Paying to Make a Difference: Executive Compensation and Product Dynamics

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Abstract

This paper develops an agency model of executive compensation in dynamic industry equilibrium. Firms differ in the quality of their products, and managers can make a difference as higher effort brings about product improvement. I show that there is an inverse relationship between the magnitude of the performance-based component of optimal compensation contracts and the degree of product differentiation, as managerial effort is less likely to make a difference for firms with more differentiated products. Empirically, I find strong evidence of this inverse relationship in the compensation of US executives. In particular, I find that pay-performance sensitivity depends negatively on industry- and firm-level measures of product differentiation, even after controlling for industry fixed effects and standard measures of product market competition. Moreover, industry leaders have weaker pay-performance sensitivity than laggards, even after controlling for firm size. My findings suggest that industry is an important determinant of executive compensation.

1 Introduction

This paper argues that industry forces are of first-order importance in determining executive compensation. I develop an agency model of executive compensation in industry equilibrium where product quality evolves over time as a result of product improvement effort by managers. In a large sample of US executives between 1993 and 2004, I find strong evidence in support of my model. In particular, I document a robust negative relation between pay-performance sensitivity and product differentiation.

The level and incentive structure of executive compensation is a controversial topic that attracts attention of both academic researchers and popular press. The classical view of executive compensation as an agency problem (Holmstrom (1979), Holmstrom and Milgrom (1987)) emphasizes the trade-off between incentives and insurance. According to this view, shareholders can ensure that managers take optimal actions by tying managers' pay to the performance of their firms, that is, by providing high-powered incentives for managers to maximize the returns to shareholders.

However, the empirical literature has found a puzzling lack of evidence of high-powered incentives, which is typically interpreted to imply that managers are not given incentives to maximize the returns to shareholders (see Bebchuk and Fried (2004) for a forceful statement of this view). This paper argues that this "pay without performance" interpretation is not granted. I depart from the assumption of exogenous returns to managerial effort, implicit in standard agency models, and emphasize that the value of managerial effort to shareholders is determined endogenously in industry equilibrium. In this case, I show that the infrequent use of high-powered incentives ceases to be a puzzle: incentives don't always make a difference for shareholders.

My model formalizes the link between executive pay and product differentiation. I introduce a standard principal-agent problem along the lines of Holmstrom (1979) and Holmstrom and Milgrom (1987) into a dynamic industry equilibrium model with differentiated Bertrand competition (e.g., Ericson and Pakes (1995), Maskin and Tirole (2000)). The key feature of the model is that firms are heterogeneous and differ in the quality of their products. Shareholders choose executive compensation, while managers make product market and effort choices. My focus is on characterizing the way the dynamic interaction between competitors affects shareholders' optimal choice of executive compensation. Since industry structure ultimately results from this dynamic interaction between competitors, the model allows for the simultaneous determination of executive compensation and industry structure and its evolution over time.

I willingly refrain from postulating an exogenous benefit or return to managerial effort and think of product improvement and the resulting industry equilibrium as the main source of return to managerial effort. I show that managerial effort makes a difference when it increases future profitability and, ceteris paribus, firm's market share, through product improvement. In this case, I show that there is an inverse relationship between the magnitude of the performance-based component of optimal compensation contracts and the degree of product differentiation. This central prediction of my model follows from the fact that managerial effort is less likely to make a difference for firms with more differentiated products.

I test this prediction empirically in a large panel of US executives between 1993 and 2004. I link two sources of data. My compensation data is from ExecuComp. I use an industry-level measure of product differentiation proposed by Rauch (1999) and widely employed in the empirical literature on international trade and product differentiation (see, for example, Bernard, Jensen, and Schott (2003)). Rauch (1999) classifies 4-digit SITC sectors into two categories. Homogeneous sectors include goods that are internationally traded in organized exchanges, with a well-defined price (e.g., wheat). Differentiated sectors are those sectors that do not satisfy this criterion. I also employ a firm-level measure of product differentiation, the ratio of selling expenses to sales, which has been previously employed, although with a different motivation, in capital structure studies (see Titman (1984), Titman and Wessels (1988)). This measure allows me to proxy for the intensity of managerial effort directed toward product differentiation.

Finally, along the lines of MacKay and Phillips (2005) I build indicators of firm position within an industry since my model also links firm position to pay-performance sensitivity.

Consistent with my industry model of executive compensation, I find strong evidence of an inverse relationship between pay-performance sensitivity and product differentiation. In particular, I find that pay-performance sensitivity depends negatively on industry- and firm-level measures of product differentiation. This finding is robust to controlling for industry fixed effects and standard measures of product market competition such as concentration ratios. Moreover, I find evidence supporting the finer prediction of my model that industry leaders have weaker pay-performance sensitivity than laggards, and document that this relationship holds even after controlling for firm size.

While my study of the link between executive pay and product differentiation within an explicit dynamic industry equilibrium setting is, to the best of our knowledge, novel to corporate finance, there are various important literatures related to my work. Schematically, my work is related to numerous recent contributions which have sought to identify, both theoretically and empirically, the importance of industry to corporate financial (e.g. Bolton and Scharfstein (1990), MacKay and Phillips (2005), Maksimovic and Zechner (1991)) and governance (e.g. Scharfstein (1988), Raith (2003), Aggarwal and Samwick (1999)) decisions. My work also builds on recent developments of structural dynamic oligopoly models to study the evolution of industry structure (e.g. Pakes and McGuire (1994, 2001), Doraszelski and Satterthwaite (2003)). I detail on the most closely related work in these literatures in turn.

My work is related to the corporate finance literature on the relationship between product market competition and managerial incentives. Aggarwal and Samwick (1999) and Kedia (2003) build on earlier theoretical contributions of Fershtman and Judd (1987) and Sklivas (1987) and document that some industry level variables, such as, for example, the Herfindahl index or whether firms compete in strategic complements or substitutes, are determinants of top management compensation. Scharfstein (1988), Schmidt (1997), and Raith (2003) study the link between product market competition and managerial incentives within models of monopolistic competition. The main question in this literature pertains to whether more intense product market competition improves incentives.

My dynamic industry equilibrium setting allows for strategic interaction among heterogeneous oligopolists, hence enriching the set of determinants of cross-sectional differences in executive compensation. It also contributes to the literature on managerial incentives and product market by bringing the theoretical predictions of this class of models closer to the data. While, in fact, attempts to empirically test the predictions of these models have been hampered by the notorious difficulty to find empirical proxies for the intensity of competition, my model links pay-performance sensitivity to a richer set of observable industry- and firm-level characteristics related to product differentiation, such as, for example, position within the industry and status as entrant, incumbent, or exiting firm.

My main argument that the dynamic interaction between competitors enriches the set of cross-sectional determinants of executive pay builds on recent theoretical advances in industrial organization. In particular, I introduce a standard agency model of executive compensation into a dynamic oligopoly setting with differentiated products (Ericson and Pakes (1995), Pakes and McGuire (1994, 2001), Doraszelski and Satterthwaite (2003)). In line with the existing literature (see Besanko and Doraszelski (2004) for a recent example), I pursue a computational approach to the Markov-perfect Nash industry equilibrium (see Maskin and Tirole (1988, 2000)).

The remainder of the paper is organized as follows. Section 2 outlines my industry model of executive compensation. Section 3 introduces my data and tests the model's main prediction of an inverse relationship between the magnitude of the performance-based component of optimal compensation contracts and the degree of product differentiation. Section 4 concludes. Proofs and details on the computation of industry equilibrium are contained in Appendix A and Appendix B respectively.

2 An Industry Model of Executive Compensation

To formalize the link between executive pay and product differentiation I introduce a standard principal-agent problem along the lines of Holmstrom (1979) and Holmstrom and Milgrom (1987) into a dynamic industry equilibrium model with differentiated Bertrand competition. Shareholders, the principal, choose executive compensation, while managers, the agent, make product market and effort choices. The key feature of the model is that, due to learning-by-doing, shareholders value managerial effort since it increases both current and expected future profitability.

In this section I outline my industry model of executive compensation. To ease exposition, I consider an industry without endogenous entry and exit and outline in the Appendix the general model with entry and exit I study through numeric simulations in Section 3. Readers who are more interested in the effect of product differentiation on executive compensation may wish to skim this section and proceed to the empirical analysis in Section 3.

My model is an infinite-horizon dynamic game in an industry that comprises two firms, indexed by $i = \{1, 2\}$. Each firm consists of a risk-neutral principal, which we refer to as the shareholder, and a risk-averse agent, the manager. The shareholder can influence firm profitability only through his choice of executive compensation, as product market and effort decisions are delegated to the manager. Shareholders' discount rate is $(1 + r)^{-1} \in (0, 1)$. Figure 1 summarizes the timing of events within each period.

Firms differ in the quality of their products. Firm i's product quality is indexed by $\omega_i \in \{1, ..., Z\} \equiv \Xi$, which represents the firm's individual state, and $Z < \infty$. The distribution of product qualities, $\omega = (\omega_1, \omega_2) \equiv \Xi^2$, summarizes the state of the industry at each point of time. The model's primitives as well as firm's own state, ω_i, and the state of the industry, ω, are common knowledge. At the beginning of each period, firms learn about the current state, ω. Once the state is realized, shareholders choose executive compensation and, given compensation, managers choose effort and compete in the product market.

There is a standard agency problem as managerial effort is not contractible, i.e., following Grossman and Hart (1986) and Hart and Moore (1990), I assume that shareholders do not have the ability to contract on managers' effort or on his actions in the product market. More precisely, period profits from the product market have three additive components:

$$\Pi = \pi + x + \varepsilon$$

where π represents firm realized profits from the product market, x is managerial effort, and ε is a noise term which is normally distributed with mean 0 and variance σ^2. Denoting by w the financial stake of the manager in the firm, then the manager's payoff is represented by the usual additively separable utility function:

$$Eu(w) - \psi(x)$$

where $\psi(x)$ is the manager's hidden cost of effort function, which I assume to take the simple quadratic form, $\psi(x) = \frac{k}{2}x^2$. Finally, I assume that the manager's attitudes towards risk can be summarized by the following mean-variance preferences:

$$Eu(w) = E(w) - \frac{\gamma}{2}Var(w)$$

where $\gamma > 0$ measures the manager's aversion to risk. Manager's reservation utility is u_0.

The central problem for shareholders is to design a managerial compensation package to motivate the manager to exert effort, without exposing him to too much risk. As is standard in the theoretical literature on executive compensation (e.g. Holmstrom and Milgrom (1987), Hellwig and Schmidt

(2002)), I only consider linear compensation contracts, i.e. contracts that specify the manager's claim as a linear function of the observable outcome:

$$w = s + \alpha\Pi$$

where s is the "base-salary" component of managerial compensation, which is non-performance based, and $\alpha\Pi(\cdot)$ is the performance-based component of managerial compensation, with the "piece-rate," α, representing the pay-performance sensitivity.

Given the probability distribution of ε, shareholders choose executive compensation (through the board of directors, or the compensation committee), $\{s, \alpha\}$, to maximize their expected profits net of wage payments to the manager subject to satisfying the manager's participation and incentive constraints. Governance decisions are rational in the sense that shareholders correctly anticipate the ensuing product market equilibrium. Formally, the shareholders' problem is given by:

$$\max_{s_t, \alpha_t} V_0 = E_0 \sum_{t=0}^{\infty} \beta^t (\Pi - w_t), \qquad s.t.$$

$$\max_{x_t} E_t(w_t) - \frac{\gamma}{2} Var_t(w_t) - \psi(x_t) \geq u_0, \ \forall t$$

Consistent with a well documented empirical property, learning-by-doing (see, for example, Hall et al. (1986) and Lach and Schankerman (1988), and Cohen (1995) for a survey), product quality is stochastically increasing in managerial effort, in the sense that although higher effort increases the likelihood of success, it does not guarantee product improvement. Accordingly, state evolution for firm i is governed by the following law of motion

$$\omega_i' = \omega_i + \nu_i - \xi \tag{1}$$

where ω_i' is firm i's state in the next period, $\nu_i \in \{0,1\}$ is firm-specific and represents product improvement, and $\xi \in \{0,1\}$ is common to all firms and represents industry-wide depreciation. As higher states correspond to higher product quality, if $\nu_i = 1$, managers are successful at increasing product quality, while if $\xi = 1$, the firm product has lower quality due to depreciation. An amount x of effort increases the probability of higher states, i.e. $P\left(\omega_i'|\omega_i, \omega_{-i}, x_i\right) = P\left(\omega_i'|x_i\right) = \frac{x_i}{1+x_i}$, if $\nu_i = 1$. A straightforward implication of my chosen specification is that the probability of product improvement is a monotonically increasing concave function of effort, a property which, as shown in the next subsection, ensures uniqueness of the solution to the problem of the optimal compensation choice. Finally, I require $\nu = 0$ with probability one if $x = 0$, i.e. there can be no product improvement without at least some effort, and $P\left(0|x\right) = 0$ for all x. Depreciation is exogenous and iid over time, i.e. $P\left(\xi|\omega_i, \omega_{-i}, x_i\right) = P\left(\xi\right) = \delta$, if $\xi = 1$.

Given demand, price competition determines product market profits, π. Every period managers compete in a differentiated Bertrand duopoly. There are D consumers. Consumer i who chooses good j obtains utility $U_{ij} = g\left(\omega_j\right) + \left(y_i - p_j\right) + e_{ij}$, where ω_j indexes product quality, $g\left(\omega_j\right)$ is the mean utility of consumers choosing good j, p_j is its price, and y_i is the consumer's income. Each consumer makes the choice that maximizes his utility. This demand structure is standard in industrial organization. As shown in Pakes and McGuire (1994), it implies that the expected fraction of consumers who choose good j, $\Sigma\left(\omega, p\right)$, is given by $\frac{\exp(g(\omega_j)-p_j)}{1+\sum_{q=1}^{J}(g(\omega_q)-p_q)}$. Hence, with constant marginal cost, c, firm i profits are given by $\pi \equiv \pi_i\left(\omega, p\right) = D\Sigma\left(\omega, p\right)\left(p_i - c\right)$. Every period, managers optimally choose the price, p, to maximize profits.

There are several noteworthy features of my model. First, my chosen specification of managerial preferences and compensation structure is entirely standard in corporate finance since the seminal contribution of Holmstrom and Milgrom (1987). Further, it is worth emphasizing that although I study executive compensation in an industry setting, I willingly abstract from issues of strategic provision of incentives such as studied in Fershtman and Judd (1987) and Sklivas (1987).

Second, my compensation framework is in line with the recent optimal delegation literature that studies the optimal degree of delegation in organizations (see, for example, Dessein (2002)) and the optimal separation of ownership and control (see, for example, Burkart, Gromb and Panunzi (1997), Gomes and Novaes (2004)).

Finally, pay-performance sensitivity choices, α, measure the extent to which shareholders induce managers to exert effort. Due to learning-by-doing managerial effort gains a dynamic component which is novel to the literature: in my model shareholders value managerial effort most when it allows them to make a difference in the sense of gaining a competitive hedge from product improvement.

2.1 Industry Equilibrium

At every point of time, industry structure is fully summarized by the current state of the industry, i.e. the distribution of product qualities, (ω_i, ω_{-i}), and whenever $\omega_i \geq \omega_{-i}$, firm i is the current industry leader and firm $-i$ is the laggard. The evolution of the state of the industry is driven by managerial effort, given the stochastic transition rule for individual states (1). I solve for equilibrium in two steps: first, for any given market structure, (ω_i, ω_{-i}), I solve for the unique effort and pricing choices of the manager, $x^* (\omega_i, \omega_{-i})$ and $p^* (\omega_i, \omega_{-i})$, and the resulting profits, $\pi^* (\omega_i, \omega_{-i})$; second, I employ the equilibrium profits obtained in the first step to solve for shareholders' optimal compensation choices and the resulting equilibrium industry structure, i.e. the constellation of Markov Perfect equilibrium (MPE) long-run states of the industry.

I start with a characterization of the equilibrium effort and pricing choices of managers. In the product market stage subgame, the Bertrand-Nash equilibrium in managers' pricing strategies is characterized by the set of first-order conditions $\frac{\partial \pi_i(\omega_i, \omega_{-i}, p_i, p_{-i})}{\partial p_i} = 0$, $\forall i = 1, 2$. For any given state of the industry, (ω_i, ω_{-i}), equilibrium profits are $\pi^* (\omega_i, \omega_{-i}) = \pi \left(\omega_i, \omega_{-i}, p_i^*, p_{-i}^*\right)$. Given profits, managers choose effort to maximize their expected utility, i.e. $\max_{x_t} E_t(w_t) - \frac{\gamma}{2} Var_t(w_t) - \psi(x_t)$. It is straightforward to show that the set of first-order condition characterizing their choice of effort, for any given compensation, $\{s, \alpha\}$, implies that $x_i = x^*(\alpha_i) = \frac{\alpha_i}{k}$, $\forall i = 1, 2$.

Shareholders choose executive compensation to maximize the discounted net present value of profits net of wage payments to the manager subject to satisfying the manager's participation and incentive constraints. Shareholders' maximization problem can be conveniently written in recursive form using the value function, $V(\omega_i, \omega_{-i})$, which is defined by the following Bellman equation

$$V(\omega_i, \omega_{-i}) = \max_{s_i, \alpha_i} \left\{ \pi^*(\omega_i, \omega_{-i}) + x^*(\alpha_i) - E(w_i) + \frac{1}{1+r} EV(\omega_i', \omega_{-i}') \right\}, \ s.t. \tag{2}$$

$$E(w_i) - \frac{\gamma}{2} Var(w_i) - \psi(x^*(\alpha_i)) \geq u_0$$

where $EV(\omega_i', \omega_{-i}') = \sum_{(\omega_i', \omega_{-i}') \in \Xi^2} V(\omega_i', \omega_{-i}') \, p(\omega_i', \omega_{-i}' | \omega_i, \omega_{-i}, x_i, x_{-i})$ is the expected value of future profits to the shareholder of firm i given state ω. Denoting the return function of firm i's shareholder by $G_i(\omega, \alpha(\omega), V_i) = \pi^*(\omega_i, \omega_{-i}) + x^*(\alpha_i) - E_{(\omega_i', \omega_{-i}')}(w_i) + \frac{1}{1+r} E_{(\omega_i', \omega_{-i}')} V(\omega_i', \omega_{-i}')$, I can rewrite the Bellman equation more compactly as $V(\omega_i, \omega_{-i}) = \max_{s_i, \alpha_i} G_i(\omega, \alpha(\omega), V_i)$. Note that the transition probability function $P(\cdot)$ is continuous, which implies that $G(\cdot)$ is a continuous function of $\alpha(\omega)$ and V_i for all ω and i. A compensation strategy, $\alpha_i(\omega)$, that attains the maximum given $\alpha_{-i}(\omega)$ is said to be optimal given $\alpha_{-i}(\omega)$. The boundedness and continuity of $G(\cdot)$ ensures that the objective is well-defined and that optimal compensation strategies exist.

In equilibrium, industry structure is determined by shareholders' choice of executive compensation, but also by managers' pricing and effort strategies. My solution concept for industry structure is Markov perfect equilibrium (MPE). This is subgame perfect equilibrium in Markov strategies, i.e. strategies that depend only on the "payoff-relevant" (Maskin and Tirole (1988, 1995)) state of the game, $\omega = (\omega_1, \omega_2)$. Further, my model implies a symmetric profit function, i.e., $\pi(\omega_i, \omega_j) = \pi_i(\omega_i, \omega_j)$ and $\pi(\omega_j, \omega_i) =$

$\pi_j(\omega_i, \omega_j)$, I can restrict attention to symmetric MPE. This implies symmetry in value functions, $V(\omega_i, \omega_j) = V_i(\omega_i, \omega_j)$ and $V(\omega_j, \omega_i) = V_j(\omega_i, \omega_j)$, and in policy functions, $\alpha(\omega_i, \omega_j) = \alpha_i(\omega_i, \omega_j)$ and $\alpha(\omega_j, \omega_i) = \alpha_j(\omega_i, \omega_j)$. Formally, I define an MPE as follows

Definition 1 *A vector of strategies, $\alpha^*(\omega) = \left(\alpha_i^*, \alpha_{-i}^*\right) \in [0, \overline{\alpha}]^2$ is an MPE if for any firm i, any state ω, and any shareholder's compensation strategy $\tilde{\alpha}(\omega) = (\alpha_i^*, \tilde{\alpha}_{-i}) \in [0, \overline{a}]^2$, $G_i(\omega, a^*(\omega), V_i) \geq G_i(\omega, \tilde{\alpha}(\omega), V_i)$.*

In words, an MPE is simply a vector of shareholder's compensation strategies such that each strategy is optimal given the rival's strategy, starting from any state. Appendix A shows my model satisfies the boundedness, continuity, and uniqueness requirements in Proposition 4 in Doraszelski and Satterthwaite (2003), which allows me to establish the following:

Theorem 1 *There exists a unique symmetric MPE in pure compensation strategies to the game satisfying* (2) *with the following properties:*

$$V(\omega_i, \omega_{-i}) = \pi^*(\omega_i, \omega_{-i}) + x_i^* - \frac{\gamma}{2}\alpha_i^{*2}\sigma^2 - \frac{k}{2}x_i^{*2} + \frac{1}{1+r}EV\left(\omega_i', \omega_{-i}'\right) \tag{3}$$

$$\alpha_i^*\left[\gamma\sigma^2 + \frac{\partial x_i^*}{\partial \alpha_i}\right] = \frac{\partial}{\partial \alpha_i}\left[x_i^* + \frac{1}{1+r}EV\left(\omega_i', \omega_{-i}'\right)\right] \tag{4}$$

Proof. *See Appendix A.* ■

The left hand side of equation (4) represents the marginal cost of high-power incentives, i.e. performance-based compensation, for shareholders: stronger reliance on performance, i.e. higher pay-performance sensitivity, α_i, increases the volatility of managerial pay, hence increasing the demand for insurance by risk-averse managers. As in standard agency problems, this cost is higher the more pronounced managerial risk-aversion, γ, is.

Insurance costs, however, are traded-off against productivity gains, as represented by the right hand side of equation (4) . The key contribution of my dynamic model is to highlight a novel source of benefit of high-power incentives: shareholders incentivize managers not only to increase current profitability, but also to make a difference, i.e. to increase future profitability, $\frac{1}{1+r}EV\left(\omega'_i, \omega'_{-i}\right)$, through product improvements.

2.2 Empirical Implications

The models most direct empirical implications can be summarized as follows.

Proposition 1 *All else equal, there is a negative relationship between pay-performance sensitivity and the degree of product differentiation. In particular, (i) an increase in product differentiation lowers pay-performance sensitivity, i.e.* $\frac{d\alpha}{d\Delta V'} > 0$*; (ii) there is a positive relationship between product differentiation effort and pay-performance sensitivity, i.e.* $\frac{dx}{d\alpha} > 0$*; (iii) industry leaders have weaker pay-performance sensitivity than laggards, i.e.* $\alpha\left(\omega_i, \omega_{-i}\right) < \alpha\left(\omega_{-i}, \omega_i\right)$, *if* $\omega_i > \omega_{-i}$.

Proposition 1 follows immediately from (applying the implicit function theorem to) equation (4). In particular, as the marginal value of product improvements decreases with product differentiation, equation (4) implies that pay-performance sensitivity should decrease as well. This negative relation between product differentiation and pay-performance sensitivity forms the basis for my main empirical tests below.

3 Data and Empirical Results

My industry model predicts an inverse relationship between the magnitude of the performance-based component of optimal compensation contracts and the degree of product differentiation, as managerial effort is less likely to make a difference for firms with more differentiated products. In this section I implement an empirical test of this argument. In particular, after describing my panel data set, I solve numerically for the industry equilibrium to show that this inverse relationship holds for reasonable parametrizations of the model. Employing a structural model of industry equilibrium also allows me to illustrate the joint determination of compensation and product qualities. I then specify an empirical model relating pay-performance sensitivity to product differentiation. I employ several industry- and firm-level proxies for the extent of product differentiation. I experiment with a number of specifications and include a variety of controls for industry effects and standard measures of product market competition that have been employed in the literature. For a large panel of US executives between 1993 and 2004, I document a reliable negative relationship between pay-performance sensitivity and product differentiation.

3.1 Data

We combine data from two separate sources to explore this relationship empirically for a large panel of US executives between 1993 and 2004. Our data on compensation are drawn from the Standard and Poors Compustat ExecuComp database. Our data on product market substitutability across different firms are drawn from the Censuses of Manufactures conducted by the Commerce department. This section describes each of these data sources in turn.

3.1.1 Executive Compensation Data

My executive compensation data is from the ExecuComp dataset compiled by Standard and Poors. This dataset includes data on total compensation for the top five executives (ranked annually by salary and bonus) at each of the firms in the S&P 500, S&P Midcap 400, and S&P SmallCap 600. In addition to measures of short-term compensation such as salary and bonus, ExecuComp contains data on components of long-term compensation such as long-term incentive plans, restricted stock, and stock appreciation rights. I use available data from 1993 to 2004. Relative to the datasets used in the studies by Jensen and Murphy (1990) and Gibbons and Murphy (1990), the advantages of the ExecuComp data are that its sample encompasses the largest 1500 firms each year and is not restricted to just chief executive officers.

Table 2 presents descriptive statistics on the components of executive compensation for all executives in the ExecuComp sample between 1993 and 2004 for whom complete data on total compensation is available. The top panel of the table pertains to the 8,320 executives who are identified as the chief executive officer of the firm. The bottom panel describes the other 38,544 executives in the sample. My measure of total compensation can be divided into short-term compensation and long-term compensation as standard in the literature (see, for example, Gibbons and Murphy (1990) and Aggarwal and Samwick (1999)). Short-term compensation consists of salary, bonus, and other annual payments (e.g., gross-ups for tax liabilities, perquisites, preferential discounts on stock purchases). Annual short-term compensation averages $1,217,000 for the CEOs and $490,000 for the Non-CEOs. Long-term compensation includes the value of restricted stock granted, stock options granted, payouts from long-term incentive plans, and all other compensation (e.g., contributions to benefit plans, severance payments). The sample averages of long-term compensation are $3,097,000 for CEOs and $922,000 for Non-CEOs. Stock options granted are by far the most important component of long-term compensation, accounting for a sample average value of $2,508,000 for CEOs and $727,000 for Non-CEOs.

3.1.2 Other Firm Level Data

I include in my panel controls for firm characteristics whose relationship wit pay-performance sensitivity has been documented in previous studies. Firm characteristics are from the CRSP/Compustat merged industrial annual database (CCM). Outliers are removed by winsorizing the extreme observations in the 1% left or right tail of the distribution. I measure capital as property, plants, and equipment (item 8).

Tobin's Q is the ratio of market value of assets to book value of assets. Market value of assets is defined as total assets (item6) plus market equity minus book equity. Market equity is defined as common shares outstanding (item 25) times fiscal-year closing price (item 199). Book equity is calculated as stockholders equity (item 216) [or the first available of common equity (item 60) plus preferred stock par value (item 130) or total assets (item 6) minus total liabilities (item 181)] minus preferred stock liquidating value (item 10) [or the first available of redemption value (item 56) or par value (item 130)] plus balance sheet deferred taxes and investment tax credit (item 35) when available minus post retirement assets (item 336) when available. Book value of assets is total assets (item 6). I measure return on equity (ROE) as the ratio of earnings to average equity for the prior fiscal year (item 20/(item 60+ item 60_{t-1})).

3.1.3 Industry Data

I use several sources for industry data. For comparability with previous studies I limit my sample to the manufacturing sector, which contains twenty 2-digit standard industrial classification (SIC) codes from 20 to 39, and, within these 2-digit SICs, 458 separate four-digit SICs (ranging from 2001 to 3999). Financing firms (SICs 6000-6999), and regulated utilities (SICs 4900-4999) are excluded. I use four-digit SIC classifications to define industry membership. In unreported tables I replicate my findings at the three-digit level with no qualitatively different results.

To proxy for product differentiation at the industry level I follow Rauch's (1999) classification of 4-digit SITC sectors into two categories. Rauch's index is widely employed in the empirical literature on international trade with differentiated products (see, for example, Bernard, Jensen, and Schott (2003)). Homogeneous sectors include goods that are internationally traded in organized exchanges, with a well-defined price (e.g., wheat). Differentiated sectors are those sectors that do not satisfy this criterion. Rauch uses two standards to make his classification, one liberal and one conservative. I use the liberal standard because it is more stringent in the classification of goods as Differentiated. When a 3-digit sector includes 4-digit subsectors that belong to different classifications, the 3-digit sector is broken down accordingly, each part including only the relevant 4-digit sectors.

To proxy for product differentiation at the firm level I use the ratio of selling expenses (Compustat item189) to sales (Compustat item 12), which has been previously employed, although with a different motivation, in capital structure studies (see Titman (1984), Titman and Wessels (1988)). In my case this ratio is a particularly direct proxy as it measures the intensity of managerial effort directed toward product differentiation.

To control for standard measures of product market competition used in previous studies, I include in my panel concentration ratios from the Census of Manufactures, conducted by the Bureau of the Census as part of the quinquennial Economic Censuses. My measure of concentration is the ratio of the sales of the top four firms in the industry to total industry sales.

3.2 Numerical Results

To show that the inverse relationship between the magnitude of the performance-based component of optimal compensation contracts and the degree of product differentiation holds for reasonable parametrizations of the model I need to solve numerically for the industry equilibrium. Compensation and product qualities are joint outcome of the equilibrium of the industry. I incorporate entry and exit into the basic model presented in Section 2 (details on the full mode with entry and exit are in Appendix B) so as to allow for an endogenous determination of industry structure. Computing equilibrium effort, compensation, pricing, and entry and exit functions allows me to characterize both the transient and ergodic properties of the Markov process that determines equilibrium industry structure, i.e. the distribution of firms over industry states, respectively in the short- and in the long-run. I simulate the model for 10,000 periods and argue that with realistic discount rates the inverse relation between pay-performance sensitivity and product differentiation emerges as an equilibrium outcome.

The model primitives I need to parametrize are $\pi(\cdot)$, γ, r, x_e, ϕ, and P, i.e. demand and costs, managerial preferences, technological opportunities, and the institutional structure of the industry. Table 1 contains a summary of parameter values. To compute the symmetric MPE, I use a variant of the iterative algorithm of Pakes and McGuire (1994) which I detail in Appendix B. Demand and cost patterns determine the profit function, $\pi(\cdot)$. I choose the market size parameter, D, so as to have at most three active firms. Consequently, I set the maximum number of active firms in the industry, N, to three.

Technological opportunities are fully described by the properties of the stochastic process that governs the law of motion between states. My chosen parameter value for the rate of depreciation, δ, is standard and implies an equal chance of incurring or not depreciation. Managerial preferences are limited to risk-aversion, γ, which I set equal to 1.2. Finally, the "institutional" structure of the industry is described by the common discount rate, $(1+r)^{-1}$, the scrap value, ϕ, and the sunk entry cost, X_e. I choose r to match a standard annual interest rate of 4%. Sunk entry cost is chosen so that on average entry costs are about 1/125th of total production costs within a period. The scrap value is chosen to be half of the sunk entry cost. This, together with our choice of a relatively high entry state ($\omega^E = 4$), ensures that in the benchmark entry is relatively cheap and exit entails a relatively low value.

The central empirical implication of the model is the inverse relation between pay-performance sensitivity and product differentiation. The top panel of Figure 2 illustrates this prediction by plotting the "piece-rate" implied by the optimal compensation contract as a function of the state of the industry: relatively higher degree of product differentiation (a right-ward movement along firm 1 axis) translates into substantially lower pay-performance sensitivity. The lower panels of Figure 2 illustrate the implied relation between product differentiation and managerial effort (right-panel) and shareholder value (left-panel), i.e. the maximized expected present value of profits net of compensation. Effort and shareholder value are plotted each as a function of the state of the industry. As for managerial effort, compensation induces managers to exert large effort at the early stages of product differentiation until there is no further benefit from product improvement.

Table 1 reports detailed statistics on the characteristics of the industry equilibrium under the chosen parametrization. There are two firms active in about 90% of the periods. The industry also displays a relatively high turnover, with average length of time such that same pair of duopolists is active of 22 periods. There are periods when one firm falls behind and eventually exits so that its rival earns monopoly profits, but these periods are negligible in the overall history of the industry. To detail how industry structures and product qualities evolve over time, Figure 3 depicts the marginal probability distribution of industry states (ω_i, ω_{-i}), after $T = 5, 25, 50$ periods, starting from state $(0, 0)$. This allows me to study the transitory (short-run) dynamics of the Markov process that drives the equilibrium dynamics of the industry. The figure also contains the distribution of industry states to which the Markov process converges in the long-run, i.e. when T is large enough.

As shown in Figure 3, the industry converges to symmetric states over time. Specifically, state $(7, 7)$ emerges as the mode of the marginal distribution after 25 years and has a probability 0.08, 0.12 after $T = 25, 50$ periods, respectively. While asymmetric states are possible if one firm's product improvement effort fails and the other's succeeds, asymmetric states become less likely over time. For example, states $(8, 6)$ and $(6, 8)$ each have a probability of 0.06, 0.05 after $T = 25, 50$ periods, respectively. This is a direct implication of the central result that managerial effort makes a difference at the early stages of product differentiation, when the laggard works harder than the leader to catch up, hence restoring symmetry. In my benchmark parametrization, the long-run equilibrium of the industry is characterized by a unimodal distribution with mode $(8, 8)$ and fraction of time spent at the mode of 0.037.

3.3 Regression Results

My industry model of executive compensation predicts a negative relation between pay-performance sensitivity and product differentiation (Proposition 1). I test this prediction using a variety of industry- and firm- level measure of product differentiation. I extend the standard econometric framework that estimates the sensitivity of pay to performance (see Murphy (1999) for a careful description of this approach) by allowing pay-performance sensitivity to vary in proportion to my measures of product differentiation. Accordingly, I estimate the following equation:

$$w_{ijt} = \alpha_1 \pi_{jt} + \alpha_2 D_j \pi_{jt} + \alpha_3 D_j + \alpha_4 X_{jit} + \varepsilon_{jit} \tag{5}$$

where the executive i works at firm j in year t. The dependent variable, w_{ijt}, is compensation, and the independent variables are firm performance, π_{jt}, alone and interacted with my measure of product differentiation, D_j. I also include as controls my measure of product differentiation itself and a number of other variables, such as a dummy that controls for whether the executive is a CEO and a concentration measure that controls for effects found in previous studies (Aggarwal and Samwick (1999). Finally, I follow Jensen and Murphy (1990) and use as my measure of firm performance, π_{jt}, the total dollar returns to shareholders including capital gains and dividends but net of inflation on their holdings at the beginning of the period.

I also include year- and 2-digit SIC industry-fixed effects. The inclusion of these industry fixed-effect ensures that it is not the variation in the average pay-performance sensitivities between 2-digit industry groups but the variation in the pay-performance sensitivity within those groups that identifies the estimated coefficient. Including the industry effects also controls for any other factor such as a macroeconomic shock that varies across broad industry groups but not within the narrow industries that comprise them. Note that I cannot estimate the model with a more disaggregated fixed effect (e.g., at the level of the firm or the executive) because my main measure of product differentiation, Rauch's (1999) index, does not vary across executives in a given firm or over the years of my data sample. The null hypothesis is that α_2, the coefficient on the interaction of performance and product differentiation, is equal to zero.

The left panel of Table 3 presents the estimates of equation (5) with total compensation as the dependent variable and Rauch's (1999) index as my industry-level measure of product differentiation. In all specifications, executive compensation is denominated in thousands and firm performance is denominated in millions of dollars divided by 100. I report results for three baseline regressions: (1) with no additional controls, then (2) including industry-fixed effects, and finally (3) including industry-fixed effects as well as controls. In all specifications, consistent with my industry model of executive compensation, I find a negative and highly significant coefficient on the interaction of product differentiation and firm performance (-0.065 in the specification with controls): firms in industries with differentiated products have lower pay-performance sensitivity.

Looking at column 1, the first coefficient shows that an executive's total compensation increases by 0.20 cents for every thousand dollars of incremental shareholder wealth per year in an industry with homogeneous products (i.e., the one for which my product differentiation dummy equals zero). The third coefficient shows that this pay-performance sensitivity decreases by 0.14 cents per thousand as one moves from an industry with homogeneous products to an industry with differentiated products. Thus, the pay-performance sensitivity is 0.06 cents per thousand in industries with differentiated products.

The second and third columns show that this result is robust to adding fixed effects and controlling for firm size and industry concentration. For example, looking at column 2, the first coefficient shows that an executive's total compensation increases by 0.16 cents for every thousand dollars of incremental shareholder wealth per year in an industry with homogeneous products (i.e., the one for which my product differentiation dummy equals zero). The third coefficient shows that this pay-performance sensitivity decreases by 0.11 cents per thousand as one moves from an industry with homogeneous products to an industry with differentiated products. Thus, the pay-performance sensitivity is 0.05 cents per thousand in industries with differentiated products. This is somewhat higher than Jensen and Murphy (1990) who found that for total compensation the pay-performance sensitivity was 3.29 cents per thousand, but in line with Aggarwal and Samwick (1999).

As my model allows for industry factors to cause one executive to be paid more than another, in my empirical specification I allow for these factors. In addition the full set of 2-digit industry and year fixed-effects, I also include my product differentiation dummy itself and a dummy variable that takes on a value of one if the executive is a CEO and zero otherwise. Including the product differentiation dummy allows for the level of compensation to be different between industries with differentiated products and industries with homogeneous products, independent of firm performance. The second row in column 3 shows that total compensation increases with product differentiation. Including the indicator variable is motivated by the differences in the level (more so than in the composition) of executive compensation revealed in Table 2. The fourth coefficient in column 3 shows that CEOs receive more in total compensation than do non-CEOs, consistent with the unconditional difference shown in Table 2.

The right panel of Table 3 presents the estimates of equation (5) using short-term compensation as the dependent variable. The results are qualitatively very similar to those in the left panel. For example, looking at column 4, the first coefficient shows that an executive's short-term compensation increases by 0.03 cents for every thousand dollars of incremental shareholder wealth per year in an industry with homogeneous products (i.e., the one for which my product differentiation dummy equals zero). The third coefficient shows that this pay-performance sensitivity decreases by 0.02 cents per thousand as one moves from an industry with homogeneous products to an industry with differentiated products. Thus, the pay-performance sensitivity is 0.01 cents per thousand in industries with differentiated products.

In Table 3 I have constrained pay-performance sensitivity to be equal for CEOs and non-CEOs, allowing only their average level of compensation to differ. In Table 4 I relax this assumption and estimate the same set of regressions restricting the sample to only CEOs. The results are qualitatively the same as in the full sample of executives, with larger magnitudes on all of the coefficients. The pay-performance sensitivities will be higher in the sample of CEOs because they bear more responsibility for decisions within the firm that affect profits. Based on the OLS estimation for total compensation, reported in the left panel of Table 4, looking at column 1, the first coefficient shows that an executive's total compensation increases by 0.48 cents for every thousand dollars of incremental shareholder wealth per year in an industry with homogeneous products (i.e., the one for which my product differentiation dummy equals zero). The third coefficient shows that this pay-performance sensitivity decreases by 0.26 cents per thousand as one moves from an industry with homogeneous products to an industry with differentiated products. Thus, the estimated pay-performance sensitivity is much larger for CEOs than on average for executives and equal to 0.22 cents per thousand in industries with differentiated products.

Throughout my theoretical and empirical work, I have limited my measure of total compensation to the annual flow of resources that the shareholders could have kept for themselves had they not used it to compensate the executive. In practice, an executive also receives incentives from the effects of her actions on the value of her holdings of stock in her own firm. If an executive owns stock in her firm, then the total increment in her wealth due to the performance of her firm will include not only the extra pay she receives as part of the pay-performance sensitivity built into her compensation but the appreciation on her personal stock holdings. Recognizing this, the shareholders of her firm will incorporate a lower pay-performance sensitivity into her contract. Hence, the optimal compensation contract becomes a function of both the degree of product differentiation and the executives holdings. Conditional on a particular allocation of the executives personal wealth, however, the relationship between product differentiation and pay-performance sensitivity is unchanged.

To check for robustness of my results to the incentives provided by inside ownership, in Table 9 I control for the executives holdings of her firm. The left panel report estimates of equation (5) using total compensation as the dependent variable, while in the right panel I report results for short-term compensation as the dependent variable. In both cases, although the estimated coefficient of insider ownership is significant, my finding of a negative relation between product differentiation and pay-performance sensitivity remains. For example, looking at column 4, the first coefficient shows that an executive's short-term compensation increases by 0.14 cents for every thousand dollars of incremental shareholder wealth per year in an industry with homogeneous products (i.e., the one for which my product differentiation dummy equals zero). The third coefficient shows that this pay-performance sensitivity decreases by 0.06 cents per thousand as one moves from an industry with homogeneous products to an industry with differentiated products. Thus, the pay-performance sensitivity is 0.08 cents per thousand in industries with differentiated products.

To test part (iii) of Proposition 1, the left panel of Table 5 presents the estimates of equation (5) with total compensation as the dependent variable and a measure of firm position within its industry built along the lines of MacKay and Phillips (2005). In particular, I measure Position as the ratio of the firm's sales to industry median sales in the beginning of the year. In all specifications, executive compensation is denominated in thousands and firm performance is denominated in millions of dollars divided by 100. Again, I report results for three baseline regressions: (1) with no additional controls, then (2) including industry-fixed effects, and finally (3) including industry-fixed effects as well as controls. In all specifications, consistent with my industry model of executive compensation, I find a negative and highly significant coefficient on the interaction of firm position and firm performance: industry leaders have lower pay-performance sensitivity than laggards.

The second and third columns show that this result is robust to adding fixed effects and controlling for firm size and industry concentration. The right panel of Table 5 presents the estimates of equation

(5) using short-term compensation as the dependent variable. The results are qualitatively very similar to those in the left panel. In Table 5 I have constrained pay-performance sensitivity to be equal for CEOs and non-CEOs, allowing only their average level of compensation to differ. In Table 6 I relax this assumption and estimate the same set of regressions restricting the sample to only CEOs. As in the case of my industry-level measure of product differentiation, the results are qualitatively the same as in the full sample of executives, with larger magnitudes on all the coefficients.

Finally, to test part (ii) of Proposition 1, the left panel of Table 7 presents the estimates of equation (5) with total compensation as the dependent variable and a measure of product differentiation effort along the lines of Titman (1989). In particular, I measure product differentiation effort as the ratio of the firm's selling expenses to sales. In all specifications, executive compensation is denominated in thousands and firm performance is denominated in millions of dollars divided by 100. Again, I report results for three baseline regressions: (1) with no additional controls, then (2) including industry-fixed effects, and finally (3) including industry-fixed effects as well as controls. In all specifications, consistent with my industry model of executive compensation, I find a positive and highly significant coefficient on the interaction of product differentiation effort and firm performance.

The second column shows that this result is robust to adding fixed effects. The right panel of Table 5 presents the estimates of equation (5) using short-term compensation as the dependent variable. The results are qualitatively very similar to those in the left panel. For example, looking at column 5, the first coefficient shows that an executive's short-term compensation increases by 0.001 cents for every thousand dollars of incremental shareholder wealth per year for firms with no product differentiation expenses. The third coefficient shows that this pay-performance sensitivity increases by 0.04 cents per thousand with an increase in product differentiation expenses. Table 8 shows that when I estimate the same set of regressions while restricting the sample to only CEOs, the results are qualitatively the same as in the full sample of executives, with larger magnitudes on all the coefficients.

In summary, the regressions of executive compensation on firm performance in Tables 3 through 9 provide strong empirical support for my model's predictions derived in Section 2. My results show that pay-performance sensitivity decreases with the degree of product differentiation. Based on these results, I conclude that industry has an important effect on the structure of executive compensation.

4 Conclusion

This paper contributes to the debate on executive compensation by arguing that industry forces are of first-order importance in determining executive compensation. I incorporate a standard agency model of executive compensation into a dynamic industry equilibrium setting to study the link between product differentiation and executive compensation. I show that there is an inverse relationship between the magnitude of the performance-based component of optimal compensation contracts and the degree of product differentiation. This central prediction of my model follows from the fact that managerial effort is less likely to make a difference for firms with more differentiated products.

I test this prediction empirically in a large panel of US executives between 1993 and 2004 and find strong evidence of an inverse relationship between pay-performance sensitivity and product differentiation. In particular, I find that pay-performance sensitivity depends negatively on industry- and firm-level measures of product differentiation, even after controlling for industry fixed effects and standard measures of product market competition. Moreover, industry leaders have weaker pay-performance sensitivity than laggards, even after controlling for firm size.

Agency models of executive compensation emphasize the trade-off between incentives and insurance but are typically silent on the sources of value of managerial effort. My model and empirical tests point to product differentiation as an important channel through which managerial effort affects shareholder value. Moreover, they provide a novel explanation for the infrequent use of high-powered incentives: they don't always make a difference for shareholders.

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Appendix A. Proofs

Proof of Theorem (1)**.** I first prove existence of a symmetric, pure strategy MPE by verifying that my model (2) satisfies the conditions of Proposition 4 in Doraszelski and Satterthwaite (2005) (DS). Using a backward induction argument for $\delta = 0$, I then show that the equilibrium is unique.

Proposition 2 (Doraszelski and Satterthwaite (2005)) *Assume that*

1. *(i) The state space is finite, i.e.* $N < \infty$ *and* $M < \infty$*. (ii) Profits are bounded, i.e. there exists* $\overline{\pi} < \infty$ *s.t.* $-\overline{\pi} < \pi_i(\omega) < \overline{\pi}$ *for all* ω *and all* i*. (iii) Investments is bounded, i.e.,* $\overline{x} < \infty$ *and* $\overline{x}^e < \infty$*. (iv) The distributions of scrap values* $F(\cdot)$ *and setup costs* $F^e(\cdot)$ *have continuous and positive densities and bounded supports, i.e. there exist* $\overline{\phi} < \infty$ *and* $\overline{\phi}^e < \infty$ *s.t. the supports of* $F(\cdot)$ *and* $F^e(\cdot)$ *are contained in the interval* $\left[-\overline{\phi}, \overline{\phi}\right]$ *and* $\left[-\overline{\phi}^e, \overline{\phi}^e\right]$*, respectively. (v) Firms discount future payoffs, i.e.,* $\beta \in [0,1)$*.*

2. $G_i(\omega, u(\omega), V_i)$ *is a continuous function of* $x(\omega)$*,* $\xi(\omega)$*, and* V_i *for all* ω *and all* i*, where* $u(\omega) = (x(\omega), \xi(\omega))$ *is the vector of firms' effort and cutoff entry/exit strategies.*

3. *Transition function* $P(\cdot)$ *is UIC admissible and* $\overline{x}$ *is finite and larger than* $\beta\left(\overline{V}^* - \underline{V}^*\right)$*, with* $V_i \in \left[\underline{V}^*, \overline{V}^*\right]^{|S|}$.

4. *The local income functions are symmetric and exchangeable, i.e.*

$$\begin{aligned} & G_i(\omega_1, ..., \omega_{i-1}, \omega_i, \omega_{i+1}, ..., \omega_N, u_1(\omega), ..., u_{i-1}(\omega), u_i(\omega), u_{i+1}(\omega), ..., u_N(\omega), V_i) \\ = \; & G_1(\omega_i, ..., \omega_{i-1}, \omega_1, \omega_{i+1}, ..., \omega_N, u_i(\omega), ..., u_{i-1}(\omega), u_1(\omega), u_{i+1}(\omega), ..., u_N(\omega), V_1) \end{aligned}$$

for all symmetric functions and all i*, and*

$$\begin{aligned} & G_1(\omega_1, \omega_2, ..., \omega_k, ..., \omega_l, ..., \omega_N, u_1(\omega), u_2(\omega), ..., u_k(\omega), ..., u_l(\omega), ..., u_N(\omega), V_1) \\ = \quad & G_1(\omega_1, \omega_2, ..., \omega_l, ..., \omega_k, ..., \omega_N, u_1(\omega), u_2(\omega), ..., u_l(\omega), ..., u_k(\omega), ..., u_N(\omega), V_1) \end{aligned}$$

for all exchangeable functions, $k \geq 2$*, and all* $l \geq 2$*.*

Under assumptions $1, 2,$ *and* 3*, an equilibrium exists in cutoff entry/exit and pure investment strategies. If, in addition assumption 4 holds, then a symmetric and anonymous equilibrium exists in cutoff entry/exit and pure investment strategies.*

Lemma 1 *There exists a symmetric MPE in pure strategies to the game that satisfies* $(3) - (4)$*.*

Proof. *It suffices to verify that the game satisfies assumptions 1-4 in Prop A-0. Note that for the basic model in Section 2 without entry and exit I only need to provide arguments for existence and uniqueness of compensation strategies.*

1. *My model has 2 firms with states* $\omega_i \in \{1, ..., M\}$ *and* $M < \infty$*. Firms discount future payoffs using* $(1+r)^{-1} \in (0,1)$*, and I assume that compensation expenditures are bounded (*$\overline{x} < \infty$*). Boundedness of cost function (assumed functional form for costs implies that* $c(M+n) = c(M)$ $\forall n$*) implies that the profit function* $\pi^*(\omega_i, \omega_j)$ *is bounded. These boundedness conditions satisfy assumption* 1 *in (DS).*

2. V_i *enters* $G_i(\cdot)$ *only through the expected value of firm* i*'s future cash flows, ensuring continuity of* $G_i(\cdot)$ *in* V_i *for all* ω *and all* i*. Moreover, current profit is additively separable from investment and the transition probability function* $P(\cdot)$ *is continuous, which implies that* $G(\cdot)$ *is a continuous function of* $x(\omega)$ *for all* ω *and* i*. Continuity of* $G_i(\omega, x(\omega), V_i)$ *in* $x(\omega)$ *and* V_i *satisfies assumption* 2 *in (DS).*

3. *My transition probability function* $P(\omega_i'|\omega_i, \omega_{-i}, x_i)$ *satisfies the unique investment choice (UIC) admissibility condition in (DS). We assume, in addition, that* $\overline{x} > \beta\left(\overline{V}^* - \underline{V}^*\right)$, *with* $V_i \in \left[\underline{V}^*, \overline{V}^*\right]^{|S|}$, *which ensures that assumption* 4 *in (DS) holds.*

4. *My model of product market competition gives rise to symmetric profit functions, i.e.* $\pi_1(\omega_i, \omega_j) = \pi_2(\omega_j, \omega_i)$. *Moreover,* $P_1\left(\omega_i', \omega_j', \omega_i, \omega_j, x_i(\omega), x_j(\omega)\right) = P_2\left(\omega_j', \omega_i', \omega_j, \omega_i, x_j(\omega), x_i(\omega)\right)$. *This ensures that the local income functions* $G_i(\cdot)$ *are symmetric and exchangeable, and, thus, satisfy assumption* 5 *in (DS).*

■

Lemma 2 *For* $\delta = 0$, *the MPE equilibrium of the game is unique.*

Proof. *I establish uniqueness inductively by first showing that it holds for boundary states, and then that it is also true for interior states. Before doing so, I restate* (3) *and* (4) *explicitly using the transition probability function* $P(\omega_i'|\omega_i, \omega_{-i}, x_i) = \frac{x_i}{1+x_i}$.

1. *Bellman equation:*

$$V(\omega_i, \omega_j) = \max_{x_i}\left\{\pi^*(\omega_i, \omega_j) - x_i + \frac{1}{1+r}\left(V(\omega_i, \omega_j) + p(x_i)\,\Delta_i\tilde{V}(\omega_i, \omega_j|x_j)\right)\right\} \tag{6}$$

2. *Optimal effort:*

$$x^*(\omega_i, \omega_j) = \sqrt{\frac{1}{1+r}\Delta_i\tilde{V}(\omega_i, \omega_j|x_j)} - 1 \tag{7}$$

where $\Delta_i\tilde{V}(\omega_i, \omega_j|x_j) \equiv \tilde{V}(\omega_i + 1, \omega_j|x_j) - \tilde{V}(\omega_i, \omega_j|x_j)$ *and* $\tilde{V}(\omega_i, \omega_j|x_j) = p(x_j)\,V(\omega_i, \omega_j + 1) + (1 - p(x_j))\,V(\omega_i, \omega_j)$ *is the expected continuation value in state* (ω_i, ω_j), *where the expectation is taken w.r.to the rival's probability of advancement.*

Substituting (7) *back into* (6)*, I obtain* $V(\omega_i, \omega_j) = \pi^*(\omega_i, \omega_j) + \frac{1}{1+r} V(\omega_i, \omega_j) + (x^*(\omega_i, \omega_j))^2$, *or*

$$V(\omega_i, \omega_j) = \frac{\pi^*(\omega_i, \omega_j) + (x^*(\omega_i, \omega_j))^2}{1 - \frac{1}{1+r}} \tag{8}$$

To establish uniqueness of MPE, I argue by induction starting at state (Z, Z)*. Note that all states* $(Z + k, Z + h)$ *are payoff-equivalent to state* (Z, Z) *for* $k, h \geq 0$*. Consequently, if a unique MPE exists for state* (Z, Z)*, the same unique equilibrium exists for all states* $(Z + k, Z + h)$*.*

State (Z, Z)*: At state* (Z, Z)*, I have* $\Delta_i E_j \tilde{V}(\omega_i, \omega_j | x_j) = 0$ *since the MPE does not vary as either* x_i *or* x_j *increases. Consequently,* (7) *has unique solution* $x_i = 0$*, which implies that* $P(\omega_i' | x_i) = \frac{x_i}{1+x_i} = 0$*, and, substituting into the Bellman equation, that* $V(Z, Z) = \frac{\pi^*(Z,Z)}{1-\frac{1}{1+r}}$*, which is unique given uniqueness of subgame-perfect equilibrium profits.*

Boundary states (L, Z), $L < Z$*: A boundary state exists whenever* $\omega_i \geq M$ *for* $i = 1, 2$*. Assume a unique MPE exists for the subgame beginning in state* $(L + 1, Z)$*. Symmetry implies that there exists a unique MPE for the subgame beginning in state* $(Z, L + 1)$*. Thus,* $\tilde{V}_i(L + 1, Z)$ *exists and is well defined.*

Using (6)*, firm* 2*'s value function is* $V(M, Z) = \max_{x_j} \left\{ \pi^*(M, Z) - x_j + \frac{1}{1+r} V(M, Z) \right\}$ *and the unique solution is* $x_j = 0$*, so that*

$$V(M, Z) = \frac{\pi^*(M, Z)}{1 - \frac{1}{1+r}}$$

Firm 1*'s value function is*

$$V(L, Z) = \max_{x_i} \left\{ \pi^*(L, Z) - x_i + \frac{1}{1+r} \left(V(L, Z) + p(x_i) \left(V(L + 1, Z) - V(L, Z) \right) \right) \right\}$$

I begin by ruling out $\overline{x}$ as an optimal choice. By construction of $\overline{V}^*$ and $\underline{V}^*$,

$$\begin{aligned} G_i(..., \overline{x}, ...) &\leq \pi_i(L, Z) - \overline{x} + \beta \overline{V}^* \\ G_i(..., 0, ...) &\geq \pi_i(L, Z) - 0 + \beta \underline{V}^* \end{aligned}$$

Hence

$$G_i(..., \overline{x}, ...) - G_i(..., \overline{x}, ...) \leq -\overline{x} + \beta \overline{V}^* - \beta \underline{V}^* < 0$$

where the last inequality follows from assumption 3. This implies that $\overline{x}$ cannot be an optimal choice and that $G_i(..., x_i(\omega), ...)$ must be decreasing somewhere on $[0, \overline{x}]$.

Equation (7) implies in a boundary state, (L, Z), that $x^*(L, Z)$ is given by the solution to

$$(x^*(L, Z) + 1)^2 (1 + r) = V(L + 1, Z) - \frac{\pi^*(L, Z) + (x^*(L, Z))^2}{1 - \frac{1}{1+r}} \tag{9}$$

which follows from substituting $V(L, Z)$ from (8) into (9). Rearranging (9), I obtain the quadratic equation in $(1 + r)(x^*(L, Z))^2 + 2rx^*(L, Z) + e = 0$ where

$$e = r + \pi^*(L, Z) - V(L + 1, Z)\left(1 - \frac{1}{1 + r}\right)$$

First, suppose that $4r^2 - 4(1 + r)e \geq 0$, or $V(L + 1, Z) \geq \frac{\pi^*(L,Z)}{1 - \frac{1}{1+r}} + 1$. Then there are two roots (which may coincide) to the quadratic equation: the smaller root is negative (since $2r \geq 0$), whereas the larger root

$$\tilde{x}(L, Z) = \frac{-r + \sqrt{r^2 - (1 + r)e}}{(1 + r)}$$

may be negative, zero, or positive.

$\tilde{x}(L,Z)$ *is thus the only candidate for an interior solution within* $(0,\overline{x})$ *to the firm's problem. The following three cases can arise:*

1. $G_i(...,x_i(\omega),...)$ *may be strictly decreasing on the interval* $[0,\overline{x}]$. *Then the unique maximizer is* 0.

2. $\tilde{x}(L,Z)\in(0,\overline{x})$ *may be a local minimum. Then, on the interval* $[0,\overline{x}]$, $G_i(...,x_i(\omega),...)$ *is strictly decreasing (increasing) to the left (right) of* $\tilde{x}(L,Z)$. *Because* $\overline{x}$ *cannot be an optimal choice, the unique maximizer is* 0.

3. $\tilde{x}(L,Z)\in(0,\overline{x})$ *may be a local maximum. Then, on the interval* $[0,\overline{x}]$, $G_i(...,x_i(\omega),...)$ *is strictly increasing (decreasing) to the left (right) of* $\tilde{x}(L,Z)$. *Hence, the unique maximizer is* $\tilde{x}(L,Z)$.

Suppose next that $4r^2-4(1+r)e<0$, *or* $V(L+1,Z)<\frac{\pi^*(L,Z)}{1-\frac{1}{1+r}}+1$, *so that the quadratic equation has no real roots. Then* $G_i(...,x_i(\omega),...)$ *must be either strictly decreasing or strictly increasing on* $[0,\overline{x}]$. *But we have already established that* $G_i(...,x_i(\omega),...)$ *must be decreasing somewhere on* $[0,\overline{x}]$; *therefore it cannot be possibly strictly increasing on* $[0,\overline{x}]$. *Hence,* $G_i(...,x_i(\omega),...)$ *is strictly decreasing on* $[0,\overline{x}]$, *and the unique maximizer is* 0.

It follows then that there is a unique solution to (9), *given* $V(L+1,Z)$ *that exists uniquely under the induction hypothesis. Moreover,* $\tilde{x}(L,Z)$ *uniquely defines* $V(L,Z)$ *according to* (8). ■

■

Appendix B. Details of Computation

This appendix describes the approach used to solve the full model with entry and exit numerically once the parameters of the model are set. Every period there are $n \leq N$ heterogeneous firms active and $N-n$ potential entrants. To enter from state ω^e shareholders must pay a random sunk cost of x_i^e drawn from a distribution $F^e(\cdot)$ independently and identically distributed across firms and periods with $E(\phi_i^e) = \phi^e$. Setup costs are private information. We let $\chi_i^e(\omega, \phi_i^e) \in \{0,1\}$ indicate stay out or entry respectively. If a string of unsuccessful outcomes occurs, shareholders may find it optimal to exit and liquidate the firm, in which case they get a sell-off value of ϕ_i dollars, exit in the next period and never re-enter again. Following Doraszelski and Satterthwaite (2003), we assume that scrap values are randomly drawn from a distribution $F(\cdot)$ with $E(\phi_i) = \phi$, independently and identically distributed across firms and periods, and privately observed prior to making exit and effort decisions. We let $\chi_i(\omega, \phi_i) \in \{0,1\}$ indicate exit or continuation respectively. With respect to our earlier definition in Section 2, the symmetric MPE now comprises also an operating probability, which for an incumbent is given by $\varphi_i(\omega) = \int \chi_i(\omega, \phi_i)\, dF(\phi_i)$ and represents the probability that incumbent i remains in the industry, while for a potential entrant is $\varphi_i^e(\omega) = \int \chi_i^e(\omega, \phi_i^e)\, dF(\phi_i^e)$ and represents the probability that potential entrant i enters the industry.

The solution to the problem of the firm is found using value and policy function iteration method along the lines of Pakes and McGuire (1994). It exploits the computational simplification entailed by the Markov Perfect assumption combined with the recursivity of the optimization problem. The algorithm iterates on the vector containing value functions, V, and the vector of policies, X, (one for each state ω), until the maximum of the element-by-element difference between successive iterations in these vectors is below a pre-specified tolerance level. All computations are carried out in Gauss 3.0.

The algorithm iterates on the V and X matrices until the maximum of the element-by-element difference between successive iterations in these matrices is below a pre-specified tolerance level. The calculations in each iteration are performed separately for each row (industry structure) using only the old values of the matrices V and X. If each element of V and X has converged, then we are assured of having computed a MPNE of the dynamic game.

I describe the process that provides us with new V and X matrices at every iteration. The computation is done separately for each element of V and X. Thus I describe what the algorithm does to $V[\omega, n]$ and $X[\omega, n]$, where ω is the industry vector, and n stands for ω_i, for every $[\omega, n] \in (\Omega^n, N)$. Although I illustrate the updating process for the typical element $[\omega, n]$, this process is done to all possible states $[\omega, n] \in (\Omega^n, N)$.

For a given (ω, n), the values of $V(\omega, n)$ and $X(\omega, n)$ at each new iteration are calculated as follows:

- V: the value function at the k^{th} iteration is written as

$$V^k(\omega, n) = \max \left\{ \begin{array}{c} \phi, \sup_{x \geq 0} A(\omega, n) - x + \beta \sum_{\tau_1=0}^{1} ... \sum_{\tau_N=0}^{1} \sum_{\nu=0}^{1} V^{k-1}(\omega + \tau - \nu, n) \times \\ p\left(\tau_1 | x_1^{k-1}, \nu\right) ..p(\tau_h | x, \nu) ..p\left(\tau_N | x_N^{k-1}, \nu\right) p(\nu) \end{array} \right\}$$

  Denote the firm's expected discounted value for each of the two possible realizations of its state process, τ, as

$$CV(z, n) = \beta \left[\begin{array}{c} \sum_{\tau_1=0}^{1} ... \sum_{\tau_{h-1}=0}^{1} \sum_{\tau_{h+1}=0}^{1} ... \sum_{\tau_N=0}^{1} \sum_{\nu=0}^{1} V^{k-1}(z - \nu, n) p(\nu) \times \\ p\left(\tau_1 | x_1^{k-1}, \nu\right) ..p\left(\tau_{h-1} | x_{h-1}^{k-1}, \nu\right) p\left(\tau_{h+1} | x_{h+1}^{k-1}, \nu\right) ..p\left(\tau_N | x_N^{k-1}, \nu\right) \end{array} \right]$$

  That is, $CV(\cdot)$ sums over the probability weighted average of the possible states of the future competitors, but not over the investing firm's own future states. Hence, I can rewrite V^k as

$$V^k(\omega, n) = \max \left\{ \phi, \sup_{x \geq 0} \left[\begin{array}{c} A(\omega, n) - x + \beta \frac{ax}{1+ax} CV(\omega + e(n), n) \\ + \beta \frac{1}{1+ax} CV(\omega, n) \end{array} \right] \right\} \qquad (10)$$

where $e(j)$ is a vector of zeros except for the j^{th} element which is one. Then, whenever $V^k(\omega) \geq \phi$

$$V^k(\omega, n) = \sup_{x \geq 0} \left[A(\omega, n) - x + \beta \frac{ax}{1+ax} CV(\omega + e(n), n) + \beta \frac{1}{1+ax} CV(\omega, n) \right]$$

- X: denote by $x^k(\omega, n)$ the level that solves (10), and by D_x the derivative with respect to x.

Assuming that the firm remains active, the optimal $x(\omega, n)$ solves

$$1 = \beta \left[D_x \left(\frac{ax}{1+ax} \right) CV(\omega + e(n), n) + D_x \left(\frac{1}{1+ax} \right) CV(\omega, n) \right]$$

$$1 = \beta \left[D_x \left(\frac{ax}{1+ax} \right) v1 - D_x \left(\frac{ax}{1+ax} \right) v2 \right]$$

and $v1 \equiv CV(\omega + e(n), n)$ and $v2 \equiv CV(\omega, n)$. Note that

$$D_x \left(\frac{1}{1+ax} \right) = \frac{a}{(1+ax)^2} = a[1 - p(x)]^2$$

when $\tau = 1$ (and, hence, $p(x) = \frac{ax}{1+ax}$). Thus, $x(\omega, n)$ solves

$$1 = \beta \left[a[1 - p(x)]^2 v1 - a[1 - p(x)]^2 v2 \right]$$

$$1 = \beta a [1 - p(x)]^2 (v1 - v2)$$

$$[1 - p(x)]^2 = \frac{1}{\beta a (v1 - v2)}$$

$$\Longrightarrow p(x) = 1 - \sqrt{\frac{1}{\beta a (v1 - v2)}}$$

Taking the inverse of $p(x)$, implies $x(\omega, n) = \frac{p(x)}{a - ap(x)}$.

- Finally, I can use the derived formula to update the value function

$$V^k(\omega,n) = \max\left\{\phi, \sup_{x\geq 0}\left[\begin{array}{c} A(\omega,n) - x(\omega,n) + \beta\frac{ax(\omega,n)}{1+ax(\omega,n)}CV(\omega+e(n),n) \\ +\beta\frac{1}{1+ax(\omega,n)}CV(\omega,n) \end{array}\right]\right\}$$

Note that if $V^k(\omega,n) = \phi$, then x is 0 with probability one. Hence, the actual x level is

$$x^k(\omega,n) = \left\{V^k(\omega,n) \geq \phi\right\} x(\omega,n)$$

where $\{\cdot\}$ is the indicator function which takes the value of one when condition inside is satisfied, and zero otherwise.

Appendix C. Figures and Tables

Figure 1: Timeline

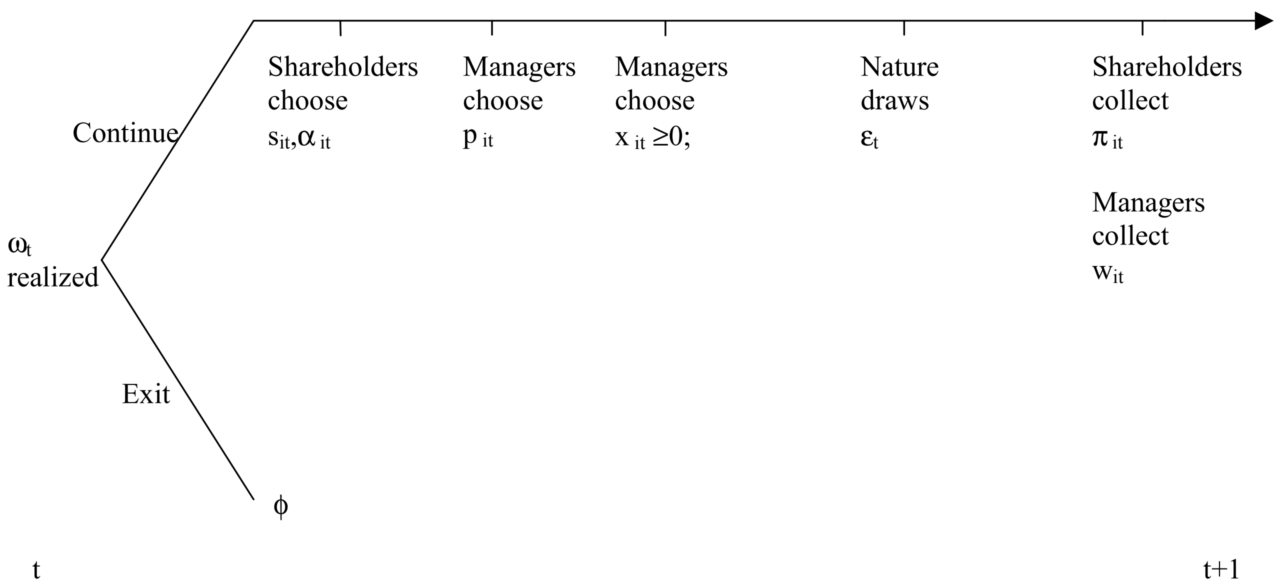
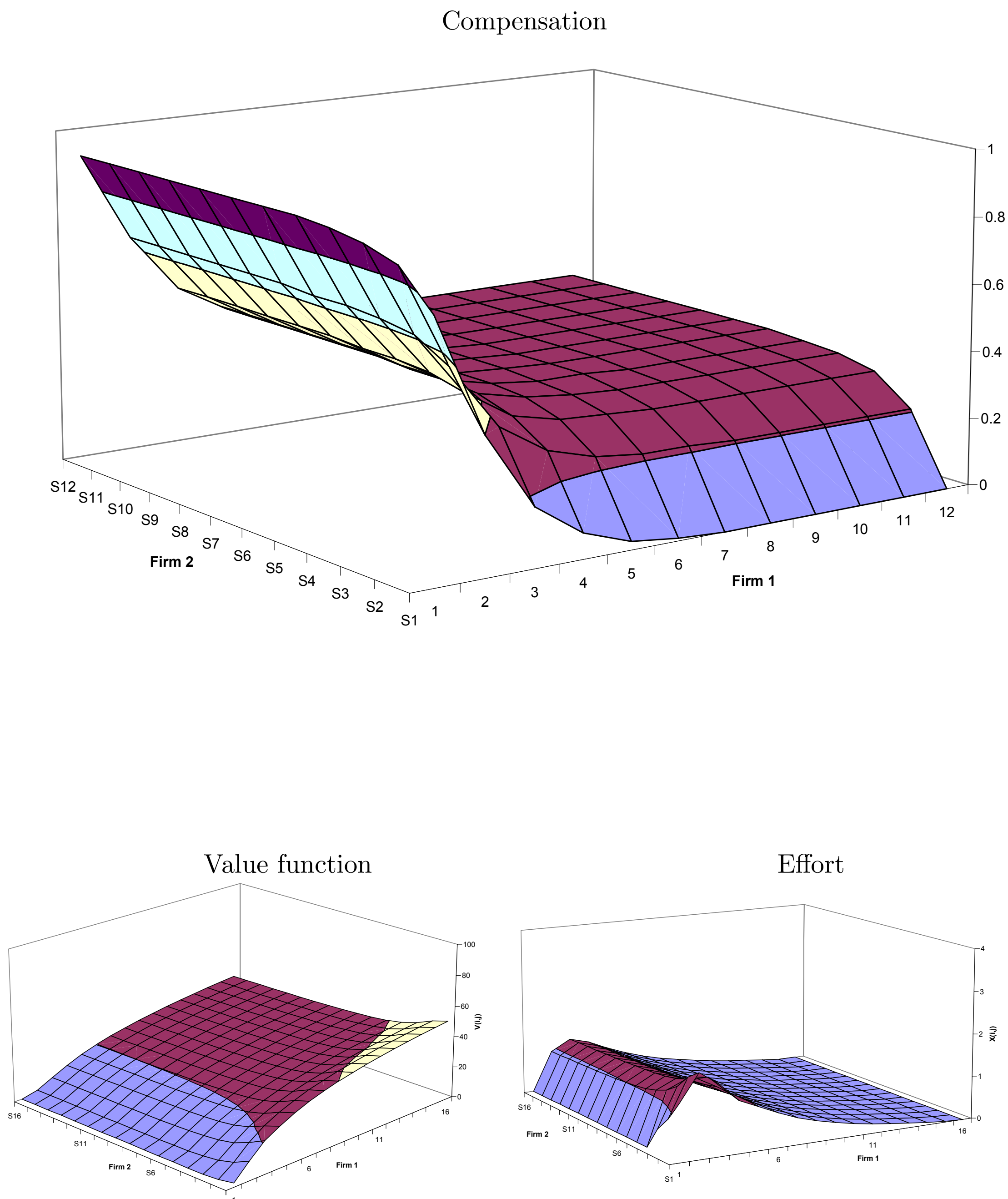
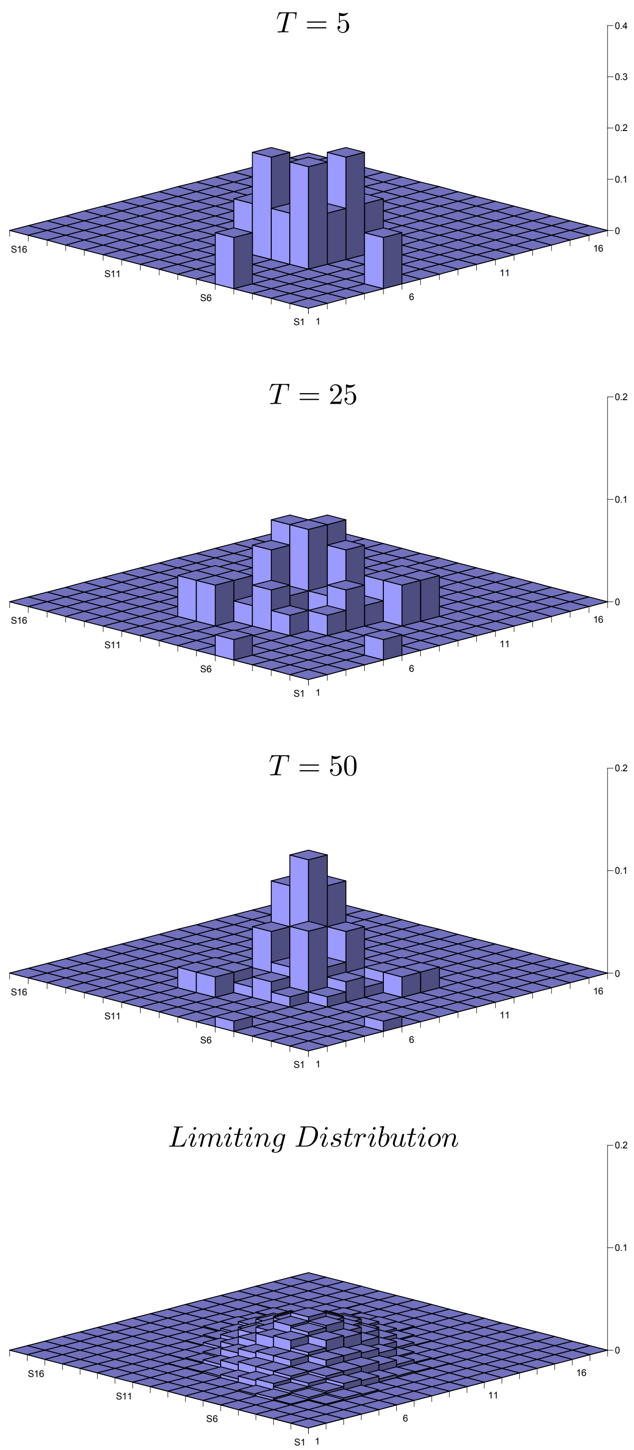


Figure 2: Compensation, Profits, and Effort



The top panel plots compensation choice of Firm 1, $\alpha_1^*(\omega_1, \omega_2)$, as a function of the state of the industry, $\omega = (\omega_1, \omega_2)$, assuming that two firms are active: Firm 1 and Firm 2. The top lower panels plot the value function of Firm 1, $V_1(\omega_1, \omega_2)$, as a function of the state of the industry, $\omega = (\omega_1, \omega_2)$, assuming that two firms are active: Firm 1 and Firm 2; and managerial effort of Firm 1, $x_1(\omega_1, \omega_2)$, as a function of the state of the industry, $\omega = (\omega_1, \omega_2)$, assuming that two firms are active: Firm 1 and Firm 2. Higher states correspond to higher product quality.

Figure 3: Evolution of Industry Structure



I plot the frequency with which an industry configuration (ω_1, ω_2) occurs after $T = 5, 25, 50$ years and the limiting distribution ($T = 10000$). States $(\cdot, 1)$ and $(1, \cdot)$ correspond to monopolization of the industry by Firm 1 (Firm 2). Higher states correspond to higher product quality.

Table 1: Industry Structure

Statistic	Value
% with 1 firm active	5.9
% with 2 firms active	88.5
% with 3 firms active	5.6
% with entry and exit	8.0
% with entry	15.3
% with exit	15.3
HHI	0.53
1/N	0.52
NVar(ms)	0.02
NVar(ms)/HHI	8%
Mean lifespan	16.54
Turnover rate	12.4
Average length of runs	
1 firm active	2.3
2 firms active	25.2
3 firms active	3.2
Effort	
1 firm active	1.31
2 firms active	1.83
3 firms active	2.52
Mean price-cost margin	2.1
Mean sunk entry inv/output	1.1%

Statistics are computed over 10000 periods (years) starting at random draws from the ergodic distribution of states. $HHI = \sum_{i=1}^{N} ms_i^2$ is the Herfindahl index of the industry, where ms_i is firm i's market share and N is the number of active firms. Var(ms) is the variance of market shares in the industry. Turnover rate is computed as {(#periods with entry+#periods with exit-#periods with entry and exit)/total #periods * 100}.

Parameters:

Parameter	Description	Value
D	demand	5
δ	rate of depreciation	0.5
ϕ	scrap value	0.1
X_e	sunk entry cost	0.2
β	discount rate	0.96
γ	manager preferences	1.2

Table 2: Components of Executive Compensation

This Table presents descriptive statistics on the components of executive compensation for all executives in the ExecuComp sample for years 1993-2004 for whom complete data on total compensation is available. The top panel of the table pertains to the executives who are identified as the chief executive officer of the firm. The bottom panel describes the other executives in the sample. The measure of total compensation can be divided into short-term compensation and long-term compensation. Short-term compensation consists of salary, bonus, and other annual payments (e.g., gross-ups for tax liabilities, perquisites, preferential discounts on stock purchases). Long-term compensation includes the value of restricted stock granted, stock options granted, payouts from long-term incentive plans, and all other compensation (e.g., contributions to benefit plans, severance payments). Long-term share is the average share of compensation that is long-term, at the individual level.

Payment Category (Thousands of Dollars)	Mean	Median	Standard Deviation
CEOs (N=8320)			
Total Compensation	4315	2051	12677
Short Term Compensation	1217	893	1180
Salary	599	544	325
Bonus	569	322	937
Other Annual	49	0	250
Long Term Compensation	3097	1011	12405
Restricted Stock Granted	283	0	1633
Stock Options Granted	2508	703	12078
LT Incentive Plan Payout	166	0	813
All Other	138	20	845
Long-Term Share of Total	0.484	0.427	0.264
Non-CEOs (N=38544)			
Total Compensation	1442	746	2844
Short Term Compensation	490	365	830
Salary	281	244	164
Bonus	191	105	752
Other Annual	19	0	185
Long Term Compensation	922	310	2516
Restricted Stock Granted	80	0	554
Stock Options Granted	727	209	2191
LT Incentive Plan Payout	50	0	263
All Other	52	9	490
Long-Term Share of Total	0.423	0.444	0.270

Table 3: Executive Compensation and Product Differentiation - All Executives

This table reports pooled OLS regressions of pay-performance sensitivity. The dependent variable is a measure of executive compensation in a particular firm year. The measure of total compensation can be divided into short-term compensation and long-term compensation. Short-term compensation consists of salary, bonus, and other annual payments (e.g., gross-ups for tax liabilities, perquisites, preferential discounts on stock purchases). Long-term compensation includes the value of restricted stock granted, stock options granted, payouts from long-term incentive plans, and all other compensation (e.g., contributions to benefit plans, severance payments). Performance is defined as the product of the total inflation-adjusted return to shareholders and the beginning of period market value of the firm divided by 100 (Jensen and Murphy (1990)). Industry is defined by four-digit SIC code. Product differentiation is a dummy variable, where 1 signifies that the industry is classified as one with differential products according to Rauch (1999). Industry concentration is domestic four-firm concentration ratio. CEO is a dummy, where 1 signifies that the executive is a CEO in a given firm year. Size is assets at the beginning of the year, winsorized at 1%. Industry fixed effects are at the 2-digit SIC level. Note that I cannot estimate the model with a more disaggregated fixed effect (e.g., at the level of the firm or the executive) because my measure of product differentiation does not vary across executives in a given firm or over the time span of data in the sample. Data is annual for 1993-2004, with only manufacturing (SIC 2000-3999) firms included. Standard errors are robust to heteroskedasticity and arbitrary serial correlation within industry-year cells.

	Total Compensation			Short Term Compensation		
	no fixed effects, no controls	fixed effects, no controls	fixed effects, controls	no fixed effects, no controls	fixed effects, no controls	fixed effects, controls
	(1)	(2)	(3)	(4)	(5)	(6)
Performance	0.199***	0.165***	0.144***	0.030***	0.022***	0.024***
	(0.003)	(0.003)	(0.003)	(0.001)	(0.001)	(0.001)
Product Differentiation	-89.763***	95.954***	72.707***	-55.596***	24.297***	26.089***
	(20.071)	(22.926)	(18.266)	(5.989)	(7.524)	(6.271)
Performance*	-0.138***	-0.107***	-0.065***	-0.023***	-0.016***	-0.009***
Product Differentiation	(0.003)	(0.003)	(0.002)	(0.001)	(0.001)	(0.001)
CEO			1339.459***			549.102***
			(13.873)			(5.050)
Concentration			371.985***			121.378***
			(33.558)			(11.427)
Performance*			-0.036***			-0.019***
Concentration			(0.004)			(0.001)
Size			0.055***			0.015***
			(0.0003)			(0.0001)
Performance*Size			-0.00001***			-0.00001***
			(0.000001)			(0.000001)
Industry fixed effects	No	Yes	Yes	No	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	21076	21076	21035	24767	24767	24722
Firms	449	449	449	449	449	449
Adjusted R^2	0.05	0.07	0.17	0.04	0.08	0.23

Table 4: Executive Compensation and Product Differentiation - CEO Only

This table reports pooled OLS regressions of pay-performance sensitivity. The dependent variable is a measure of executive compensation in a particular firm year. The measure of total compensation can be divided into short-term compensation and long-term compensation. Short-term compensation consists of salary, bonus, and other annual payments (e.g., gross-ups for tax liabilities, perquisites, preferential discounts on stock purchases). Long-term compensation includes the value of restricted stock granted, stock options granted, payouts from long-term incentive plans, and all other compensation (e.g., contributions to benefit plans, severance payments). Performance is defined as the product of the total inflation-adjusted return to shareholders and the beginning of period market value of the firm divided by 100 (Jensen and Murphy (1990)). Industry is defined by four-digit SIC code. Product differentiation is a dummy variable, where 1 signifies that the industry is classified as one with differential products according to Rauch (1999). Industry concentration is domestic four-firm concentration ratio. Size is assets at the beginning of the year, winsorized at 1%. Industry fixed effects are at the 2-digit SIC level. Note that I cannot estimate the model with a more disaggregated fixed effect (e.g., at the level of the firm or the executive) because my measure of product differentiation does not vary across executives in a given firm or over the time span of data in the sample. Data is annual for 1993-2004, with only manufacturing (SIC 2000-3999) firms included. Standard errors are robust to heteroskedasticity and arbitrary serial correlation within industry-year cells. The sample is limited to include only executives that were a CEO in a given firm year.

	Total Compensation			Short Term Compensation		
	no fixed effects, no controls	fixed effects, no controls	fixed effects, controls	no fixed effects, no controls	fixed effects, no controls	fixed effects, controls
	(1)	(2)	(3)	(4)	(5)	(6)
Performance	0.485***	0.423***	0.296***	0.096***	0.057***	0.067***
	(0.015)	(0.015)	(0.017)	(0.005)	(0.005)	(0.005)
Product Differentiation	-506.002***	-105.697	47.384	-218.371***	-82.400*	0.891
	(101.897)	(126.461)	(128.090)	(33.451)	(42.897)	(32.827)
Performance*	-0.256***	-0.211***	-0.066***	-0.071***	-0.032***	-0.021***
Product Differentiation	(0.015)	(0.015)	(0.015)	(0.005)	(0.005)	(0.004)
Concentration			1063.316***			410.518***
			(234.679)			(60.281)
Performance*			-0.144***			-0.060***
Concentration			(0.025)			(0.006)
Size			0.145***			0.034***
			(0.002)			(0.001)
Performance*Size			-0.0001***			-0.00003***
			(0.00001)			(0.000001)
Industry fixed effects	No	Yes	Yes	No	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3784	3784	3776	3799	3799	3791
Firms	448	448	448	448	448	448
Adjusted R^2	0.08	0.11	0.16	0.07	0.12	0.21

Table 5: Executive Compensation and Industry Leadership - All Executives

This table reports pooled OLS regressions of pay-performance sensitivity. The dependent variable is a measure of executive compensation in a particular firm year. The measure of total compensation can be divided into short-term compensation and long-term compensation. Short-term compensation consists of salary, bonus, and other annual payments (e.g., gross-ups for tax liabilities, perquisites, preferential discounts on stock purchases). Long-term compensation includes the value of restricted stock granted, stock options granted, payouts from long-term incentive plans, and all other compensation (e.g., contributions to benefit plans, severance payments). Performance is defined as the product of the total inflation-adjusted return to shareholders and the beginning of period market value of the firm divided by 100 (Jensen and Murphy (1990)). Industry is defined by four-digit SIC code. Position is the ratio of the firm's sales to industry median sales in the beginning of the year, winsorized at 1%. Product differentiation is a dummy variable, where 1 signifies that the industry is classified as one with differential products according to Rauch (1999). Industry concentration is domestic four-firm concentration ratio. CEO is a dummy, where 1 signifies that the executive is a CEO in a given firm year. Size is assets at the beginning of the year, winsorized at 1%. Industry fixed effects are at the 2-digit SIC level. Note that I cannot estimate the model with a more disaggregated fixed effect (e.g., at the level of the firm or the executive) because my measure of product differentiation does not vary across executives in a given firm or over the time span of data in the sample. Data is annual for 1993-2004, with only manufacturing (SIC 2000-3999) firms included. Standard errors are robust to heteroskedasticity and arbitrary serial correlation within industry-year cells.

	Total Compensation			Short Term Compensation		
	no fixed effects, no controls	fixed effects, no controls	fixed effects, controls	no fixed effects, no controls	fixed effects, no controls	fixed effects, controls
	(1)	(2)	(3)	(4)	(5)	(6)
Performance	0.020***	0.018***	0.114***	0.002***	0.002***	0.008***
	(0.0001)	(0.0001)	(0.022)	(0.0001)	(0.0001)	(0.002)
Position	79.615***	78.849***	64.165***	21.617***	22.688***	13.802***
	(3.320)	(3.334)	(0.612)	(2.153)	(1.154)	(0.187)
Performance*Position	-0.0002***	-0.0002***	-0.001***	-0.0001***	-0.0001***	-0.0001***
	(0.00001)	(0.00001)	(0.00002)	(0.00002)	(0.00001)	(0.00001)
Product Differentiation			40.359**			12.641**
			(16.538)			(5.134)
Performance*			-0.063***			-0.006***
Product Differentiation			(0.019)			(0.001)
CEO			1302.478***			549.023***
			(12.543)			(4.133)
Concentration			264.368**			97.031***
			(130.264)			(9.333)
Performance*			0.002			0.001
Concentration			(0.032)			(0.003)
Size			0.035***			0.009***
			(0.0002)			(0.0001)
Performance*Size			-0.00001			-0.00001***
			(0.0001)			(0.000001)
Industry fixed effects	No	Yes	Yes	No	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	45545	45545	21028	53736	53736	24715
Firms	1056	1056	448	1056	1056	448
Adjusted R^2	0.06	0.07	0.18	0.06	0.10	0.25

Table 6: Executive Compensation and Industry Leadership - CEO Only

This table reports pooled OLS regressions of pay-performance sensitivity. The dependent variable is a measure of executive compensation in a particular firm year. The measure of total compensation can be divided into short-term compensation and long-term compensation. Short-term compensation consists of salary, bonus, and other annual payments (e.g., gross-ups for tax liabilities, perquisites, preferential discounts on stock purchases). Long-term compensation includes the value of restricted stock granted, stock options granted, payouts from long-term incentive plans, and all other compensation (e.g., contributions to benefit plans, severance payments). Performance is defined as the product of the total inflation-adjusted return to shareholders and the beginning of period market value of the firm divided by 100 (Jensen and Murphy (1990)). Industry is defined by four-digit SIC code. Position is the ratio of the firm's sales to industry median sales in the beginning of the year, winsorized at 1%. Product differentiation is a dummy variable, where 1 signifies that the industry is classified as one with differential products according to Rauch (1999). Industry concentration is domestic four-firm concentration ratio. Size is assets at the beginning of the year, winsorized at 1%. Industry fixed effects are at the 2-digit SIC level. Note that I cannot estimate the model with a more disaggregated fixed effect (e.g., at the level of the firm or the executive) because my measure of product differentiation does not vary across executives in a given firm or over the time span of data in the sample. Data is annual for 1993-2004, with only manufacturing (SIC 2000-3999) firms included. Standard errors are robust to heteroskedasticity and arbitrary serial correlation within industry-year cells. The sample is limited to include only executives that were a CEO in a given firm year.

	Total Compensation			Short Term Compensation		
	no fixed effects, no controls	fixed effects, no controls	fixed effects, controls	no fixed effects, no controls	fixed effects, no controls	fixed effects, controls
	(1)	(2)	(3)	(4)	(5)	(6)
Performance	0.101***	0.103***	0.329***	0.007***	0.007***	0.044***
	(0.001)	(0.001)	(0.017)	(0.0002)	(0.0002)	(0.005)
Position	147.092***	145.959***	150.961***	28.358***	30.052***	27.803***
	(15.953)	(16.015)	(17.685)	(1.443)	(1.403)	(1.891)
Performance*Position	-0.001***	-0.001***	-0.002***	-0.0002***	-0.0003***	-0.001***
	(0.0001)	(0.0001)	(0.0001)	(0.00002)	(0.00001)	(0.0001)
Product Differentiation			-65.822			81.334
			(124.768)			(52.142)
Performance*			-0.161***			-0.011*
Product Differentiation			(0.015)			(0.006)
Concentration			1214.593***			375.665***
			(228.241)			(59.702)
Performance*			0.017			0.004
Concentration			(0.027)			(0.007)
Size			0.073***			0.026***
			(0.002)			(0.001)
Performance*Size			-0.0001***			-0.00002***
			(0.00001)			(0.000001)
Industry fixed effects	No	Yes	Yes	No	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	8111	8111	3788	8166	8166	3788
Firms	1054	1054	447	1055	1055	447
Adjusted R^2	0.08	0.09	0.18	0.08	0.12	0.23

Table 7: Executive Compensation and Product Uniqueness - All Executives

This table reports pooled OLS regressions of pay-performance sensitivity. The dependent variable is a measure of executive compensation in a particular firm year. The measure of total compensation can be divided into short-term compensation and long-term compensation. Short-term compensation consists of salary, bonus, and other annual payments (e.g., gross-ups for tax liabilities, perquisites, preferential discounts on stock purchases). Long-term compensation includes the value of restricted stock granted, stock options granted, payouts from long-term incentive plans, and all other compensation (e.g., contributions to benefit plans, severance payments). Performance is defined as the product of the total inflation-adjusted return to shareholders and the beginning of period market value of the firm divided by 100 (Jensen and Murphy (1990)). Product Uniqueness is defined as selling expense scaled by sales (Titman (1989)). Industry is defined by four-digit SIC code. Product differentiation is a dummy variable, where 1 signifies that the industry is classified as one with differential products according to Rauch (1999). Industry concentration is domestic four-firm concentration ratio. CEO is a dummy, where 1 signifies that the executive is a CEO in a given firm year. Size is assets at the beginning of the year, winsorized at 1%. Industry fixed effects are at the 2-digit SIC level. Note that I cannot estimate the model with a more disaggregated fixed effect (e.g., at the level of the firm or the executive) because my measure of product differentiation does not vary across executives in a given firm or over the time span of data in the sample. Data is annual for 1993-2004, with only manufacturing (SIC 2000-3999) firms included. Standard errors are robust to heteroskedasticity and arbitrary serial correlation within industry-year cells.

	Total Compensation			Short Term Compensation		
	no fixed effects, no controls	fixed effects, no controls	fixed effects, controls	no fixed effects, no controls	fixed effects, no controls	fixed effects, controls
	(1)	(2)	(3)	(4)	(5)	(6)
Performance	0.004***	0.004***	0.144***	0.0004**	0.0008***	-0.005
	(0.001)	(0.001)	(0.052)	(0.0002)	(0.0001)	(0.007)
Product Uniqueness	-10.001*	-11.819***	-41.466***	-4.816***	-5.252***	-10.961***
	(5.385)	(5.095)	(13.966)	(1.821)	(1.723)	(4.103)
Performance*	0.210***	0.180***	-0.243	0.041***	0.035***	0.026***
Product Uniqueness	(0.004)	(0.004)	(0.192)	(0.001)	(0.001)	(0.006)
Product Differentiation			479.639***			89.491***
			(83.559)			(14.474)
Performance*			-0.007			0.007
Product Differentiation			(0.033)			(0.005)
CEO			2930.626***			755.127***
			(236.266)			(16.091)
Concentration			717.474***			125.997***
			(161.680)			(18.128)
Performance*			-0.128**			0.0002
Concentration			(0.058)			(0.005)
Size			0.138***			0.024***
			(0.009)			(0.002)
Performance*Size			-0.0001**			-0.00001
			(0.00005)			(0.00001)
Industry fixed effects	No	Yes	Yes	No	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	38567	38567	19890	45543	45543	23404
Firms	824	824	423	824	824	423
Adjusted R^2	0.02	0.03	0.10	0.03	0.05	0.21

Table 8: Executive Compensation and Product Uniqueness - CEO Only

This table reports pooled OLS regressions of pay-performance sensitivity. The dependent variable is a measure of executive compensation in a particular firm year. The measure of total compensation can be divided into short-term compensation and long-term compensation. Short-term compensation consists of salary, bonus, and other annual payments (e.g., gross-ups for tax liabilities, perquisites, preferential discounts on stock purchases). Long-term compensation includes the value of restricted stock granted, stock options granted, payouts from long-term incentive plans, and all other compensation (e.g., contributions to benefit plans, severance payments). Performance is defined as the product of the total inflation-adjusted return to shareholders and the beginning of period market value of the firm divided by 100 (Jensen and Murphy (1990)). Product Uniqueness is defined as selling expense scaled by sales (Titman (1989)). Industry is defined by four-digit SIC code. Product differentiation is a dummy variable, where 1 signifies that the industry is classified as one with differential products according to Rauch (1999). Industry concentration is domestic four-firm concentration ratio. Size is assets at the beginning of the year, winsorized at 1%. Industry fixed effects are at the 2-digit SIC level. Note that I cannot estimate the model with a more disaggregated fixed effect (e.g., at the level of the firm or the executive) because my measure of product differentiation does not vary across executives in a given firm or over the time span of data in the sample. Data is annual for 1993-2004, with only manufacturing (SIC 2000-3999) firms included. Standard errors are robust to heteroskedasticity and arbitrary serial correlation within industry-year cells. The sample is limited to include only executives that were a CEO in a given firm year.

	Total Compensation			Short Term Compensation		
	no fixed effects, no controls	fixed effects, no controls	fixed effects, controls	no fixed effects, no controls	fixed effects, no controls	fixed effects, controls
	(1)	(2)	(3)	(4)	(5)	(6)
Performance	0.049***	0.039***	0.315*	-0.0008	-0.0004	-0.026
	(0.003)	(0.003)	(0.177)	(0.0006)	(0.0007)	(0.017)
Product Uniqueness	-102.907*	-94.599*	-93.705**	-59.438***	-56.440***	-23.501*
	(58.260)	(54.245)	(37.785)	(13.715)	(14.254)	(13.693)
Performance*	0.431***	0.407***	-0.689	0.157***	0.133***	0.089***
Product Uniqueness	(0.030)	(0.028)	(0.645)	(0.006)	(0.006)	(0.017)
Product Differentiation			852.443***			111.979***
			(322.299)			(41.165)
Performance*			0.034			0.017
Product Differentiation			(0.094)			(0.012)
Concentration			1992.895***			409.759***
			(682.986)			(75.317)
Performance*			-0.292			0.017
Concentration			(0.199)			(0.015)
Size			0.301***			0.048***
			(0.034)			(0.005)
Performance*Size			-0.0003*			-0.00003
			(0.0002)			(0.00002)
Industry fixed effects	No	Yes	Yes	No	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6901	6901	3562	6951	6951	3577
Firms	822	822	423	823	823	423
Adjusted R^2	0.04	0.05	0.08	0.04	0.08	0.39

Table 9: Executive Compensation and Product Differentiation - Robustness

This table reports pooled OLS regressions of pay-performance sensitivity. The dependent variable is a measure of executive compensation in a particular firm year. The measure of total compensation can be divided into short-term compensation and long-term compensation. Short-term compensation consists of salary, bonus, and other annual payments. Long-term compensation includes the value of restricted stock granted, stock options granted, payouts from long-term incentive plans, and all other compensation. Performance is defined as the product of the total inflation-adjusted return to shareholders and the beginning of period market value of the firm divided by 100 (Jensen and Murphy (1990)). Industry is defined by four-digit SIC code. Product differentiation is a dummy variable, where 1 signifies that the industry is classified as one with differential products according to Rauch (1999). Industry concentration is domestic four-firm concentration ratio. CEO is a dummy, where 1 signifies that the executive is a CEO in a given firm year. Size is assets at the beginning of the year, winsorized at 1%. High-tech is a dummy variable, where 1 signifies that the firm is from one of the high-tech industry defined by Loughran and Ritter (2004). Percentage Owned is the percentage of common equity held by the executive through stocks and options. Industry fixed effects are at the 2-digit SIC level. Note that I cannot estimate the model with a more disaggregated fixed effect (e.g., at the level of the firm or the executive) because my measure of product differentiation does not vary across executives in a given firm or over the time span of data in the sample. Data is annual for 1993-2004, with only manufacturing (SIC 2000-3999) firms included. Standard errors are robust to heteroskedasticity and arbitrary serial correlation within industry-year cells.

	Total Compensation		Short Term Compensation	
	other industry characteristics	managerial incentives	other industry characteristics	managerial incentives
	(1)	(2)	(3)	(4)
Performance	0.144***	0.451***	0.015***	0.142***
	(0.003)	(0.050)	(0.001)	(0.020)
Product Differentiation	72.325***	152.809***	23.312***	25.475
	(17.553)	(45.970)	(5.632)	(15.610)
Performance*Product Differentiation	-0.068***	-0.100**	-0.003***	-0.061***
	(0.002)	(0.045)	(0.001)	(0.018)
CEO	1338.48***	608.32***	547.415***	296.216***
	(13.329)	(28.659)	(4.541)	(11.473)
Concentration	304.100***	308.966***	127.287***	-46.831
	(32.178)	(96.948)	(9.795)	(34.704)
Performance*Concentration	-0.020***	-0.581***	0.001	-0.153***
	(0.005)	(0.052)	(0.001)	(0.018)
Size	0.054***	0.471***	0.014***	0.190***
	(0.0003)	(0.009)	(0.0001)	(0.003)
Performance*Size	-0.00001***	-0.00001***	-0.00001***	0.00003
	(0.000001)	(0.000001)	(0.000001)	(0.00004)
Hi-Tech	-4.035		-25.881***	
	(17.567)		(5.241)	
Performance*Hi-Tech	-0.005***		-0.007***	
	(0.001)		(0.0003)	
Percentage Owned		-16.163***		-3.137***
		(1.853)		(0.739)
Industry fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Observations	21035	3308	24722	3328
Firms	448	352	448	353
Adjusted R^2	0.18	0.17	0.23	0.23