specific skill to be firm-specific skill only acquired when CEO.\(^{17}\) The fact that skill

\(^{15}\) See Stokey (2009) and the references therein. Taylor (2010) provides a quantitative model of the effects of fixed costs on turnover rates. In general, in a dynamic model fixed costs will also lead to real option effects on the decision to replace managers, as in McDonald and Siegel (1986).


\(^{17}\) To fully analyze the model equilibrium in this case, one must consider that the firm will internalize the impact of its hiring and firing
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 CEOs, or that individual divisions are smaller than firms. Note that considering a less productive 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 CEOs from departing. In practice, firms can draw from multiple industries and executive levels when choosing their replacements. Since we have only one replacement pool, and since replacements can only be drawn away from jobs in which their skills have lower values, we specify that productivity in industry B is everywhere lower than that in industry A. This ensures that even the lowest productivity firms in industry A have available replacement managers.

Table 1 contains the skill weights for managers and firms at dates zero and one. These skill weights and levels for firms and managers are given as follows: Type $x$ managers are sales-growing managers. They have firm-specific skills $\alpha_x^0$ distributed uniformly between one and three if they work at their incumbent firm in industry A. Type $x$ managers have sales-growth skills distributed uniformly between zero and two, and have zero cost-cutting skills. Thus, for managers of type $x$, we have firm-specific skills

$$\alpha_x^0 \sim U(1,3),$$

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

$$\alpha_x^1 \sim U(0,2),$$

and cost-cutting skill $\alpha_x^2 = 0$. Type $z$ managers are cost-cutting managers. They have firm-specific skills $\alpha_z^0$ 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 skill. Thus, for type $z$ managers we have

$$\alpha_z^2 \sim U(0,2),$$

$$\alpha_z^0 = 0, \text{ and } \alpha_z^1 = 0.$$  

Again, firm-level productivity will be given by the inner product of managerial skill levels and firm skill weights, and output will equal this productivity level times the capital stock of one unit. 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:

$$\theta_A^0 \sim U(1,3), \quad \theta_A^1 \sim U(1,3) \quad \text{and} \quad \theta_A^2 = 0,$$

where the numbering follows that of managers. We assume that $\theta_A^0$ and $\theta_A^1$ 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 be 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:

$$\theta_B^0 = 0, \quad \theta_B^1 \sim U(0,\frac{1}{2}) \quad \text{and} \quad \theta_B^2 \sim U(0,\frac{1}{2}).$$

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, all type $x$ managers 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 $\alpha_x^0 > 0$ 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 \( n \in \{1,2\} \), \( a_k[y] \) gives the ability level of the \( j \)-th type \( y \) manager along skill dimension \( n \). The derivative of the inverse distribution describes how fast skill levels increase with manager index, and satisfies \( a_{y}^n[i] \geq 0 \). 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 (SC) 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 (PC) 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 employ sales-growth, type \( x \) managers, where boldface type is used to denote vectors:

\[
V(a^x[i],\theta^x[i]) - w^x[i] \geq V(a^x[k],\theta^x[i]) - w^x[k] \quad \forall i, j, k \in [0,1] \quad SC^x(i,j),
\]

Taking the limit as \( \epsilon \to 0 \) yields the slope of wages as firm index increases. This equation also shows that in equilibrium, output will increase weakly faster in firm index than wages will. In Section 2.3, we discuss how this affects incentives for turnover at the top and bottom of the firm productivity distribution in competitive assignment equilibria.

Integrating, and adding the binding participation constraint yields the wage profile, or wages as a function of firm index and managerial type:

\[
w^x[i] = w^0 + \int_{0}^{i} V_a(a^x[j],\theta^x[j]) \cdot \theta^x[j] \, dj. \tag{11}
\]

Thus, wages and profits are such that, at any given point in the distribution of skill levels or weights, the increase in output is shared between the CEO and the firm in proportion to their relative contribution to the increase.

**Definition 1.** A competitive assignment equilibrium is given by, for each date:

(i) wages and profits as a function of managerial and firm indices, and

(ii) an assignment of type \( x \) and \( z \) managers to firms in industries A and B, such that

(a) the assignment satisfies the sorting and participation constraints in (6)–(9), and analogous constraints for industry A firms employing type \( z \) managers and for industry B firms, given wages and profits, and

(b) at date zero, wages and profits are given by (11) and (12), and their type \( z \) analogues, respectively.

An analogous condition to (11) which incorporates binding cross-industry sorting constraints yields wages at date one and profits are computed as the residual from output less wages.

We begin by computing equilibrium allocations at date zero. Appendix B provides the details for computing output, wages, and profits. Table 2 contains output and wages at dates 0 and 1.

To illustrate the allocations in industry A at time 0, take for example, firm \( 4 \) who is matched with manager \( z \). 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. Fig. 1 plots output, wages, and profits in industries A (top panel) and B (bottom panel). This figure displays how output increases with firm index as skill

\[\text{Footnote 18:} \text{ Firm-specific skills are unpriced and have a wage of zero at date zero. Thus, one can take the limit only over the part of V which comes from general skills, and then add the output and profits from general skills separately.}\]
### Table 2
Output and wages in two-industry economy.

This table shows output and wages in industries A and B at dates 0 and 1, as a function of the firm index $i$.

<table>
<thead>
<tr>
<th>Date 0</th>
<th>Industry A</th>
<th>Industry B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Output: $1 + 6i + 8i^2$</td>
<td>Wages: $2i + 2i^2$</td>
</tr>
<tr>
<td>Date 1</td>
<td>Industry A</td>
<td>Industry B</td>
</tr>
<tr>
<td>Firm index</td>
<td>Output</td>
<td>Wages</td>
</tr>
<tr>
<td>$i \leq [i_A^*]$</td>
<td>$(1 + 2i)(1 + 2i)$</td>
<td>$\frac{1}{2} + \frac{1}{2}i + 2i^2 + 2i$</td>
</tr>
<tr>
<td>$i \in [i_A^<em>, i_B^</em>]$</td>
<td>$(1 + 2i)(1 + 2i)$</td>
<td>$\frac{1}{2}(i^2 - \frac{1}{2}i + i + 2i^2)$</td>
</tr>
<tr>
<td>$i \in [i_B^*, 1]$</td>
<td>$(1 + 2i)(1 + 2i)$</td>
<td>$-\frac{1}{2} + i + i - i^2 + 2i$</td>
</tr>
</tbody>
</table>

**Fig. 1.** Two-industry economy: output, wages, and profits in industries A and B at times 0 and 1. Industry A, time 0: Type $x$ sales growers are allocated assortatively to firms. Industry A, time 1: Firms with indices below $i_A^*$ fire their incumbent sales grower and replace them with the top cost cutters from industry B with indices $i_B^*, i_B^*$. Industry B, time 0: Type $z$ cost cutters are allocated assortatively to firms. Industry B, time 1: Firms with indices below $2i_A^*$ employ sales growers and cost cutters with indices below $i_A^*$. Firms with indices above $2i_A^*$ employ cost cutters with indices $i_B^*, i_B^*$. 

---

weights and managerial ability increase. Output from general skill is split between firms and managers according to their relative contributions. Since managerial talent increases faster than firm productivity, in industry A managers’ share of output from general skill is higher (and increases faster) than firms’ share. However, firms’ share of total output is higher and increases faster with firm index than managers’ share due to the contribution to output from unpriced, firm-specific skill. By contrast, in industry B, all increases in output are shared equally between managers and firms.

At the beginning of date 1, industry A experiences a shock to firm skills. 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 shock in which the weights on sales growth and cost cutting in industry A, \( \theta^A_1 \) and \( \theta^A_2 \), exchange values. Thus, \( \theta^A_1 \) becomes zero for all firms, and \( \theta^A_2 \) becomes positive. After the shock, the weight on cost cutting in industry A is distributed uniformly across firms between one and three, and is increasing in firm index. Weights in industry B do not change. Output immediately declines in industry A due to the match-quality shock, which shifts firms’ skill weights to skills which their managers do not possess. Firms’ demand for the skill newly valuable in the changed environment drives managerial turnover.

The managerial reallocation which results from the shock to skill weights in industry A 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 \( i^*_A \). This index identifies the firm which is just indifferent between hiring the best cost cutter from industry B, and retaining the less talented sales grower which they are currently assigned. Firms below the threshold \( i^*_A \) will prefer to fire their sales-growth managers and hire cost cutters since they can attract more 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 \( i^*_A = 1 - i^*_B \). 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. Fig. 2 describes the turnover and reallocation of managers in industries A and B.

We solve for the competitive assignment equilibrium at date 1 as follows: First, we guess that there is an industry-level threshold rule for managerial performance below which managers are terminated and replaced. Conditional on this rule, we compute equilibrium wages and output using the binding within or across industry sorting constraints. We then solve for the threshold \( i^*_A \), and verify that we have found an equilibrium. Table 2 displays the resulting output and wages. Additional details are contained in Appendix C.

We organize our main empirical implications into two categories, match dissolution, and match formation. We examine these implications empirically in Section 4. The equilibrium of the two-industry competitive-assignment economy displays the following properties at date 1 after the reallocative shock to skill weights:


---

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 \( i^*_A > i^*_B \), similar conditions would hold with mixing in industry B of managers of both types up to the managers with index \( i^*_B \).
3. Match formation, Replacement type: Replacement managers for managers terminated after the shock are drawn from outside of industry A.
4. Match formation, Performance: Output increases at firms in which incumbents are fired and replaced by industry outsiders, and decreases at firms where the incumbents are retained.
5. Match formation, Compensation: The pay of managers brought in to replace fired industry A managers will exceed that of the replaced or retained incumbents.

These results, illustrated in Fig. 1, are directly implied by the solution to the model, however, for completeness, we include the relevant calculations in Appendix D. In particular, as the figure shows, at the bottom of industry A, the firms which were the poorest performers at date zero actually have higher output and profits after the industry-level negative shock to match quality. This is because they can attract the high-talent cost-cutting managers from the less productive industry B. They do not have to compete with the better firms in industry A since the potential loss of firm-specific skill prevents those firms from replacing their managers. Note also that these outside replacements become the highest paid managers in the entire industry, although they do not work at the best firms. This is because they are hired for, and produce output with, their general, market-priced skill.

The intuition for these five main results is as follows: When a shock to manager-firm match quality arrives, 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 sourced from 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 manager 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 managers will have the desired general skills optimal for the new industry conditions, performance will improve under these new replacements. In the next subsection, we provide examples which illustrate in detail the forces for and against observing an industry-level threshold rule for firings in a competitive assignment model, and we discuss the limitations of our theoretical approach.

2.3. Discussion of the theoretical framework

The model we constructed is stylized, but we argue that it captures relevant empirical drivers of managerial turnover. Despite the assumptions we have made in order to solve the model, there are sufficiently many forces at work to make it difficult to construct simple necessary or sufficient conditions for our main results. However, it is useful to consider a couple of further simplifications in order to understand what is required for the industry to terminate below a performance threshold, and to therefore exhibit what appears to be RPE.

Consider first a two-date economy like that in Section 2.2, but in which only firm-specific skill weights vary. There is an infinitely elastic supply of each of the two manager types, all with an outside option of \( w \). Any manager at an incumbent firm has \( a_0 = 1 \) and zero otherwise. All sales growers (type \( x \)) have \( a^+_1 = 1 \), and \( a^+_2 = 0 \). All cost cutters (type \( z \)) have \( a^-_1 = 0 \), and \( a^-_2 = 1 \). In this partial equilibrium setting, we can consider a single industry in which wages are fixed at \( w \). Firms have date-zero skill weights as follows:

\[
\theta_0 \sim U(0,2), \quad \theta_1 = 1 \quad \text{and} \quad \theta_2 = 0.
\]

Output at date zero is \( 2i + 1 \), wages are \( w \), and profits are \( 2i + 1 - w \). At date one, a shock to skill weights changes firms’ skill weights to weight cost cutting instead of sales growth as follows:

\[
\theta_0 \sim U(0,2), \quad \theta_1 = 0 \quad \text{and} \quad \theta_2 = 1.
\]

For firms which retain their managers, output is \( 2i \), wages are \( w \), and profits are \( 2i - w \). For firms which fire their managers, output is \( 1 \), wages are \( w \), and profits are \( 1 - w \). Thus, firms will fire their managers if \( 2i < 1 \). All firms below \( i^* = \frac{1}{2} \) will fire their manager. Thus, the economy in which only firm-specific skill weights increase with firm index exhibits an industry performance threshold below which termination occurs. Intuitively, firm-specific skill acts as a fixed cost to termination which increases with firm productivity. All other costs and benefits are equal across firms.

Consider next a two-date economy like that in Section 2.2, but in which only general firm skill weights vary. Managerial skill weights are the same as in the previous example, and again, there is an infinitely elastic supply of managers of each type with outside options of \( w \). Firms have date-zero skill weights as follows:

\[
\theta_0 = 1, \quad \theta_1 \sim U(0,2) \quad \text{and} \quad \theta_2 = 0.
\]

Output at date zero is \( 1 + 2i \), wages are \( w \), and profits are \( 1 + 2i - w \). At date one, a shock to skill weights changes firms’ skill weights to weight cost cutting instead of sales growth as follows:

\[
\theta_0 = 1, \quad \theta_1 = 0 \quad \text{and} \quad \theta_2 = \sim U(0,2).
\]

For firms which retain their managers, output is \( 1 \), wages are \( w \), and profits are \( 1 - w \). For firms which fire their managers, output is \( 2i \), wages are \( w \), and profits are \( 2i - w \). Thus, firms will fire their managers if \( 2i > 1 \). All firms above \( i^* = 0.5 \) will fire their manager. Thus, the economy in which only general skill weights increase with firm index exhibits an industry performance threshold above which termination occurs. Intuitively, the benefit to replacing one’s manager increases with firm productivity, while the cost is fixed.
Combining the intuition from these two simple examples illustrates how, ceteris paribus, variation in firm-specific skill weights helps to yield the empirically relevant threshold rule, whereas variation in general skill weights leads to pressure for firings at the top of the distribution. This is because higher general skill weights induce a higher benefit to reallocation, and more productive firms have higher weights. By contrast, higher specific skill weights induce a higher cost to reallocation, and again, more productive firms have higher weights. Thus, if the weights of both skills vary, the firm-specific skill needs to be important enough, and to increase quickly enough, to outweigh the effects of the variation in general skill. Note that we do not need perfect correlation between firm-specific and general skill weights. In fact, one can construct an economy which generates our results but in which the weights on firm-specific skills and general skills are perfectly negatively correlated. What is key is that firm-specific skills are important enough such that the most productive firms have the highest ability to deploy firm-specific skill. If these firms’ output were to depend less on general skill, this would actually alleviate their incentive to terminate their manager and make it more likely for them to choose inaction.

The competitive assignment model in Section 2.2 also adds the effect of equilibrium price variation. The effects of equilibrium prices on the decision to fire one’s manager in the competitive assignment model (if anything) generate additional pressure for firings at the top of the distribution. This is because for variation in wages to induce more productive firms to retain their managers, the increase in wages as ability increased would have to be greater than the increase in output. In other words, it would need to be the case that wages increase faster with firm index than output does, so that incremental output was more expensive for more productive firms. This cannot be the case, as one can see from Eq. (10), which combines consecutive sorting constraints to generate the slope of wages. This equation states that the increase in output as one considers more able managers must always weakly exceed the increase in wages. Otherwise, the sorting constraints will be violated. Thus, in any competitive assignment equilibrium, the effect of firm index on output relative to wages will, if anything, exert a force which makes the desire to replace one’s manager higher for the top firms. The fact that there is pressure for the more productive firms to fire their managers may not be surprising since in a competitive assignment model with assortative matching, the benefit to having the right person is larger for the top firms.

We argue that the assumptions needed in our model in order to produce termination below an industry threshold are plausible. Basically, the fixed costs that prevent turnover must be higher for better performing firms. We model these fixed costs as the loss of firm-specific skills. Then, we need two things from these firm-specific skills. First, they have to be relatively important contributors to firm output. This seems reasonable since the vast majority of CEOs come from within the firm, indicating the importance of firm-specific skill. Second, a certain level of firm-specific skill must produce more output at larger firms than at smaller firms. In our two-industry economy, firm-specific skill weights increase with firm index at the same rate as general-skill weights, but are larger contributors to output by a fixed amount. This is consistent with most CEOs being firm insiders and with firm productivity being a single value which then multiplies industry weights on firm-specific and general skills. Moreover, in practice, other fixed costs such as foregone output during the transition may be also higher for more productive firms.

Note also that perhaps the simplest way of considering managerial reallocation in the standard competitive assignment model with one industry and one dimension of ability would lead to counterfactual results for turnover. If one considered an industry in equilibrium, and then shocked a random fraction of firms’ sizes, these firms would have poor performance, and would experience managerial turnover. However, their managers would quit. Moreover, without costs of separation, the entire industry would reallocate their managers. One could generate firings by shocking managerial ability, however, an industry-level shock to overall ability might be hard to interpret.

In the model, the shock which drives turnover is a match-depreciation shock. Importantly, any shock that reduces weights on incumbents’ skills will depreciate matches and will lead to a reduction in current output absent managerial replacement. Thus, the model displays a natural asymmetry between positive and negative performance. This is because productivity declines whenever firms’ skill demands are no longer compatible with their CEO’s skill set. Perhaps counterintuitively, this includes shocks which change the weights from cost cutting to sales growth. The reason that one intuitively does not expect an industry which switches from cost cutting to sales growth to experience a decline in output, is because this type of match-quality shock is likely to coincide with a positive overall demand shock. Moreover, our one-period model is best able to generate predictions for flow variables such as output, rather than stock variables which incorporate future cash flows, such as value.

In our model, we do not consider level shifts in productivity or demand, which would be indicated by increases or decreases in the vector of skill weights \( \theta \) (i.e., weights \( \theta_0, \theta_1 \), and \( \theta_2 \), either all increase, or all decrease). These level demand shifts, however, certainly occur in the data and in many situations have opposing effects on firm value to those of the match-depreciation shocks that are the focus of the model. This will bias the empirical tests against finding support for the model. Ideally, in our empirical work we would identify match-depreciation shocks that are unaccompanied by other events, such as an increase or decrease in demand, and study the model-implied effects of these shocks on CEO turnover and firm outcomes. Unfortunately, it is impossible to unambiguously characterize that an industry is undergoing a match-depreciation shock only, and no other type of change. In particular, the problematic cases are those where match-depreciation shocks coincide with increases in overall demand, because the combination of these two events will have ambiguous effects on productivity. Nonetheless, by focusing on events where the industry productivity is lower than in the past, we are likely to be capturing events in which demand shifts are, if anything, negative and
mimic the effects of match depreciation. Since the natural life cycle of industries is one of growth and then consolidation, considering match-depreciation shocks which coincide with decreases in overall demand will include most industry changes. Note, however, that observing a negative shock in industry productivity could also indicate simply a drop in demand, and may not be accompanied by a match-depreciation shock as we have in mind in the model. Hence, this will bias downward the estimates of the effects of the match-depreciation shock on the likelihood of firings and outside industry replacements, and on changes in CEO pay and firm performance around the time of these shocks.

Although difficult to systematically identify in the data, there are, however, several well-known examples of turnover events which appear to be related to shocks which depreciate matches but indicate an increase in overall demand. A prototypical example of a shock which was good but did lead to turnover in the computer industry is the case of IBM in 1993. In the early 1990s with the rise of the Internet, a good demand shock came to computing, but it was bad news for firms with current matches geared towards the old technology. IBM was performing poorly and replaced John F. Akers (a 33-year IBM veteran) with Lou Gerstner. Gerstner was an industry outsider from RJR Nabisco and American Express who is credited with changing the focus and culture of IBM away from personal computing and toward IT services, which he knew were crucial inputs to the large corporations in which he had gained his experience. Such restructuring shocks are good news in the long run and for new firms, but potentially bad news for managers with outdated skill sets. Similarly, Kodak replaced its manager Kay Whitmore with the former CEO of Motorola, George M.C. Fisher. At the time, digital photography was taking off (good news for overall demand) but older firms like Kodak were suffering and needed to change tack. Recent examples of CEO turnover at ailing firms in thriving industries include former Google executive Marissa Mayer becoming the CEO of Yahoo, low-end retailer JCPenney hiring former Apple Senior Vice-President of Retailing Ron Johnson, and Hewlett-Packard (HP) hiring former eBay CEO Meg Whitman. Some Internet companies are doing great, but the landscape has changed since Yahoo was founded. Similarly, some discount retailers are thriving, but JCPenney’s strategy was deemed outdated. Finally, Apple has energized the personal computing industry and HP has yet to catch up.

3. Data

We use three main sources of data: Execucomp for the name and compensation of the CEOs of 2,779 publicly traded companies during 1992–2006, Center for Research on Securities Prices (CRSP)/Compustat for stock returns and accounting data, and Factiva for news stories published in a three-year window around CEO departures. The Factiva data contain information about the reason why a CEO left and where the replacement CEO came from.20

We identify instances where a CEO was replaced based on whether the same individual has the CEO title (i.e., 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 \( t \). Table 3 presents summary statistics for these events. We find that of all 2,113 CEO departures in our sample, 29.25% are the result of a planned retirement decision, 15.52% of replacements are instances in which the incumbent CEO was forced out, and the remaining 55.23% are cases that do not clearly fit into either of these two categories and thus we label them unclassified departures. Similar to Jenter and Kanaan (forthcoming), and building on the procedure proposed by Parrino (1997), CEO departures were classified as planned retirements if they were announced at least six months before the succession, or caused by a well-specified health problem. Instances where the press reported that the CEO was fired or left the company due to policy differences with, or pressure from, the board or from shareholders, were classified as forced-out departures. All other events (e.g., unexpected retirements, the acceptance of another position, vaguely described health problems) were labeled unclassified departures, as it is not possible to separate whether the firm or the incumbent CEO initiated the separation. As noted in the general theoretical framework presented in Section 2.1, in a competitive assignment environment it is natural to find turnover events that cannot be clearly defined as firings or quits, since in many instances both parties are better off by dissolving the current match.

We categorize CEO replacement types as either from inside the company, from outside the company but inside the industry, or from outside the industry, by manually looking up the firms from which the new CEOs arrive. The industries to which these firms belong are found by using Compustat in the case of publicly traded enterprises, and the Hoovers database and Vault.com in the case of privately held ones. As Table 3 shows, of all CEO replacements, 70.75% are company insiders, 8.19% are company outsiders from the same industry, and 21.06% are industry outsiders. Here and throughout the rest of the analysis, we categorize firms using the Fama-French 48-industry classification scheme, but we obtain similar results if we use the two-digit Standard Industrial Classification (SIC) system.21

(footnote continued)

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 (forthcoming) data set, 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 (forthcoming) data.

21 Our CEO turnover data-set is posted electronically on our research Web sites.

20 We are also grateful to Dirk Jenter for sharing the data from Jenter and Kanaan (forthcoming) regarding whether or not a CEO was forced
Nonetheless, we checked for firms covered by Execucomp how correlated the correlation coefficient is 0.996. We base our proxy for the occurrence of an industry skill-weights shock, we use an indicator variable (IndustryROABelowTrendi) equal to one if the average profitability in the industry during the preceding three years is below its value during the preceding 10 years. We measure industry profitability as the average of Earnings before interest and tax (EBIT)/Assets, or return on assets (ROA), across all firms in the industry in a given year. We interpret these drops in industry profitability as a signal that the industry has experienced a match-quality shock. We base our proxy for the occurrence of the shock on ROA because this variable captures industry profitability per unit of capital stock deployed, in line with the setting of the model, where the capital stock is normalized to 1.22 In other words, if a(m)k corresponds to EBIT, then for our firms which have k = 1, a(m) corresponds to EBIT/Assets. When a shock to θ weights changes a(m), this shock then corresponds empirically to a decline in EBIT/Assets. Prior empirical work (e.g., Parrino, 1997) has used ROA as a measure of productivity that is not confounded by effects related to the firms’ capital structure or by market expectations about future outcomes. That being said, this is a noisy proxy for identifying skill-weights shocks, because, as discussed in Section 2.3, the industry ROA may also fall below trend due to demand shocks which are outside of our model and difficult to identify empirically. Hence, this biases the data analysis against finding support for the model.

### Table 3
Summary statistics for CEO turnover.

Turnover events are identified using Execucomp data for years 1992–2006. The resulting 2113 departures are labeled as forced out, unclassified, or due to retirement, and replacements as from inside the company, outside the company but inside the industry, or from outside the industry, as described in Section 3. The presence of an industry skill-weights shock in a given year is identified by whether the average industry ROA (specifically, EBIT/Assets) in the preceding three years is below the average in the preceding 10 years.

<table>
<thead>
<tr>
<th>Departure type</th>
<th>Forced out</th>
<th>Unclassified</th>
<th>Retirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>If industry skill-weights shock</td>
<td>15.52%</td>
<td>55.23%</td>
<td>29.25%</td>
</tr>
<tr>
<td>If no industry skill-weights shock</td>
<td>15.93%</td>
<td>57.29%</td>
<td>26.78%</td>
</tr>
<tr>
<td></td>
<td>15.01%</td>
<td>32.63%</td>
<td>32.37%</td>
</tr>
<tr>
<td>Replacement type</td>
<td>Company insider</td>
<td>Company outsider &amp; industry insider</td>
<td>Industry outsider</td>
</tr>
<tr>
<td>Overall</td>
<td>70.75%</td>
<td>8.19%</td>
<td>21.06%</td>
</tr>
<tr>
<td>After forced-out turnover</td>
<td>58.54%</td>
<td>11.89%</td>
<td>29.57%</td>
</tr>
<tr>
<td>After unclassified turnover</td>
<td>70.35%</td>
<td>8.23%</td>
<td>21.42%</td>
</tr>
<tr>
<td>After retirement turnover</td>
<td>77.99%</td>
<td>6.15%</td>
<td>15.86%</td>
</tr>
<tr>
<td>If industry skill-weights shock</td>
<td>70.34%</td>
<td>7.88%</td>
<td>21.78%</td>
</tr>
<tr>
<td>If no industry skill-weights shock</td>
<td>71.28%</td>
<td>8.57%</td>
<td>20.15%</td>
</tr>
</tbody>
</table>

As our empirical proxy for the occurrence of an industry skill-weights shock, we use an indicator variable (IndustryROABelowTrendi) equal to one if the average profitability in the industry during the preceding three years is below its value during the preceding 10 years. We measure industry profitability as the average of Earnings before interest and tax (EBIT)/Assets, or return on assets (ROA), across all firms in the industry in a given year. We interpret these drops in industry profitability as a signal that the industry has experienced a match-quality shock.

In the next section, we test our predictions regarding the importance of industry skill-weights shocks for match dissolution, match formation, firm performance, and CEO wages.

### 4. Empirical results

#### 4.1. Match dissolution: absolute and relative performance effects

As a first indication that forced CEO turnover depends on industry conditions, we observe that in our data, firings are relatively concentrated in certain industries and years. Specifically, 50% of all forced-turnover events occur in just seven industries (Business Services, Computers, Retail, Utilities, Chips, Machinery, and Drugs), while 35% of firings are accounted for by 5% of the industry-year bins in the sample. Consistent with the prediction that more forced turnover will be observed if an industry suffers from a shock to match quality, Table 3 shows that, conditional on the incumbent CEO being replaced, the likelihood that his/her departure is a firing is higher at the time of such a shock in the industry, relative to other times (15.93% vs. 15.01%, respectively).

To further investigate the role of industry match-quality shocks on the likelihood of forced CEO turnover, in the left panel of Table 4 we estimate a multinomial logit model for the CEO departure type. The dependent variable is categorical and can have four values, indicating whether in particular firm: there was no CEO change between years t and t - 1, the CEO in place in year t was fired and a new CEO took over in year t + 1, the CEO in place in year t retired and a new CEO took over in year t + 1, and the CEO in place in year t left for unknown reasons (potentially quit) and in year t + 1 a new CEO took over.23 The right-hand side variables of

---

22 Technically, (EBIT + CEO Wage)/Assets best corresponds to our measure of industry output per unit of capital stock. However, we do not know the CEO wage for the vast majority of firms in the industry, since Execucomp only covers a relatively small fraction of the universe of publicly traded firms. Hence, we are limited to using EBIT/Assets. Nonetheless, we checked for firms covered by Execucomp how correlated EBIT/Assets is with (EBIT + CEO wage)/Assets, and, reassuringly, we found that the correlation coefficient is 0.996.

23 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
interest include firm relative to industry performance, as well as industry performance, measured as stock returns or ROA, and the indicator variable \( \text{IndustryROABelowTrend}_t \), which is our proxy for the occurrence of an industry skill-weights shock. As controls, the model includes industry and year fixed effects, firm size measured as the natural log of the firm assets, and the age of the incumbent CEO.

We find that firings are significantly \( p < 0.01 \) 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 empirical literature on the role of relative performance on turnover and as predicted by our model, and if the industry-wide stock returns are low, in line with the findings of Jenter and Kanaan (forthcoming). An increase of 1% in firm performance relative to the industry, measured as either stock returns or ROA, leads to a decrease in the odds of firings relative to no turnover.

Footnote continued)
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; Kaplan and Minton, 2006; Jenter and Kanaan, forthcoming). The evidence in these papers, and in our own data, indicates that relative performance is an important determinant of whether a CEO is replaced.
(i.e., \(P(\text{firing})/P(\text{no turnover})\)) of 2.28% and 2.17%, respectively. An increase of 1% in the industry stock return leads to a 1.35% drop in the odds of firings relative to no turnover. Furthermore, we find that our indicator measure for the occurrence of an industry skill-weights shock is significant (\(p < 0.05\)) and positive predictor of the likelihood of observing forced turnovers. Specifically, the estimated coefficient on the variable IndustryROABelowTrend, in the multinomial logit model (i.e., 0.40) indicates that the occurrence of unusually low productivity in the industry leads to a 48.97% increase in the odds that forced turnover will occur relative to there being no turnover. Using only the summary statistics from Table 3, a simple calculation shows that the increase in the odds of firings relative to no turnover due to the occurrence of an industry shock is 23%, a smaller figure than that obtained in the multivariate analysis in Table 4, indicating the importance of firm, year, and industry controls in the estimation of these effects.

In light of the model, when we examine events that are firings and those that refer to unclassified turnover or retirements, we should observe differences with respect to the effect of firm and industry performance on the likelihood of these two types of separations. In fact, we see such differences. For example, the effect of firm relative to industry stock return or return on assets on the likelihood of a separation from the CEO is higher when separation is a firing, than when it is an unclassified turnover or a retirement event. Also, the industry match-quality shock indicator is a significant predictor of firings only, and has no effect on the probability of potential quits or retirements. These empirical patterns are direct implications of our model, which predicts that firings are the type of CEO replacements that are specifically linked to firm and industry performance.

Finally, the results in Table 4 show that the control variables included in the estimation are relevant. Older CEOs are significantly more likely to either retire or leave for unknown reasons, but the likelihood of being fired relative to continuing as a CEO does not depend on the executive’s age. Retirements and firings are more likely to occur in larger firms.

4.2. Match formation: replacement type

The summary statistics in the bottom panel of Table 3 show that replacements by industry outsiders are more likely to occur in industries that have experienced below-trend productivity, and to follow the firing of incumbent CEOs, as predicted by the model. Specifically, we find that the frequency of hiring industry outsiders, conditional on there being turnover, is 21.78% following the likely occurrence of industry match-quality shocks (as captured by our below-trend ROA indicator), and 20.15% at other times. Moreover, following the firing of incumbent CEOs, in 29.57% of cases an industry outsider is brought in, but the frequency of such appointments is much lower following either retirements or unclassified turnover (15.86% and 21.42%, respectively). In other words, fired CEOs, relative to any other type of departing executives, are more likely to be replaced with industry outsiders. This finding is in line with, and specific to, our theoretical predictions and cannot be generated by standard RPE or learning models. We check the statistical significance of these differences by estimating a multinomial logit model of the relative likelihood of various types of replacement CEOs as a function of the prior CEO’s departure reason. The results, omitted for brevity, confirm that replacements by industry outsiders are significantly more likely (\(p < 0.01\)) after the prior CEO was forced out, relative to other types of departures of the incumbent. Importantly, however, we also observe that replacements by company outsiders from the same industry, while less prevalent than replacements by industry outsiders, are more common (11.89%) following firings of incumbent CEOs, compared to situations when the incumbents’ departure was either unclassified or a retirement (8.23% and 6.15%, respectively).

To understand whether replacements by industry outsiders specifically, and not by company outsiders in general, occur in accordance to the model predictions, we test the role of industry conditions for the identity of newly hired CEOs. In the right panel of Table 4 we present estimates from a multivariate logit model where the dependent variable is the type of CEO newly hired, namely, a company insider, a company outsider from the same industry, or an industry outsider. These models include as right-hand side controls year fixed effects, industry fixed effects, firm relative to industry stock return and ROA, industry stock return and ROA, firm size, and the age of the incumbent CEO, as well as the variable of interest, which is our proxy for the occurrence of industry match-quality shocks (i.e., the indicator IndustryROABelowTrend). The evidence in the right panel of the table is consistent with the model predictions that an industry skill-weights shock will increase the likelihood of observing a CEO replacement coming from outside of the industry if turnover occurs. Specifically, the occurrence of below-trend productivity in the industry is followed by a significant (\(p < 0.05\)) increase of 80.11% in the odds that the replacement is an industry outsider, relative to being a company outsider from the same industry (i.e., \(P(\text{industry outsider})/P(\text{company outsider & industry insider})\)). The same table shows that the occurrence of industry skill-weights shocks does not significantly change the relative likelihood that the replacement is a company insider relative to being a company outsider from the same industry. In other words, replacements from outside the industry (unlike the other replacements) are the type of new CEO that is specifically related to the occurrence of events indicating industry match-quality shocks, just like firings (unlike other decisions about the incumbent CEO, see the left panel of Table 4) are the type of turnover that is specifically driven by such events, in line with our theoretical predictions.

\footnote{In a multinomial logit model, the parameter estimates represent marginal effects of each right-hand side variable \(k\) on the logarithm of the odds ratio for outcome \(i\) relative to the base (or reference) outcome \(j\). In other words, each parameter \(\beta_{ik}\) measures \(\log(P_i/P_j)/\partial x_k\). A positive parameter \(\beta_{ik}\) indicates that the relative probability of outcome \(j\) increases relative to the probability of outcome \(i\) if the value of the right-hand side variable \(k\) increases.}
null hypothesis that the median residual change in the logarithm of firm assets.\(^{26}\) The figure shows the value of \(\text{ROA}_{t+1} - \text{ROA}_t\) for the sample of outside industry CEO replacements is equal to zero \((p < 0.02)\). A Wilcoxon signed-rank test rejects the null hypothesis that the median residual change in ROA for the sample of outside industry CEO replacements is equal to zero \((p < 0.02)\).

### 4.3. Match formation: performance

The implication of the model regarding firm output is that firms that replace their CEOs with managers from outside the industry following an industry skill-weights shock will experience a significant increase in productivity, unlike the firms in the industry that do not change managers. Fig. 3 presents evidence supporting this prediction.

In the figure we use residual values for the change in each firm’s productivity (i.e., \(\text{ROA}_{t+1} - \text{ROA}_t\)) around the occurrence of industry skill-weights shocks. We obtain these residuals by regressing the annual change in the firm’s ROA on industry fixed effects, year fixed effects, and the logarithm of firm assets.\(^{26}\) The figure shows the value of the median residual productivity change \(\text{ROA}_{t+1} - \text{ROA}_t\) for firm-year observations around the arrival of industry skill-weights shocks (as proxied by the IndustryROABelow-Trend, indicator variable), for four types of observations: where the incumbent CEO stayed on, was replaced by a company insider, by a company outsider from the same industry, or by an industry outsider. Supporting the theoretical prediction, we find that firms where an industry outsider is brought in, including those times when he/she comes from outside the industry, due to accounting manipulations or other factors outside of our model, the firm’s performance under the new CEO may be better than its performance under the replaced CEO.

Alleviating these concerns, Fig. 3 shows that the median residual ROA change around CEO replacements by industry outsiders (i.e., 0.68\%) is significantly greater, at \(p < 0.05\) or better in two-sample Wilcoxon rank-sum tests, than the year-to-year productivity change observed when no turnover occurs (0.22\% median increase in ROA), or when the replacement CEO is a company insider (0.14\% median increase in ROA), or a company outsider from the same industry (0.04\% median increase in ROA). Hence, outside industry replacements following industry skill-weights shocks have a particularly beneficial effect on firm productivity, which is not simply a mean-reversion effect, or an effect that occurs after all CEO turnover events.

### 4.4. Match formation: compensation

However, there are two concerns that need to be addressed before we can interpret this result as evidence for the prediction regarding the performance-improving role of outside industry replacements with the newly required skills. First, it could be that this effect simply captures mean reversion in ROA: that is, firms in industries with unusually low recent ROA may have higher ROA in the future for some mechanical reason, irrespective of which type of CEO is in charge. Second, it could be that every time a new CEO is brought in, including those times when he/she comes from outside the industry, due to accounting manipulations or other factors outside of our model, the firm’s performance under the new CEO may be better than its performance under the replaced CEO.

To account for the known fact that wages increase in firm size, and also to be consistent with the model (where the firm assets are normalized to 1), we examine CEO pay per unit of capital stock, calculated by dividing the value

\(^{26}\) In this analysis of ROA changes, as well as in the analysis conducted to test the model implications regarding changes in CEO turnover, we eliminate the top and bottom 1% of observations in our regressions to lessen the effect of extreme outliers (which are likely due to incorrect entries in Compustat or Execucomp).
of overall pay, namely the TDC1 variable in Execucomp, by the value of firm assets. Our goal is to understand how this assets-adjusted pay changes around times when industry skill-weights shocks occur, particularly when an industry outsider CEO is brought in. Hence, for all firm-year observations corresponding to industry skill-weights shocks, we calculate the year-to-year change in the assets-adjusted pay (i.e., $TDC1_{t+1}/Assets_{t+1} - TDC1_t/Assets_t$). We then regress this change in the normalized pay measure on industry fixed effects, time fixed effects, and the logarithm of firm assets. The residuals in this regression therefore capture the change in CEO pay per unit of capital stock after accounting for heterogeneity in pay changes that occurs for reasons outside of the model. We then use these residuals to test the model's predictions regarding the dynamics of pay after the arrival of industry match-quality shocks, in firms where there is and those where there is not a replacement of the CEO by an industry outsider.

As shown in Fig. 4, we find evidence consistent with the model: median residual pay increases are significantly higher in firms where a CEO from outside of the industry is brought in, relative to other firms when the industry ROA is below trend, our proxy for the occurrence of industry match-quality shocks. Specifically, pay increases by a median value of $0.91 per $1,000 of firm assets, after an industry outsider is hired. This value is significantly higher than zero ($p < 0.01$ in a Wilcoxon signed-rank test), and significantly higher ($p < 0.01$ in two-sample Wilcoxon rank-sum tests) than the median residual increase in assets-adjusted pay experienced by continuing incumbents ($0.04 per $1,000 of firm assets), or by new CEOs from inside the company ($0.02 per $1,000 of firm assets).27

To put this effect in perspective, in the overall sample the median assets-normalized pay is $1.48 per $1,000 of firm assets. We also find that pay increases by $0.8 per $1,000 of firm assets when new CEOs are hired from outside the company, but from the same industry. This increase is lower than that observed in the case of replacements from outside the industry, but the difference is not statistically significant.28

In other words, while the evidence on pay changes is consistent with the model, other factors outside of our theoretical framework seem to matter for CEO compensation. In particular, hiring outsiders in general is followed by significant pay increases. Our model cannot speak to events where industry insiders are hired following industry skill-weights shocks, since such appointments would not occur in equilibrium in our framework, but clearly, these events happen in reality for other reasons.29 That being said, the evidence we have documented here shows that inside industry appointments do not match the data as well as outside industry appointments with respect to their dependence on industry match-quality shocks, or with respect to changes in firm performance around these shocks.

Lastly, we would like to note that there may be firm-specific factors not considered here that could drive CEO compensation or firm productivity. However, the testable implications of the model refer to the changes from year to year in performance or CEO pay within the same firm, around the occurrence of industry skill-weights shocks, and to how these changes depend on the choice to keep or replace the incumbent CEO. Hence, time-invariant firm characteristics omitted from our regressions are not of concern when we interpret the empirical results in the paper. However, an important caveat is that there may be omitted time-varying firm-specific variables that we do not control for, which may happen to coincide with industry skill-weights shocks or with the timing of CEO replacements, and as a result, could influence changes in CEO pay or firm output but are orthogonal to our model.

5. Conclusion

We consider the link between industry conditions and the CEO labor market in the context of a competitive assignment model in which 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 in which 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 understand the dynamics of CEO turnover. Our model has important implications for a large body of the empirical literature on CEO turnover which interprets the effect of poor relative performance on termination decisions as being informative about boards’ monitoring effectiveness. We show that even in the absence of information-asymmetry or agency problems, fixed costs of termination lead to firm-level threshold rules.

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27 We analyzed the distribution of times during the year when new CEOs arrive to see whether there is a systematic bias in the measure of pay of the replaced and the new CEO. Ideally, all new CEOs should be hired in the month of January, so we have the complete 12-month pay of the CEO departing in year $t$, and that of the new CEO hired in January of year $t+1$. The most common month during which new CEOs are hired is in fact January (31.6%). Furthermore, for CEOs joining during the rest of the year, the arrival times are close to uniformly distributed between the months of February and December. We observe the same patterns for events where the new CEO comes from outside the industry. Therefore, the timing of CEO replacements does not lead to a systematic bias in measuring the pay of departing and new CEOs.

28 We obtain results of similar statistical significance and economic magnitude as those shown in Fig. 4 if we repeat this empirical procedure using two alternative measures of CEO pay changes, namely, the percentage annual change in the total pay TDC1, and the change in the natural logarithm of TDC1. Similar results are also obtained if we analyze the difference in pay between year $t+2$ and year $t$ (instead of year $t+1$ and year $t+1$), since pay offered to the new CEO at the time of hiring (year $t+1$) may include special one-time items, such as compensation for unvested benefits at the CEO’s prior workplace.

29 A different literature has focused on modeling inside promotion decisions and understanding successor grooming (e.g., Lazear and Oyer, 2004). In contrast to that literature, studies of relative performance evaluation focus on match dissolution (e.g., forced CEO turnover) and not on match formation, and hence, has been in large part silent regarding the relative importance of inside promotions vs. outside hires.
for firing, which can result in what appears to be relative performance evaluation. Conversely, the fact that industry conditions are not filtered out of the firing decision does not mean that boards act inefficiently. If industry conditions affect the outside options of matched managers and firms, for example by changing the appropriate industry skill sets, such conditions will naturally drive turnover.

We show that our model is consistent with existing empirical findings that are puzzling when interpreted in the context of a principal-agent model, such as the negative relationship between industry performance and the likelihood of forced CEO turnover. Furthermore, the model yields novel predictions which are supported by our empirical evidence. In particular, we document that replacements from outside the industry are the type of new CEOs that are specifically related to the occurrence of forced turnover of the incumbent, or to our empirical proxy for the occurrence of match-quality shocks in the industry. These industry outsiders have a particularly beneficial effect on firm productivity, which is not simply a mean-reversion effect, or one that occurs following other types of appointments. Pay increases are also the highest following the hiring of a CEO from outside the industry.

While our equilibrium model is stylized, it captures empirically relevant drivers of CEO turnover. Considering the fact that industry shocks may drive CEO–firm match quality, and hence the outside options of both managers and firms, may be key to understanding why absolute performance matters for turnover. Considering the role of fixed costs in creating firm-level threshold rules for termination may help to understand the role of performance relative to the industry as a driver of CEO turnover. Several extensions provide opportunities for future work. For example, it would be interesting to consider turnover in a more dynamic framework, and include real-option-like effects in managerial hiring. These effects could have implications for cross-industry turnover rates depending on the nature of shocks across industries. It would also be interesting to consider the tradeoffs between internal and external promotions, for example by incorporating the ideas in Murphy and Zabojnik (2004, 2007). Finally, it would be fruitful to use the general framework we develop to specify an empirical model with which to tease out the hedonic prices of various managerial skills.

Appendix A. Identifying quits vs. fires in a matching framework

We discuss ambiguity in identifying “quits” vs. “fires” in the context of two specific definitions but note that the matching framework permits others. We introduce time subscripts and suppress individual agent subscripts and define a separation as follows:

Definition 2. A separation occurs in the current period when a match satisfies the following two conditions:

Condition 1. \( V_t - V^m_t - V^f_t < 0 \)

and

Condition 2. \( V_{t-1} - V^m_{t-1} - V^f_{t-1} > 0 \).

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). \( V_t - V^m_{t-1} - V^f_t > 0 \)
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 **Condition 1** and Q together simply say that \( V_t^m > V_{t-1}^m \), while **Condition 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 3.** 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 4.** 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 \( V_t^m < V_{t-1}^m \) and requiring a fire to satisfy \( V_t^f > V_{t-1}^f \) and \( V_t^f < V_{t-1}^f \), would lead to even more ambiguous separations.

### Appendix B. Output, wages, and profits: two-industry economy at date 0

**We begin with payoffs in industry A.** To compute output, note that output equals \( \theta_1(i)(a_0(i) + \theta_1(i)\alpha_1(i) + \theta_2(i)\alpha_2(i)) \) and use the distributions for skills and weight to compute output as a function of \( i \). In particular, note that \( \theta_0^2 = 1 + 2i, \alpha_0^2 = 1 + 2i, \theta_1^2 = 1 + 2i, \alpha_1^2 = 2i, \theta_2^2 = 0, \) and \( \alpha_2^2 = 0 \). Thus, output in industry A is given by\n
\[
V^A(i,i) = 1 + 6i + 8i^2.
\]

For wages, note that \( \alpha_1^2[j] = 2j \) so that \( \alpha_1^2[j] = 2j \), and \( \theta_1^2[j] = 1 + 2j \) so since \( w = 0 \), wages are \( j_0^1 \theta_1^2(j)\alpha_1^2[j] \) dj, or \( w^A(i) = 2i + 2i^2 \).

For profits from general skills, note that \( \theta_1^2[j] = 1 + 2j \) so \( \theta_1^2[j] = 2j \) so profits from general skills are \( J_0^1 \theta_1^2(j)\alpha_1^2[j] \) 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**

\[
\theta_0^2(i)(a_0(i) + \theta_1(i)\alpha_1(i) + \theta_2(i)\alpha_2(i)), \quad \text{and in industry B } \theta_0^2 = 0, \alpha_0^2 = 0, \theta_1^2 = \frac{1}{2}i, \alpha_1^2 = \frac{1}{2}i, \alpha_2^2 = 2i \text{. Thus, we have } V^B(i,i) = i^2.\]

For wages, note that \( \alpha_2^2[j] = 2j \) so that \( \alpha_2^2[j] = 2j \), and \( \theta_2^2[j] = j/2 \) so wages are \( J_0^1 \theta_2^2(j)\alpha_2^2[j] \) dj, or \( w^B(i) = \frac{1}{2}i^2 \).

For profits from general skills, note that \( \theta_2^2[j] = j/2 \) so \( \theta_2^2[j] = j/2 \) so profits from general skills are \( J_0^1 \alpha_2^2(j)\theta_2^2[j] \) dj = \( \frac{1}{2}i^2 \). Thus, since there is no weight on or accumulation of firm-specific skill in industry B, profits are \( \pi^B(i) = \frac{1}{2}i^2 \).

### Appendix C. Output, wages, and profits: two-industry economy at 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 \( 2i^2 \). Output is \( \theta_0^2(i)(a_0(i) + \theta_1(i)\alpha_1(i) + \theta_2(i)\alpha_2(i)) \). Note that firm and managerial indices may not coincide after management reallocation across industries even though there is still assortative matching overall. Firms with \( i \in [0,2i^2] \) employ managers with \( j \in [0,i^2] \) of types \( x \) and \( z \). From the distributions for skill weights and ability levels, we have \( \theta_0^2 = \frac{1}{2}i, \alpha_1(i) = i, \) and \( \alpha_2(i) = i \) (due to mixing). Output for firms in industry B with \( i < 2i^2 \) 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,

\[
w^B(i) = J_0^1 \theta_2^2(j)\alpha_2^2[j] \ dj = J_0^1 \frac{1}{2}i \ dj.
\]

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

Firms in industry B with indices \( i > 2i^2 \) employ type \( z \) managers with \( j \in [i^2,2i^2] \). Using the fact that \( \theta_2^2 = \frac{1}{2}i \) and \( \alpha_2^2(j) = 2j \) where \( j = i^2 \), we have that output equals
\( \int^2_{-2} i^2 - i^2 \). For wages, note that within-industry sorting constraints imply that wages must be continuous around firm index \( z_i \) and so the intercept of wages for firms above \( 2i \) is \( w(z_i) \), or \( i z_i \). As in the lower region of industry B, wages at the top of industry B are determined by the binding within-industry sorting constraints, hence:

\[
\begin{align*}
\omega^B(i) &= w(2i) + \int_{2i}^{i} \theta(z_i)\omega^a(2i) \, dz \\
&= w(2i) + \int_{2i}^{i} j \, dz,
\end{align*}
\]

since \( \omega(z_i) = 2 \) at the top of industry B. Therefore, wages are equal to \( \frac{i^2}{2} - i^2 \).

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 indices \( i < z_i \) fire their managers and replace them with managers with indices \( i \in (z_i + c, i) \) from industry B. Output is \( \omega_{x} = \omega_{i} + \omega_{j} + \omega_{j} \omega_{i} + \omega_{j} \omega_{i} \). Since these firms hire cost cutters with no firm-specific skill, this simplifies to \( \theta_{i}(i)\omega_{i}(j) = (1 + 2)(1 + 2) \) with \( j = i - 1 - z_i, \) Thus, output is given by \( (1 + 2)(2i - 2 - 2i) \).

The intercept for wages at the bottom of industry A is
\[
\omega^A(i) = \frac{i^2}{2} - i^2.
\]

For wages, note that within-industry sorting constraints imply 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

\[
\begin{align*}
\omega^A(i) &= w(i) + \int_{0}^{i} \theta(z_i)\omega^a(2i) \, dz \\
&= w(i) + \int_{0}^{i} (1 + 2)j \, dz.
\end{align*}
\]

Hence, wages are equal to \( \frac{i^2}{2} - i^2 \).

Firms in industry A with indices \( i > z_i \) retain their type x managers. Output comes from firm-specific skill only and is equal to \( (1 + 2)(1 + 2) \). 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 \( j < (z_i, i) \) and work at firms \( i \in (z_i, i) \) in industry A. These sales managers earn the same wage as cost-cutting managers with skill index \( j \in (z_i, i) \), who work at the top of industry B (for firms with productivity index between \( z_i \) 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 \( \omega^A(i) = i \).

The binding cross-industry sorting constraints yield the additional wages for firms with higher indices,

\[
\begin{align*}
\omega^A(i) &= \omega^A(i) + \int_{2z_i}^{i} \theta(z_i)\omega^a(2i) \, dz \\
&= \omega^A(i) + \int_{2z_i}^{i} j \, dz.
\end{align*}
\]

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 \( i + z_i \). Skill weights are \( \theta_i(i) = \frac{i}{i} \) 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 \( \frac{i^2}{2} - i^2 + \frac{i}{i} \).

References


