Competition, Quality and Managerial Slack*

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Abstract

We consider the role of product market competition in disciplining managers in a moral hazard setting. Competition has two effects on a firm. First, the expected revenue or the marginal benefit of effort declines, leading to weakly lower effort. Second, the cost of inducing high effort increases (decreases) if competition increases (decreases) the probability of failure at a firm. Both effects imply a change in the optimal level of effort as competition increases. The manager in our model enjoys slack if he supplies low effort in equilibrium. We show that, if competition increases the probability of failure, managerial slack increases with competition. We reconcile this result with contrary empirical findings by pointing out that what has been empirically tested is changes in slack in response to exogenous changes in the private benefit of low effort, rather than the level of managerial slack itself.

1 Introduction

Does product market competition exert discipline on managers? If so, how does it affect internal governance? The ability of product markets to deliver effective governance mechanisms is a question of great concern. This is primarily because social policy broadly encourages competition in product markets. However, if such competition leads to sub-optimal governance, the drive to freer markets could have unintended and pernicious consequences.

In this paper, we provide a simple framework that relates internal governance and product market competition. A large number of firms compete in an industry. At each firm, a risk-neutral principal writes an optimal contract to elicit effort from a risk-averse agent (a manager). This contract captures the notion of internal governance. Low effort provides a private benefit to the manager and a manager enjoys slack if he is allowed to shirk and consume this benefit. The magnitude of this private benefit may depend on the external environment, for example through regulation, and is inversely related to the strength of external governance.

If the agent exerts effort, the good is more likely to be of high quality and to generate high revenue for the principal. Product market competition affects a firm's decision on whether to induce high or low effort. Competition affects the choice of effort in two ways. First, as is standard in the literature, the marginal benefit of high effort decreases with competition. That is, the marginal revenue from high effort at a firm falls as an industry becomes competitive: all else fixed, competition reduces firms' rents. Second, crucial to our analysis, the marginal cost of inducing high effort changes with competition. Specifically, if increased competition decreases the likelihood of earning high revenue (equivalently, increases the probability of bankruptcy), then inducing high effort becomes more costly. We call such products standard goods. By contrast, if there are positive spillovers between firms so that competition increases the likelihood of a firm being successful, the cost of inducing high effort decreases with competition. These sorts of externalities could arise with new products, goods with word-of-mouth communication, or goods that are sold in close proximity. We call these network goods, and they correspond to Cournot complements. Intuitively, the distinction determines if competition makes the contracting problem between the principal and agent more noisy and therefore more expensive: A risk averse agent requires more insurance if the principal is less able to identify high effort.

At the level of a single firm, we define managerial slack directly in terms of whether the firm induces low effort. At the level of the industry, managerial slack is then defined simply by the number of low-effort firms. As is intuitive, an exogenous increase in the private benefit of low effort weakly increases managerial slack. That is, weak external governance leads to weak internal governance, so that the two are complements.

Since firms are ex ante identical, the degree of competition may be defined just in terms of the number of firms in the market. We consider a short-run situation in which the number of firms is fixed, as this allows us to comment on the relationship between slack and firm value. However, the relationship between managerial slack and firm value is distinctly ambiguous. Firm value can change while slack is constant, and vice versa. Greater managerial slack translates to less intense competition in our framework, which under some circumstances can lead to an increase in firm value.

Interestingly, we show that slack is higher, rather than lower, in industries with a large number of competing firms. As a large number of firms signals greater competition, on the surface this finding is puzzling. It appears to contrast with the empirical findings of Giroud and Mueller (2010), who show that anti-takeover laws have a greater negative impact on concentrated industries than on competitive ones. As the relationship between slack and firm value is ambiguous in our setting, our theoretical predictions can be reconciled with their findings by considering circumstances in which slack is unchanged, but the value of a high-effort firm falls.

As managerial slack is not directly observed in our model, we consider the relationship between managerial compensation in an industry and potential managerial slack (the private benefit of low effort). For network goods, greater wage dispersion unambiguously signals that potential slack is greater and average quality is lower. However, for standard goods, the relationship is again muddled and no inferences can be drawn.

Finally, we consider the effect of the entry of new firms on managerial slack. Starting with a situation in which some firms provide high effort, we show that entry on a sufficient scale leads all firms to supply low effort instead. That is, free entry both increases managerial slack and reduces the average quality in the industry. While this effect may seem counter-intuitive, it seems to have occurred in a number of empirical settings.[1]

The previous literature on the effect of product market competition on managerial incen-

[1]See, for example, Keeley (1990) on banks, Becker and Milbourn (2009) on credit rating agencies, and Propper, Burgess and Gossage (2003) on the National Health Service in the UK. Each of these papers shows a decline in the quality of the good produced by the industry following an increase in competition.

tives largely takes the industry structure as exogenous, with the exception of Raith (2003), which we discuss later. Early work in this area includes Hart (1983), who provides a model in which competition reduces managerial slack by making it easier (i.e., cheaper) to provide the agent with incentives to put in high effort. Scharfstein (1988) demonstrates that Hart's result relies critically on a discontinuity in the utility function. With a continuous utility function and a strictly risk-averse agent, competition exacerbates the incentive problem when there is perfect correlation in outcomes across firms.

In Hart (1983) and Scharfstein (1988) contracts are only based on an individual firm's absolute performance, rather than its relative performance in the industry. Holmström (1982) and Nalebuff and Stiglitz (1983) point out that, if output in an industry is correlated, then an important benefit of competition is the ability to base the agent's compensation on her relative performance. An immediate implication is that a monopolist would benefit from hiring multiple agents to generate more information. Unlike their frameworks, in our model, the industrial structure (i.e., one principal matched with one agent) is not inefficient per se: while a monopolist might internalize the market revenue externality we present, it could not arrange production more cheaply than a series of isolated principal-agent pairs.

Hermalin (1992) considers a manager offering a contract to shareholders (so the manager's participation constraint clearly does not bind). He demonstrates that competition has an ambiguous effect on managerial incentives: Competition may change the relative payoff of actions, and may induce the manager to consume different amounts of perquisites. He also identifies a "risk-adjustment" effect that arises because competition may change the informativeness of the agent's action. In our model, increased competition may decrease the informativeness of an agent's action, which therefore requires a risk premium. This increased cost to the competing principals affects their equilibrium quality choice.

Schmidt (1997) considers the effect of competition on managerial incentives to reduce costs with a risk-neutral manager who incurs a utility cost if the firm goes bankrupt. Competition is modeled in reduced form, via a parameter in a firm's demand function. Increased competition increases the likelihood of a firm going under, so the manager works harder in an effort to stave off the personal cost of bankruptcy. Thus, increased competition unambiguously reduces the cost to implementing a higher level of effort. However, the marginal benefit of cost reduction (i.e., greater effort) is ambiguous in sign, and may decrease as competition increases. The tradeoff between these two effects implies that competition may sometimes lead to lower effort. Notably, in his model, if the participation constraint of a manager is binding (i.e., if managers in a competitive industry are not "scarce"), increased competition unambiguously leads to greater effort provision. In our model, the participation constraint always binds as employees are not scarce, yet we obtain the opposite result: with a risk-averse agent, competition can increase the cost of providing incentives.

An important point of departure for our paper from the literature cited so far is that we endogenize the structure of the industry, by considering a Nash equilibrium in which each firm optimally chooses its effort level (i.e., its contract) in response to the choices of other firms in the market. This enables a direct comparison of the first-best structure with the outcome of a long-run equilibrium with free entry.

A related paper is Raith (2003), which models entry and exit of firms on a circle. Each firm consists of a risk-neutral principal and a risk-averse agent. Production costs are decreasing in the unobservable effort exerted by an agent. However, as Raith assumes that realized costs are directly contractible, and any noise in the mapping from effort to cost is independent across firms, the cost of providing incentives is independent of the degree of competition. Rather, only the benefit to inducing a particular level of effort changes with changes in competition. By contrast, we find that the cost of inducing a particular quality level in the optimal contract depends on the market structure. Indeed, the cost of inducing high effort can be increasing in the number of competing firms.

In our model, we assume that the marginal revenue from high effort decreases in the number of firms in the industry. This assumption builds on the work of Martin (1993), who considers a Cournot model in which each firm induces how much labor to induce from its manager. With a large number of firms in the market, the anticipated market share of each firm is small, so that the benefit of inducing labor falls. Piccolo, D'Amato and Martina (2008) consider the use of profit targets rather than cost-plus mechanisms in such a setting, and show that profit targets improve productive efficiency.

We describe our model in Section 2. Section 3 derives some results on the cost of inducing high effort. Managerial slack is considered in Section 4, and Section 5 considers the relationship between slack and quality. Section 6 concludes. All proofs are in the Appendix.

2 Model

An industry with n firms provides an experience good or service that can be of variable quality. Each firm is owned by a risk-neutral principal (a shareholder) who contracts with a risk-averse agent (a manager) to produce the good. The agent chooses an effort $e \in \{e_h, e_\ell\}$, where $e_h > e_\ell$. Effort level e generates a high-quality good with probability e and a low-quality good with probability $1-e$. The agent derives a private benefit b from low effort. The agent's preferences are separable; his utility from income w is $u(w)$ if he chooses high effort and $u(w)+b$ if he chooses low effort, where $u(\cdot)$ is strictly concave. All agents are identical. The agent has a reservation utility u_0. For simplicity, we assume that compensation to the agent represents the only cost of production for the firm.

We assume that the probability of a good having high or low quality depends only on the effort of the agent and is independent of the actions of other firms. That is, we use an absolute rather than relative notion of quality. After the good has been produced, each firm may be either successful or unsuccessful at selling its product. At this stage, for a given quality there is no further difference between a high or low effort firm, and success depends only on the structure of the industry.

The revenue earned by a firm is αy if it successfully sells its product and zero otherwise. Here, $\alpha > 0$ is a parameter that depends on the consumer's willingness to pay for the product and $y(\cdot)$ may depend on the actions of other firms. A good of quality $j \in \{h, \ell\}$ earns revenue αy with probability q_j and zero with probability $1 - q_j$. Here, $q_h > q_\ell$. Notice that quality affects the likelihood of a successful sale, but not the revenue conditional on success. Implicitly, the consumer only obtains a possibly noisy signal of quality before she consumes the good. Sometimes, she thinks a low-quality good may instead have high quality. That is, the good is an experience good.

Let n_h denote the number of high-effort firms and n_ℓ the number of low-effort firms in the industry. We assume each firm is infinitesimal in size, so n_h and n_ℓ are treated as real numbers. At stage 1, a firm expects that if it induces effort e, the probability of earning revenue αy is $p_e(n_h, n_\ell) = eq_h(n_h, n_\ell) + (1-e)q_\ell(n_h, n_\ell)$. Note that the probability depends on the industry structure. Although the quality of firm i's product is not affected by the choices of other firms, its revenue depends on the the number of high and low quality firms. The effort choices of other firms in turn induce a distribution over their qualities, and hence affect the probability of a sale.

The revenue when the firm is successful, αy, may also be a function of industry structure. This revenue should depend on the quality realizations of other firms, which are random given the effort choices of firms. With a slight abuse of notation, we write $\alpha y(n_h, n_\ell)$ as the expected revenue conditional on a successful sale, where the expectation is taken over the quality realizations of the other firms in the industry. At date 0, the expected industry structure may then be parameterized by the effort choices of firms (more precisely, by n_h and n_ℓ).

Figure 1 demonstrates the effects of effort on quality and quality on revenue.

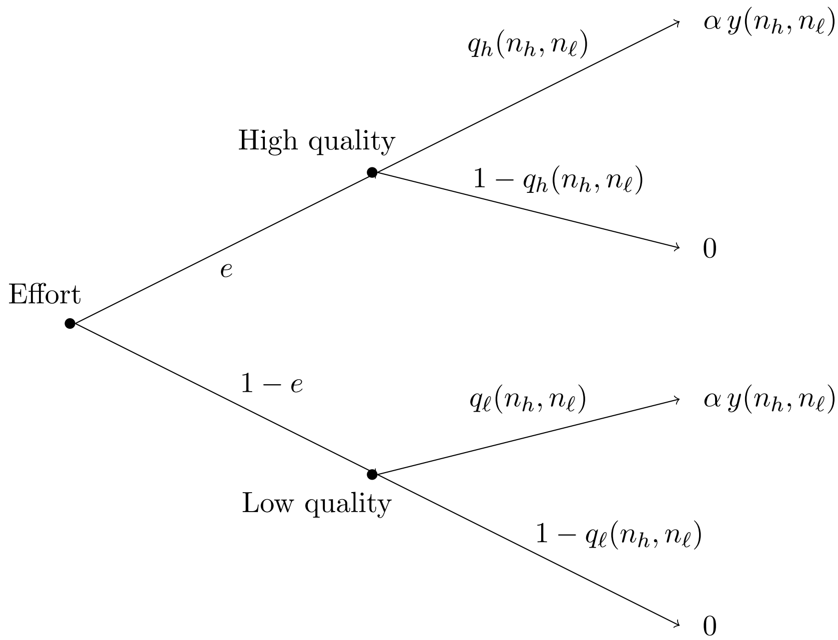

Figure 1: Effort, Quality, Revenue

The principal observes the revenue state αy or zero, but not the actual exerted effort or the quality of the good. Corresponding to the two revenue states, there are two wage levels she optimally offers, designated as w_h and w_ℓ respectively.

The timing of events is as follows. Firms simultaneously offer contracts to their agents at stage 1. Agents simultaneously choose their efforts at stage 2. Since the agent's effort is induced by the contract offered, we can think of firms as directly choosing efforts at stage 1. At stage 3, the qualities are realized and revenues earned.

We adopt the following terminology.

Definition 1 *(a) For a standard good,* $\frac{\partial q_i}{\partial n_j} < 0$ *for* $i, j = h, \ell$.
(b) For a network good, $\frac{\partial q_i}{\partial n_j} > 0$ *for* $i, j = h, \ell$.

That is, for a standard good, the entry of new firms into the market reduces the likelihood that any given firm will be successful. We expect mature products to be standard goods. For a network good, in contrast, new firms entering a market deepen the market by increasing the likelihood a given firm is successful. The positive externality generated by new firms may occur due to technological spillovers or increased market demand for the good. In some cases, the presence of additional firms increases overall consumer awareness of the product. For example, the co-location of firms (such as the Diamond District in New York) may increase overall demand. Similarly, banking services may be thought of as a network good: by facilitating easy transfer of money, the demand for banking services at one bank likely leads to an increase in the demand for banking services at another bank.

Since our goal is to examine the effect of changes in external governance on firm value as the degree of competition varies, we often consider a short-run situation in which there are at most n firms in the industry. Our notion of equilibrium is then a Nash equilibrium in the firms' game, in which each of the n firms may choose to provide high effort, provide low effort, or stay out of the market.

Let $R_e(n_h, n_\ell) = \alpha p_e(n_h, n_\ell) y(n_h, n_\ell)$ be the expected revenue at stage 1 of a firm with effort $e \in \{e_h, e_\ell\}$, and let $\Delta_R(n_h, n_\ell) = R_h(n_h, n_\ell) - R_\ell(n_h, n_\ell)$. We make two sets of assumptions, first on the revenue functions (part (a) below) and second on the mapping between quality and success (part (b)).

Assumption 1 *(a) (i)* R_h *and* R_ℓ *are each strictly decreasing in* n_h, n_ℓ *(ii) keeping the number of firms in the market fixed at* n, $R_\ell(k, n-k)$ *and* $\Delta_R(k, n-k)$ *are strictly decreasing in* k *and (iii)* $R_\ell(0,0) \geq u^{-1}(u_0 - b)$ *and* $R_h(0, n) \to 0$ *as* $n \to \infty$.
(b) (i) $q_h(\cdot)$ *and* $q_\ell(\cdot)$ *are both either increasing in* n_h, n_ℓ *or decreasing in* n_h, n_ℓ *(ii) for every* n_h, n_ℓ, $\left|\frac{\partial q_h}{\partial n_h}\right| > \left|\frac{\partial q_h}{\partial n_\ell}\right|$, *(iii) for each* $j = h, \ell$, $\left|\frac{\partial q_h}{\partial n_j}\right| \geq \left|\frac{\partial q_\ell}{\partial n_j}\right|$ *and (iv) for each* $j = h, \ell$, $\frac{q_\ell}{q_h} \leq \frac{\partial q_\ell / \partial n_j}{\partial q_h / \partial n_j}$.

Our framework is reduced form, in that we do not specify the actual competition that determines the probability of the high revenue state or the level of revenue. However, we submit that most natural models of competition (for example, the Cournot model or a model with differentiated products) will satisfy parts (a) (i) and (ii) of the assumption. Regardless of effort, the expected revenue of a firm is decreasing in the extent of competition that it faces (part (a) (i)). An increase in either n_h or n_ℓ, keeping the number of firms at the other effort level fixed, represents greater competition. Observe that our assumption does not preclude the revenue y from increasing in n_h and n_ℓ. For example, positive spillovers across firms may lead to greater revenue in the high state. However, the expected revenue must decline with the number of competitors. Part (ii) further implies that $R_e(k, n-k)$ decreases in k, so that keeping the number of firms fixed, if a competitor switches from low to high effort, the expected revenue of a firm (low or high effort) decreases. The requirement that $\Delta_R(k, n-k)$ be decreasing in k is satisfied if either $y(k, n-k)$ decreases in k fast enough or the good is a standard good and $\Delta_q(k, n-k) = q_h - q_\ell$ decreases in k. Part (iii) merely ensures that low effort is profitable for a monopolist and that as the number of firms becomes infinite, the total industry revenue remains finite, so that the revenue of even a high-effort firm goes to zero.

Turning to the mapping between quality and success (part (b) of the assumption), an increase in either the number of low or high effort firms has the same directional effect on the probability of success (part (i)). That is, each good is either a standard good or a network good. In part (ii), we assume that an increase in the number of high-effort firms has a greater impact on the industry (specifically, a greater impact on the success probability of a firm) than an increase in the number of low-effort firms. Part (iii) says that increased competition has a weakly greater impact on a high-quality firm than a low-quality firm, and part (iv) is a restriction on the relative effect of increased competition on high and low quality goods.

Two special cases of the model that are of interest are:

1. The multiplicative case: Suppose $q_h(\cdot) = \theta q_\ell(\cdot)$ for each n_h, n_ℓ, where $\theta > 1$ is some constant. Then, all three parts of (b) are immediately satisfied, and part (a) (ii) of the assumption is satisfied if $R_\ell(k, n-k)$ is decreasing in k.

2. The high-quality only case: Suppose $q_\ell(\cdot) = 0$ for each n_h, n_ℓ. Then, only the high-quality good is bought by the consumer. In this case, we can write $p_h(n_h, n_\ell) = \frac{e_h}{e_\ell} p_\ell(n_h, n_\ell)$, so that $R_h(n_h, n_\ell) = \frac{e_h}{e_\ell} R_\ell(n_h, n_\ell)$. Again, all three parts of (b) are satisfied, and part (a) (ii) is satisfied if $R_\ell(k, n-k)$ is decreasing in k.

Now, consider the optimal low-effort contract. Since the agent is risk-averse, it is immediate that if low-effort is induced, the wage paid is $\underline{w}(b) \equiv u^{-1}(w_0 - b)$ regardless of the revenue realized by the firm.[2] The cost to the firm of inducing low effort is therefore just $\underline{w}$. Let the expected cost to a firm of inducing high effort be $c(n_h, n_\ell)$. That is, $c(n_h, n_\ell)$ is the expected wage paid to the agent under the optimal contract that elicits high effort (this optimal contract is exhibited in Section 3). Then, the expected profit of a high-effort firm at time 1 is $\pi_h = R(n_h, n_\ell) - c(n_h, n_\ell)$, and the expected profit of a low-effort firm is $\pi_\ell = R(n_h, n_\ell) - \underline{w}$.

Definition 2 A market equilibrium with n potentially active firms is defined by a pair $(n_h, n_\ell) \in [0, n]^2$ such that:

(i) If $n_h > 0$, $\pi_h(n_h, n_\ell) \geq \max\{\pi_\ell(n_h, n_\ell),\ 0\}$.

(ii) If $n_\ell > 0$, $\pi_\ell(n_h, n_\ell) \geq \max\{\pi_h(n_h, n_\ell),\ 0\}$

(iii) If $n - n_h - n_\ell > 0$, $\max\{\pi_h(n_h, n_\ell),\ \pi_\ell(n_h, n_\ell)\} \leq 0$.

Part (i) of the definition ensures that every high-effort firm earns a weakly higher profit than it would if it either shut down or provided low effort. Parts (ii) and (iii) similarly ensure that a low-effort firm and a firm that stays out, respectively, are playing best responses.

3 Cost of High Effort

Consider the optimal contract when high effort is desired. In this case, the compensation of the agent will depend on the firm's revenue. Let w_h be the wage paid to the agent when the firm is successful (i.e., earns the high revenue y) and w_ℓ the wage when the firm is unsuccessful (i.e., earns revenue zero). As the probability of obtaining high revenue, p_h, depends on n_h and n_ℓ, so will w_h and w_ℓ.

To induce high effort, the incentive compatibility condition for the agent is

$$p_h u(w_h) + (1 - p_h) u(w_\ell) \quad \geq \quad p_\ell u(w_h) + (1 - p_\ell) u(w_\ell) + b, \tag{1}$$

[2] Note that we assume the private benefit can be extracted by the principal. Further, b must be strictly smaller than w_0. If the private benefit cannot be extracted, the optimal low-effort contract is to pay w_0 in both revenue states.

where we suppress the dependence of p_h and p_ℓ on n_h and n_ℓ. Similarly, the participation constraint is

$$p_h u(w_h) + (1 - p_h)u(w_\ell) \quad \geq \quad u_0 \tag{2}$$

Since the principal is risk-neutral, the optimal contract that induces high effort minimizes the expected compensation to the agent. That is, w_h, w_ℓ are chosen to minimize $c(n_h, n_\ell) = p_h w_h + p_\ell w_\ell$.

The next lemma details the utility of the agent in each state optimal high-effort contract. Essentially, both the incentive compatibility and participation constraints must bind, which pins down the contract. The optimal wage levels may be found by inverting the utility levels. For any variable x, let $\Delta_x = x_h - x_\ell$.

Lemma 1 *Among all contracts that elicit high effort, the contract that is uniquely optimal results in the following utilities for the agent in the two revenue states:* $u(w_\ell) = u_0 - \left(e_\ell + \frac{q_\ell}{\Delta_q}\right) \frac{b}{\Delta_e}$ *and* $u(w_h) = u_0 + \left(\frac{1-q_\ell}{\Delta_q} - e_\ell\right) \frac{b}{\Delta_e}$.

The structure of the industry potentially affects the agent's utility in both the high and low revenue states. Both q_h and q_ℓ change with n_h and n_ℓ. The total expected compensation to the agent is $c = p_h w_h + p_\ell w_\ell = p_\ell \left(\frac{e_h}{e_\ell} w_h + w_\ell\right)$. The effect of increased competition on cost therefore depends on the relative rates of change of p_ℓ and w_h as n_h or n_ℓ increase. We show that the cost of high effort also increases with competition for standard goods and decreases with competition for network goods.

Proposition 1 *For each* $j = h, \ell$, $\text{sign}\left(\frac{\partial c}{\partial n_j}\right) = -\text{sign}\left(\frac{\partial q_h}{\partial n_j}\right)$. *That is, both the high-state wage and the cost to a firm of inducing high effort increase with competition for standard products and decrease with competition for network products.*

In particular, suppose the product is a standard good. In the proof of the proposition, we show that $u(w_h)$ increases and $u(w_\ell)$ weakly decreases in n_h and n_ℓ. Since outcomes are binary, increased competition is therefore naturally associated with the agent bearing greater risk. The increase in the cost of high effort may therefore be thought of as compensating the agent for the extra risk he bears. Conversely, if the product is a network good, $u(w_h)$ decreases and $u(w_\ell)$ weakly increases as competition increases. In this case, the agent bears less risk as competition increases, and so must be compensated less. This effect results in a fall in the cost of high effort as the number of firms increases. In the two special cases (multiplicative and high-quality only), u_ℓ stays constant as n_h and n_ℓ changes whereas u_h changes, so the results are even more transparent.

The private benefit of low effort, b, is considered exogenous in our setting. Governance forces other than product market competition may affect the cost of effort. For example, the anti-takeover laws passed in many states in the US during the mid to late 1980s (see Bertrand and Mullainathan, 2003, for details) correspond to a reduced cost of shirking, or an increase in b. We are therefore also interested in how the cost function is affected by changes in the private benefit of low effort, $\frac{\partial c}{\partial b}$, and the effect of competition on that derivative, i.e., in $\frac{\partial^2 c}{\partial b \partial n_h}$.

It is intuitive that the cost of high effort will increase as the private benefit of low effort increases. We show further that the marginal effect of such an increase on the cost of inducing high effort increases with competition for standard products and decreases with competition for network goods. Recall that an industry is more competitive than another industry if both industries have the same number of firms at one effort level and the first industry has a greater number of firms at the other effort level.

Proposition 2 *If the private benefit of low effort increases, so does the cost of high effort;* $\frac{\partial c}{\partial b} > 0$*. Further, firms in a more competitive industry experience a greater increase in the cost of high effort if the product is a standard good, and a smaller increase if the product is a network good. That is, for* $j = h, \ell$*,* $\operatorname{sign}\left(\frac{\partial^2 c}{\partial b \partial n_j}\right) = -\operatorname{sign}(\frac{\partial q_h}{\partial n_j})$.

Therefore, the degree of competition affects both the level of the cost function in an industry and the extent to which the cost function is affected by changes in the private benefit of low effort. Observe that when high effort is induced, incentive compatibility for the manager binds. That is, a manager with high private benefits must earn a sufficiently high compensation to be induced to give up his private benefit. If low effort is provided, of course, the manager directly consumes his private benefit. In the next section, we use the private benefit to define a notion of managerial slack. We then relate slack to both the degree of competition and the cost of inducing high effort.

4 Managerial Slack

How should managerial slack be defined in our setting? Suppose that in equilibrium a firm provides low effort. The manager of the firm then consumes his private benefit b. The private benefit is lost if the firm either provides high effort or shuts down. As a result, we say a manager enjoys slack whenever the firm provides low effort in equilibrium.

Definition 3 A firm exhibits managerial slack if it provides effort e_ℓ in equilibrium.

We consider a short-run situation in which the potential number of firms in the market is fixed at n. A firm may decide to enter or stay out of the market, so the actual number of competitors can vary. The empirical work on managerial slack (for example, Bertrand and Mullainathan, 2003, and Giroud and Mueller, 2010) considers firms in the years immediately before and after a regulatory change. It is natural to consider such periods as short-run ones.

We refer to the equilibrium in which each firm chooses its optimal effort level subject to the incentive problem as a market equilibrium. A useful benchmark is a full-information scenario in which effort is directly contractible in each firm, but each firm still chooses its effort on its own. We define a full-information equilibrium as a Nash equilibrium in which each firm chooses its effort optimally given the efforts of all other firms, given that effort is directly contractible.

The agents in our model are risk-averse. Therefore, if effort is directly contractible, it is immediate that the optimal wage will be w_0 if high effort is induced and $\underline{w}(b) = u^{-1}(w_0 - b)$ if low effort is induced. The choice between these two, of course, will depend on the level of the private benefit b and on the effect of competition on expected firm revenue, as captured by the functions $p_h(\cdot)$ and $p_\ell(\cdot)$.

We provide a condition under which all firms provide high effort in a full-information equilibrium. Let n be the potential number of firms in the market in a short-run equilibrium.

Assumption 2 $R_h(n,0) - w_0 \geq \max\{R_\ell(n,0) - \underline{w}(b), 0\}$.

Recall that $\underline{w}$ decreases with b. Therefore, Assumption 2 essentially implies that b must be relatively small, compared to $R_h(n,0) - R_\ell(n,0)$. For the rest of the paper, we assume that Assumption 2 holds.

Lemma 2 *Consider a short-run situation in which there are n potential firms in the market. Under Assumption 2, in the unique full-information equilibrium, all n firms participate and each firm provides high effort.*

Now, consider a social planner who can both directly choose the effort level of each firm and also whether a firm is operational. Under Assumption 2, the planner will never operate a low-effort firm. However, the planner may choose to shut down some of the n firms. In a Nash equilibrium, each firm ignores the externality it imposes on other firms when it enters the market (i.e., it ignores the fact that R_h and R_ℓ depend on the number of high and low effort firms). A planner, however, must consider the externality and may wish to have fewer than n firms operational. Our definition of managerial slack is therefore also meaningful when compared to a planning benchmark. If the firm is shut or provides high effort, the manager loses his private benefit b. In any scenario in which he consumes b, he enjoys managerial slack.[3]

Our notion of managerial slack is straightforwardly extended to the level of the industry: the number of low-effort firms in a market equilibrium is directly a measure of industry-level slack. Let $\hat{n}_{\ell i}$ be the number of low-effort firms in a market equilibrium i. Consider two short-run market equilibria with the same number of potentially active firms, n. Then, we say the industry exhibits greater slack in equilibrium i compared to equilibrium j if $\hat{n}_{\ell i} > \hat{n}_{\ell j}$.

We now turn to the effect of an exogenous change in the private benefit of low effort on two industries that differ in the number of firms in the industry. Giroud and Mueller (2010) consider the effect of business combination laws on industries of varying degrees of competition, which they measure by the distribution of sales across firms (specifically, the Herfindahl–Hirschman Index). Business combination laws make it more difficult to subject managers to financial market discipline (by posing frictions to takeovers) and therefore increase the benefit of low effort (b) in our model. As business combination laws were passed by different states in the US at different points of time, they are an appealing source of exogenous legal variation that allows for difference-in-difference estimation. Giroud and Mueller (2010) find that in competitive industries there is little or no change in measures

[3] One could argue that even if a planner would choose some firms to operate at low effort, it is reasonable to say that a firm exhibits managerial slack whenever the manager enjoys his private benefit. However, note that slack itself is a less important economic concept if it is part of a first-best world.

of value when a business combination law is passed, whereas there is a fall in values in less competitive industries. They conclude that "competition mitigates managerial slack."

To replicate the thought experiment at the heart of their estimation, we consider in our model the effect of a change in b when the number of firms can vary across industries. Define $\bar{n}$ to be the maximal number of firms such that a firm is indifferent between high and low effort if all other firms provide low effort. That is, $\bar{n}$ satisfies

$$\bar{n} \quad = \quad \max\{n \mid R_h(0,n) - c(0,n) = R_\ell(0,n) - \underline{w}\}.$$

Now, by Assumption 1 (a) (ii), $\Delta_R(0,n)$ is decreasing in n. If the product is a standard good, $c(0,n)$ is increasing in n. It follows that $\bar{n}$, which satisfies $\Delta_R(0,n) - c(0,n) = \underline{w}$, is uniquely defined. If the product is a network good, there may be multiple values of n that satisfy the conditions on the right-hand side of equation (3), in which case we take $\bar{n}$ to be the maximum number of firms that satisfies the definition.

Consider an industry in the short-run at $t = 0$ with n active firms. We define the industry to be *competitive* if $n \geq \bar{n}$, and *concentrated* if $n < \bar{n}$. We first show that, if the product is a standard good and if α (the revenue parameter) is sufficiently high, the equilibrium involves only low-effort firms in a competitive industry, but at least some high-effort firms in a concentrated one. One factor to keep in mind is that the number of firms that defines the threshold for a competitive industry (i.e., $\bar{n}$) increases with α.

Lemma 3 *There exists an $\underline{\alpha}$ such that for all $\alpha > \underline{\alpha}$:*
(i) If the industry is competitive, there is a unique market equilibrium in which all firms provide low effort.
(ii) If the industry is concentrated, in equilibrium some firms provide high effort. In the multiplicative and high-quality only cases, the equilibrium is unique for a standard good.

With a network good and a concentrated industry, there may be multiple equilibria. In this case, we focus on the equilibrium that maximizes the number of high-effort firms, or minimizes managerial slack. As the first-best outcome involves only high-effort firms, this equilibrium provides an outcome closer to first-best.

4.1 Regulatory Change: Increase in Private Benefit of Low Effort

The private benefit of low effort, b, affects the cost of high effort in the second-best problem, but not in the first-best one. Changes in b will therefore have a direct effect on managerial slack. We treat b as exogenous to our model. In practice, we expect b to depend on other governance forces that are brought to bear on the manager and also on the manager's ability to extract rents from the principal when negotiating his contract. For example, better monitoring from the board will reduce b, and a change in regulations or the market environment that makes takeovers more difficult will increase b.

Consider the following scenario. Due to a regulatory change, there is an exogenous increase in b. What effect will this have on managerial slack and managerial value in a given industry? To address this question, we start by determining how the cost of both high and low effort respond to the change in b. Suppose the regulatory change occurs between times $t = 0$ and $t = 1$. Let b_t denote the private benefit at time t, so that $b_1 > b_0$. Observe that a change in regulation potentially affects all firms. We postulate that a manager's outside option is to work at another firm and provide low effort. Then, the regulatory change also increases the reservation utility of the manager, to $u_1 = u_0 + (b_1 - b_0)$.

Let $c_t(\cdot)$ denote the cost of high effort and $\underline{w}(u_t, b_t)$ the cost of low effort at time t. We show that the cost of low effort does not change as a result of the increase in b, but the cost of high effort increases.[4]

Lemma 4 *(i) For each (n_h, n_ℓ) pair, $c_1(n_h, n_\ell) > c_0(n_h, n_\ell)$.*
(ii) $\underline{w}(u_1, b_1) = \underline{w}(u_0, b_0)$.

Next, consider the change in managerial slack as b increases. We find that managerial slack weakly increases in all cases, and strictly increases if the equilibrium at $t = 0$ features both high- and low-effort firms.

Proposition 3 *Suppose that at $t = 0$ the market is in short-run equilibrium with n active firms. Then, regardless of whether the product is a network or standard good, managerial slack is weakly higher at $t = 1$. Further, if at $t = 0$ the short-run equilibrium has both high- and low-effort firms active, managerial slack is strictly higher at $t = 1$.*

The intuition behind the previous proposition is as follows. An increase in b strictly increases the cost of high effort. To satisfy incentive compatibility, the wedge between the

[4] If the private benefit cannot be extracted by the principal, the reservation utility remains u_0, but again the cost of low effort does not change. It remains optimal to offer w_0 in both states if low effort is desired. See also footnote 2.

high-output wage and low-output wage must increase, which is costly since the agent is risk-averse. Meanwhile, the cost of low effort (i.e., the wage paid when low effort is desired) remains the same. Therefore, at the margin the incentive for each firm to provide low effort strictly increases. If all firms are providing low effort, of course, there can be no change in slack. If all firms are providing high effort, it is possible that the incentive to provide low effort has no effect. However, in any equilibrium in which firms are indifferent between high and low effort, it must be that the number of low effort firms increases, thereby increasing managerial slack.

Observe that external and internal governance are effectively complements in this setting. To the extent that the private benefit of low effort, b, is set by external forces, it is a proxy for external governance. A higher b implies weaker external governance. Similarly, a firm that allows its manager to consume slack may be thought of as having weak internal governance. From Proposition 3, weaker external governance leads to weaker internal governance, so that the two are complements.[5]

We now consider the effect of a regulatory change that affects b on firm value. Let $\underline{\alpha}_0$ be the threshold value of α (as in Lemma 3) at time 0. In a competitive industry, the increase in b has no effect. In a concentrated industry, both firm value and managerial slack can change. However, as part (ii) of the next proposition shows, average firm value can fall without a change in slack, and as part (iii) shows, firm value can increase while slack increases. Therefore, the link between managerial slack and firm value is ambiguous.

Proposition 4 *Suppose $\alpha > \underline{\alpha}_0$ and all n firms continue to be active at $t = 1$.*

(i) If the industry is competitive at $t = 0$, at $t = 1$ managerial slack and average firm value are unchanged.

(ii) If the industry is concentrated and both high- and low- effort firms exist at $t = 0$, managerial slack is strictly higher at $t = 1$. However, the average value of a firm is higher (rather than lower) at $t = 1$.

(iii) If the industry is concentrated and there are only high effort firms at $t = 0$:

(a) If there are only high-effort firms in the industry at $t = 1$, managerial slack is unchanged but firm value is lower than at $t = 0$.

[5] Cohn and Rajan (2010) consider a setting in which the choice of internal governance affects the incentives of an external activist. In such a setting, internal and external governance may sometimes be complements.

(b) If there are both high- and low-effort firms in the industry at $t = 1$, managerial slack is higher than at $t = 0$, but firm value may be higher, the same, or lower.

The relationship between slack and firm value is therefore subtle. In a concentrated industry with only high effort firms, a small change in b is likely to imply that firms continue to provide high effort. However, in this case the profit of each firm must fall, as the cost of inducing high effort has strictly increased. Conversely, a large change is likely to induce some firms to switch to low effort. In this case, managerial slack in the industry is clearly higher after the increase in b. However, firm value may actually increase rather than decrease. As there are fewer high-effort firms in equilibrium, the revenue of a firm that chooses to provide low effort is strictly higher at $t = 1$ (compared to its potential revenue at $t = 0$), while the cost of inducing low effort has remained the same. In other words, higher slack implies less intense competition in the industry, allowing each firm to earn a higher expected profit.

If the industry has both high and low effort firms, an increase in b unambiguously leads to an increase in managerial slack. However, the profit of each low effort firm increases, since its revenue is higher and the cost stays the same. In this case, all firms must be earning the same profit in equilibrium, so every firm experiences an increase in profit.

Empirically, the "difference-in-difference" empirical test employed by Giroud and Mueller (2010) compares the relative change in firm value between a concentrated and a competitive industry following a regulatory change. We interpret a new business combination law as increasing the private benefit of low effort, b, and also increasing the reservation utility of the manager. Giroud and Mueller find that firms in concentrated industries lose more in value than firms in competitive industries.

Their findings correspond to parts (i) and (iii) (a) of Proposition 4. As we show, the relative value of firms in a concentrated industry falls even with no change in realized managerial slack in either kind of industry. In particular, we make a distinction between *potential* managerial slack, which may be measured directly by the private benefit b, and *realized* managerial slack, which can only be consumed by the manager if the firm induces low effort in equilibrium. An increase in potential slack will increase the cost of providing incentives to the manager, even if there is no change in realized slack (that is, the firm continues to provide high effort).

Further, even in this case, the interpretation of the empirical findings is reversed in our model. In our setting, realized slack is greatest in a competitive industry. If all firms provide low effort, industry-level slack is just equal to the number of firms in the industry. A regulatory change in b leads to no change in slack in a competitive industry, but it can increase slack in a concentrated industry. However, the increase in slack may or may not be accompanied by a decline in average firm value.

Note that the proposition holds as long as the increase in b is sufficiently small that no firm in the competitive industry exits the market. If firms exit the market, slack can fall under competition as well. In this scenario, a direct comparison will need to be made between the changes in the slack in each industry.

Finally, observe that although the degree of competition in the industry may be approximated by the number of firms (as in, for example, the Herfindahl index), heterogeneity of effort across firms implies that competition cannot be measured simply the number of firms. In particular, an industry with some high-effort firms may be competitive (firms may be earning zero profit), whereas an industry with a relatively large number of low-effort firms may be uncompetitive (firms may be earning positive profit).

5 Slack and Quality

Consider an industry with n firms. It is immediate that, comparing any two situations in which all n firms are active, the average quality of goods in the industry is inversely related to industry-level managerial slack. However, the relationship between industry-level slack and quality is more ambiguous if the industry with greater slack also has a greater number of high-quality firms.

We first consider the following situation: how do slack and quality in an industry relate to the observed wages? Suppose there are a sufficient number of high-quality firms in the industry so that the high-effort wages conditional on both success and failure (i.e., w_h and w_ℓ) are observed. Let w_{hj} ($w_{\ell j}$) for $j = 1, 2$ denote the wage in the high-revenue (low-revenue) state and b_j the private benefit of effort in equilibrium j. To draw inferences on quality from observed wages, we further restrict attention to the two special cases metioned earlier — the multiplicative and high-quality only cases.

Proposition 5 *Consider two market equilibria* $1, 2$ *with the same number of active firms. Suppose* $w_{\ell 1} < w_{\ell 2}$ *and* $w_{h1} > w_{h2}$*. Then, in both the multiplicative and high-quality only cases,* *(i) If the product is a network good, $b_1 > b_2$ and the average quality of the good is weakly lower in equilibrium 1.*

(ii) If the product is a standard good, both b and the average quality may be higher or lower in equilibrium 1.

In Proposition 5, the two equilibria may refer to either the same industry at different points of time or different industries at the same point of time. Observe that the inference about potential slack (b) depends on whether the product is a network or standard good. As potential and realized industry-level slack are positive related, so does the inference about realized slack. In particular, with a standard good, observing the range of high-effort wages does not allow for an unambiguous inference about slack and quality.

Finally, we consider the effect of an increase in competition on slack and quality. Since firms are infinitesimal in our framework, an increase in competition is defined as the entry of a positive mass of firms. We show that if sufficient entry occurs, all firms induce low effort so that maximal slack obtains.

Proposition 6 *Suppose $\alpha > \underline{\alpha}$. Consider an industry with n firms, at least some of which are providing high effort. If there is sufficient entry into the industry, regardless of whether the product is a standard or network good, in the new equilibrium all firms provide low effort.*

Competition can therefore lead to an increase rather than a decrease in slack, and an accompanying loss of quality in the product market. If enough entry occurs, there is a "race to the bottom" with all firms providing low effort.

Of course, the question of how much entry leads to an adverse effect on quality is an empirical one. In the credit ratings market, Becker and Milbourn (2009) find that the entry of Fitch (which effectively increases the number of credit rating agencies from two to three) led to a decine in the average quality of credit ratings. Along similar lines, Propper, Burgess and Gossage (2003) find a negative relationship between quality and the degree of competition following a reform of the National Health Service in the UK. Both these instances are consistent with the increase in competition leading to greater managerial slack.

The literature on banking and competition finds mixed effects of competition on quality. For example, Keeley (1990) argues that, in the presence of deposit insurance, increased competition led to excessive risk-taking by banks. Boyd and de Nicolo (2005) provide a model of competition over deposits that generates this feature, and then demonstrate that adding competition in the loan market reverses the result, with competition leading to more prudent behavior.

6 Conclusion

We show that the connection between competition, managerial slack and firm value is ambiguous in many respects. In our setting, slack is optimally chosen by a profit-maximizing firm. The cost of inducing high effort varies with the degree of competition, increasing with competition for standard goods and decreasing with competition for network goods. The expected marginal revenue from high effort always decreases with competition. The eventual effect of competition on effort (and hence slack) is determined by the interplay of these two forces.

Our results on slack suggest that the connection between slack and firm value is ambiguous. As slack is typically not directly observed, this makes it difficult to draw clean inferences. Firm value can increase even while slack increases, and slack can increase even though firm value remains constant. By definition, firms which experience slack must face some friction that prevents its mitigation. Thus, there is no monotone relationship between slack and firm value.

Our reduced form model is more appropriate for service than manufacturing industries. First, we assume an immediate link between agent effort and product quality. The service sector is more consistent with flexible quality choice: It is more difficult to upgrade a car factory than it is to provide incentives for better service. Second, quality is not verifiable to a third party, so cannot be directly contracted on. By nature, services are experience goods: It is easier to measure a car's attributes than to determine if a waiter was polite. We note that the service industry is large: In the U.S., it accounts for approximately two-thirds of domestic production and includes most of the financial sector.

The standard argument in favor of competition is that, fixing a production technology and factor prices, free entry drives firms to produce at the minimum of the long run cost curve, which is socially efficient. In service industries, the good being produced is typically intangible and depends on the interaction of agents. Indeed, there is no reason to view the "cost function" as invariant to market structure, an idea fundamental to the efficiency of competitive equilibrium. We show that competition can change the cost of producing high quality services, rendering the notion of "the minimum of the long run average cost curve" specious.

Over the last twenty years, social policy has encouraged competition in service industries, for example the deregulation of financial markets (the National Market System), competitive provision of directory assistance in the UK or the plethora of subprime mortgage brokers. Recent experiences suggest that competition in service sectors has not been exemplary. For example, Propper, Burgess and Gossage (2003) examine the reforms of the National Health Service in the UK. Using quality measures (such as mortality) they find a negative relationship between quality and the degree of competition. Similarly, a National Audit Office Report on the privatization of Britain's directory enquiry services in November 2003 concluded that, initially, the proportion of accurately provided telephone numbers was only 62%. While this improved to 86% over a year, usage had fallen off dramatically, especially in the over-55 age group. Meanwhile, competition had increased substantially: A year after the privatization, as many as 217 directory enquiry numbers were in service.

These observations are consistent with our model. While competition may have an effect on firms' expected revenue, it may also affect principals' incentives to elicit high effort and consequently quality. The competitive market may fall short of the appropriate benchmark. In this paper we do not explore remedies, but various spring to mind. First, barriers to entry in as much as they facilitate corporate governance may be efficient. Second, laws that affect governance should be tailored to the type of good produced by the industry (standard or one with externalities). Finally, dispersed share ownership (equivalent to our principal and risk averse agent problem) can induce inefficiencies in competition; therefore firm size should be limited in some industries.

Appendix: Proofs

Proof of Lemma 1

It is immediate that the participation constraint (2) must bind. Suppose not; then, w_h and w_ℓ can both be reduced in a manner that preserves the difference $u(w_h) - u(w_\ell)$, and hence continues to satisfy the incentive compatibility constraint.

Next, consider the incentive compatibility constraint, (1). This constraint may be restated as

$$u(w_h) - u(w_\ell) \quad \geq \quad \frac{b}{p_h - p_\ell}. \tag{3}$$

If the IC does not bind, the first-order conditions imply that $u'(w_h) = u'(w_\ell)$, or $w_h = w_\ell$. However, a constant wage violates the IC constraint. Therefore, the IC constraint must bind.

With both constraints holding as equalities, solving for $u(w_h)$ and $u(w_\ell)$ yields

$$\begin{aligned} u(w_\ell) &= u_0 - \frac{p_\ell}{p_h - p_\ell} b \\ u(w_h) &= u_0 + \frac{1 - p_\ell}{p_h - p_\ell} b. \end{aligned}$$

Now, $p_\ell = q_\ell + e_\ell \Delta_q$, and $p_h - p_\ell = \Delta_e \Delta_q$. Therefore,

$$u(w_\ell) = u_0 - \left(e_\ell + \frac{q_\ell}{\Delta_q} \right) \frac{b}{\Delta_e} \tag{4}$$

$$u(w_h) = u_0 + \left(\frac{1 - q_\ell}{\Delta_q} - e_\ell \right) \frac{b}{\Delta_e}. \tag{5}$$

■

Proof of Proposition 1

Denote $u_h = u(w_h)$ and $u_\ell = u(w_\ell)$. First, consider a change in n_h. From equation (5), it follows that

$$\begin{aligned} \frac{\partial u_h}{\partial n_h} &= -\frac{b}{\Delta_e \Delta_q^2} \left[\frac{\partial q_h}{\partial n_h} - \frac{\partial q_\ell}{\partial n_h} + q_h \frac{\partial q_\ell}{\partial n_h} - q_\ell \frac{\partial q_h}{\partial n_h} \right] \\ &= -\frac{b}{\Delta_e \Delta_q^2} \left[(1 - q_\ell) \frac{\partial q_h}{\partial n_h} - (1 - q_h) \frac{\partial q_\ell}{\partial n_h} \right]. \end{aligned} \tag{6}$$

Now, $1 - q_\ell > 1 - q_h$. Suppose the good is a standard good, so that q_h, q_ℓ are decreasing in n_h. Under Assumption 1 part (b) (iii), it follows that $\frac{\partial q_h}{\partial n_h} \leq \frac{\partial q_\ell}{\partial n_h}$. Therefore, the term $(1 - q_\ell)\frac{\partial q_h}{\partial n_h} - (1 - q_h)\frac{\partial q_\ell}{\partial n_h}$ is negative, so that $\frac{\partial u_h}{\partial n_h} > 0$.

Similarly, for a network good, $\frac{\partial q_h}{\partial n_h} \leq \frac{\partial q_\ell}{\partial n_h} > 0$. Therefore, the term $(1 - q_\ell)\frac{\partial q_h}{\partial n_h} - (1 - q_h)\frac{\partial q_\ell}{\partial n_h}$ is positive, so that $\frac{\partial u_h}{\partial n_h} < 0$.

Next, consider how u_ℓ changes when n_h changes. From equation (4), we have

$$\begin{aligned} \frac{\partial u_\ell}{\partial n_h} &= -\frac{b}{\Delta_e \Delta_q^2}\left[(q_h - q_\ell)\frac{\partial q_\ell}{\partial n_h} - q_\ell(\frac{\partial q_h}{\partial n_h} - \frac{\partial q_\ell}{\partial n_h})\right] \\ &= -\frac{b}{\Delta_e \Delta_q^2}\left[q_h \frac{\partial q_\ell}{\partial n_h} - q_\ell \frac{\partial q_h}{\partial n_h}\right]. \end{aligned} \tag{7}$$

Suppose the good is a standard good. Then, under Assumption 1 part (b) (iv), it follows that $q_h \frac{\partial q_\ell}{\partial n_h} - q_\ell \frac{\partial q_h}{\partial n_h} \geq 0$, so that $\frac{\partial u_\ell}{\partial n_h} \leq 0$. Now, as n_h increases, u_h strictly increases and u_ℓ weakly decreases. As the agent's expected utility u_0 remains the same, it follows that $c(\cdot)$ increases.

Next, suppose the good is a network good. Then, it follows that $q_h \frac{\partial q_\ell}{\partial n_h} - q_\ell \frac{\partial q_h}{\partial n_h} \leq 0$, so that $\frac{\partial u_\ell}{\partial n_h} \geq 0$. Now, as n_h increases, u_h strictly decreases and u_ℓ weakly increases. As the agent's expected utility u_0 remains the same, it follows that $c(\cdot)$ decreases.

Therefore, for both a network and standard good, $\text{sign}\left(\frac{\partial c}{\partial n_h}\right) = -\text{sign}\left(\frac{\partial q_h}{\partial n_h}\right)$. The analysis is exactly similar for changes in n_ℓ. ■

Proof of Proposition 2

As in the proof of Proposition 1, let u_i denote $u(w_i)$, for $i = h, \ell$. From the expressions for u_h and u_ℓ in equations (5) and (4), it follows that $\frac{\partial u_h}{\partial b} = \frac{1}{\Delta_e}\left(\frac{1-q_\ell}{\Delta_q} - e_\ell\right) > 0$ and $\frac{\partial u_\ell}{\partial b} = -\frac{1}{\Delta_e}\left(e_\ell + \frac{q_\ell}{\Delta_q}\right) < 0$. Therefore, it must be that $c(\cdot)$ increases as b increases.

Now, consider $\frac{\partial^2 u_i}{\partial n_j \partial b}$ for $i, j = h, \ell$. Given the expressions for $\frac{\partial u_i}{\partial b}$ in the previous paragraph, it is immediate that $\frac{\partial(\partial u_i/\partial b)}{\partial n_j}$ has the same sign as $\frac{\partial u_i}{\partial n_j}$. From the proof of Proposition 1, it follows that for a standard good, $\frac{\partial u_h}{\partial b}$ increases as n_h increases, and $\frac{\partial u_\ell}{\partial b}$ weakly decreases. Therefore, an increase in b has a greater impact on u_h and u_ℓ in a more competitive industry. It follows that $c(\cdot)$ increases by a larger amount in a competitive industry; that is, $\frac{\partial^2 c}{\partial n_i \partial b} > 0$.

For a network good, the profo is similar: $\frac{\partial u_h}{\partial b}$ decreases as n_h increases, and $\frac{\partial u_\ell}{\partial b}$ weakly increases. Again, an increase in b has a greater impact on u_h and u_ℓ in a more competitive industry. It follows that $c(\cdot)$ decreases by a larger amount in a competitive industry; that is, $\frac{\partial^2 c}{\partial n_i \partial b} < 0$. Therefore, for both a standard and a network good and for each $j = h, \ell$, $\text{sign}\left(\frac{\partial^2 c}{\partial b \partial n_j}\right) = -\text{sign}(\frac{\partial q_h}{\partial n_j})$. ■

Proof of Lemma 2

Suppose effort is directly contractible. Observe that a contract with $u(w_h) = u(w_\ell) = u_0$ satisfies the individual rationality constraint of an agent who supplies high effort. As the agent is risk-averse, the contract is clearly optimal among all feasible contracts. In the contract specified, $w_h = w_\ell = w_0$. Therefore, the cost of high effort to the firm is $c(n_h, n_\ell) = w_0$ for all n_h, n_ℓ.

Now, suppose the firm induces low effort. From the participation constraint

$$p_\ell u(w_h) + (1 - p_\ell)u(w_\ell) + b \quad \geq \quad u_0,$$

it is immediate that the optimal wage is $\underline{w}(b) = u^{-1}(u_0 - b)$ in both revenue states.

Now, suppose all n firms participate and provide high effort. Then, the profit of each firm is $R_h(n, 0) - w_0$. Since $R_h(n, 0) \geq w_0$, each firm is willing to participate in the market. As $R_h(n, 0) - w_0 \geq R_\ell(n, 0) - \underline{w}(b)$ (by Assumption 2), no firm has an incentive to switch to low effort. Finally, observe that $\Delta_R(k, n-k) = R_h(n-k) - R_\ell(k, n-k)$ decreases with k, given Assumption 1, part (a) (ii). Therefore, there cannot be any other equilibrium in which some firms provide low effort. In any such scenario, a low-effort firm strictly gains by deviating and providing high effort instead. ∎

Proof of Lemma 3

(i) Suppose there are $\hat{n} > \bar{n}$ firms in the industry at $t = 0$. Suppose all other firms are supplying low effort, and consider firm i. If it induces high effort, its expected profit is $\pi_h = R_h(0, \hat{n}) - c(0, \hat{n})$. If it induces low effort, its expected profit is $\pi_\ell = R_\ell(0, \hat{n}) - \underline{w}(u_0, b_0)$. The difference is $\pi_h - \pi_\ell = \Delta_R(0, \hat{n}) - c(0, \hat{n}) - \underline{w}(u_0, b_0)$. By Assumption 1 (a) (ii), $\Delta_R(0, \hat{n})$ is decreasing in $\hat{n}$. Now, for a standard good, $c(0, \hat{n})$ is increasing in $\hat{n}$, so it follows $\pi_\ell > \pi_h$. If the good is a network good, $c(0, \hat{n})$ is instead decreasing in $\hat{n}$. But by the definition of $\bar{n}$, there is no greater n such that $\Delta_R(0, n) = c(0, n) - wubar(u_0, b_0)$. Further, as n becomes large, it must be that $\Delta_R(0, n) \to 0$, since $R_h(0, n) \to 0$ (Assumption 1 (a) (iii)). However, $c(0, n)$ remains bounded below by $\underline{w}(u_0, b_0) > 0$. Therefore, it must be that $\pi_\ell > \pi_h$; that is, a firm prefers to provide low effort rather than high effort.

Thus, regardless of whether the product is a standard or network good, if $\pi_\ell \geq 0$ it is a best response for firm i to supply low effort. Choose an $\tilde{\alpha}$ such that $\bar{n}$ is positive, and choose an $\hat{n} > \bar{n}$. Consider $R_\ell(0, \hat{n}) = \alpha p_\ell(0, \hat{n}) y(0, \hat{n})$. Define $\alpha_1 = \frac{\underline{w}}{p_\ell(0,\hat{n}) y(0,\hat{n})}$. Then, for $\alpha > \alpha_1$, it is a unique Nash equilibrium for all firms to supply low effort.

(ii) Next, suppose there are $\tilde{n} < \bar{n}$ firms in the industry. Suppose all other firms are supplying low effort, and consider firm i. If it supplies high effort, its expected profit is $\tilde{\pi}_h = R_h(0, \tilde{n}) - c(0, \tilde{n})$. If it supplies low effort, its expected profit is $\tilde{\pi}_\ell = R_\ell(0, \tilde{n}) - \underline{w}$. Following the same logic as for the case $\hat{n} > \bar{n}$, it follows that $\tilde{\pi}_\ell < \tilde{\pi}_h$. Choosing the same $\tilde{\alpha}$ as before such that $\bar{n}$ is positive, consider $\tilde{n} < \bar{n}$. Define $\alpha_2 = \frac{c(0,\tilde{n})}{R_h(0,\tilde{n})}$. Then, for $\alpha \geq \alpha_2$, it is a best response for firm i to supply high effort. Therefore, in equilibrium at least some firms will provide high effort.

Finally, define $\underline{\alpha} = \min\{\alpha_1, \alpha_2\}$.

To show that for a standard product the equilibrium in part (ii) is unique in the multiplicative and high-quality only cases, consider the cost function $c(k, n-k)$ as k varies. It follows that $\frac{\partial c}{\partial k} = \frac{\partial c}{\partial n_h} - \frac{\partial c}{\partial n_\ell}$.

We exhibit the multiplicative case here; the proof for the high-quality only case is similar. In the multiplicative case, $q_h(n_h, n_\ell) = \theta q_\ell(n_h, n_\ell)$ for each n_h, n_ℓ, where $\theta > 1$. Therefore, $\frac{\partial q_h}{\partial n_j} = \theta \frac{\partial q_\ell}{\partial n_j}$ for each $j = h, \ell$. From equation (7) in the proof of Proposition 1, it follows that $\frac{\partial u_\ell}{\partial n_j} = 0$.

Define $g_j = u^{-1}(u_j)$ to be the inverse utility in revenue state j. Then, we can write $c = p_h w_h + (1-p_h) w_\ell = p_h g_h + (1-p_h) g_\ell$. As u_ℓ is invariant to changes in n_h and n_ℓ, so is g_ℓ. Therefore, $\frac{\partial c}{\partial n_j} = p_h g_h' \frac{\partial u_h}{\partial n_j} + (g_h - g_\ell)\frac{\partial p_h}{\partial n_j}$.

Now, in the multiplicative case, substituting $q_h = \theta q_\ell$ in equation (6), we obtain $\frac{\partial u_h}{\partial n_j} = -\frac{b}{\Delta_e(\theta-1)q_\ell^2}(\theta-1)\frac{\partial q_\ell}{\partial n_j}$, which is immediately seen to be positive when $\frac{\partial q_\ell}{\partial n_j} < 0$ (i.e., for a standard good). Further, $p_h = e_h q_h + (1-e_h) q_\ell = [1 + e_h(\theta-1)] q_\ell$. Therefore, we can write

$$\frac{\partial c}{\partial n_j} \quad = \quad \frac{\partial q_\ell}{\partial n_j}\{1 + e_h(\theta - 1)\}\left[g_h - g_\ell - g_h' \frac{1}{(\theta-1)q_\ell}\frac{b}{\Delta_e}\right].$$

From Proposition 1, we know that for a standard good $\frac{\partial c}{\partial n_j} > 0$. Therefore, it must be that $g_\ell > g_h - g_h' \frac{1}{(\theta-1)q_\ell}\frac{b}{\Delta_e}$ (this also follows directly from the convexity of the inverse utility function g). Now, from Assumption 1 (b) (ii), it follows that $\frac{\partial c}{\partial k} > 0$.

Under Assumption 1 (a) (ii), $\Delta_R(k, n-k)$ is decreasing in k. In equilibrium, either $\Delta_R(k^*, n-k^*) = c(k^*, n-k^*)$ for some k^*, or $\Delta_R(n, 0) \geq c(n, 0)$. As $\Delta_R(k, n-k)$ decreases in k and $c(k, n-k)$ increases in k for a standard product, in either case the equilibrium is unique. ∎

Proof of Lemma 4

(i) Since n_h and n_ℓ are being held fixed, q_h and q_ℓ are also unchanged. From equations (4) and (5), it is immediate that $u(w_\ell)$ decreases in b and $u(w_h)$ increases in b. Further, at $t = 1$, the manager's participation constraint is

$$p_h u(w_h) + p_\ell u(w_\ell) \quad \geq \quad u_1 \; > \; u_0.$$

Therefore, the expected utility of the manager is higher at $t = 1$ than at $t = 0$, and the range between the high and low wages has also increased. As the manager is risk-averse, the cost to the principal is strictly higher. Since the argument holds for any value of the pair (n_h, n_ℓ), $c_1(\cdot) > c_0(\cdot)$.

(ii) The optimal low-effort wage at $t = 0$ is $\underline{w}(u_0, b_0) = u^{-1}(u_0 - b_0)$. The optimal low-effort wage at $t = 1$ is $\underline{w}(u_1, b_1) = u^{-1}(u_1 - b_1)$. But $u_1 = u_0 + b_1 - b_0$, so $\underline{w}(u_1, b_1) = \underline{w}(u_0, b_0)$.

■

Proof of Proposition 3

Suppose first that the market equilibrium at $t = 0$ has both high and low effort firms active. Let z be the number of low effort firms, so that $n - z$ is the number of high-effort firms. At $t = 0$, the optimal low-effort wage is $\underline{w}(u_0, b_0)$, and the expected cost of inducing high effort with the optimal contract is $c_0(n - z, z)$.

As each firm is infinitesimal, in equilibrium each firm must be indifferent between choosing high and low effort. Therefore, it must be that $R_h(n - z, z) - c_0(n - z, z; b) = R_\ell(n - z, z) - \underline{w}(u_0, b_0)$. Therefore, it must be that

$$\Delta_R(n - z, z) \quad = \quad c_0(n - z, z) - \underline{w}(u_0, b_0). \tag{8}$$

Now, Lemma 4 shows that $c_1(\cdot) > c_0(\cdot)$, and $\underline{w}(u_1, b_1) = \underline{w}(u_0, b_0)$. Therefore, at $t = 1$, the right-hand side of equation (8) is strictly higher. The left-hand side is unaffected by b. Further, $\Delta_R(n - z, z)$ increases as z increases (by Assumption 1 part (a) (ii)). Therefore, it must be that z strictly increases; that is, managerial slack increases.

Now, suppose the market equilibrium has only high-effort firms. In this case, slack is zero, so that (8) may be written as $\Delta_R(n, 0) \geq c_0(n, 0) - \underline{w}(u_0, b_0)$. Now, a small increase in b may be followed by no change in the number of low-effort firms, as the inequality may still be satisfied. Therefore, there is only a weak increase in managerial slack.

Finally, if the market equilibrium has only low-effort firms, then $\Delta_R(0, n) < c_0(0, n) - \underline{w}(u_0, b_0)$. An increases in b increases the right-hand side, so that it is still optimal for each firm to provide low effort. Therefore, there is no change in managerial slack. ■

Proof of Proposition 4

(i) As shown in Lemma 4, an increase in b results in $c_1(\cdot) > c_0(\cdot)$ and $\underline{w}(u_1, b_1) = \underline{w}(u_0, b_0)$. Suppose the industry at $t = 0$ is competitive. Then, at $t = 1$ it remains a best response for each firm to provide low effort, so there is no change in slack. As neither revenues nor costs have changed, the value of the firm remains the same as well.

(ii) Next, suppose the industry at $t = 0$ is concentrated and the equilibrium at $t = 1$ has both high and low effort firms. Let k_t be the number of high-effort firms at time t. Then, $c_1(\cdot) > c_0(\cdot)$ implies that $k_1 < k_0$. Now, both at $t = 0$ and $t = 1$, each firm is indifferent between high and low effort. A low-effort firm earns a profit $R_\ell(k_t, n - k_t) - \underline{w}(u_t, b_t)$ at time t. Assumption 1 (ii) implies that $R_\ell(k_1, n - k_1) > R_\ell(k_0, n - k_0)$. Further, from Lemma 4 (ii), $\underline{w}(u_0, b_0) = \underline{w}(u_1, b_1)$. Therefore, each low-effort firm earns a higher profit at $t = 1$. Since every firm (high or low effort) earns the same profit, the average firm value has increased.

(iii) Finally, suppose the industry at $t = 0$ is concentrated with only high-effort firms. Then, it must be that $R_h(n, 0) - c_0(n, 0) \geq R_\ell(n, 0) - \underline{w}(u_0, b_0)$. Denote by $\hat{k}$ the number of high-effort firms in the new equilibrium at time 1. There are two possibilities:

(a) $\hat{k} = n$. Then, since $c_1(n, 0) > c(n, 0)$, it is clear that the profit (and hence value) of each firm is lower at $t = 1$. However, slack is unchanged at zero.

(b) $\hat{k} \in (0, n)$. In this case, industry slack has increased to $n - \hat{k}$. As in part (ii), the profit of a low effort firm must have increased. However, in this case it is possible that $R_h(n, 0) - c_0(n, 0) > R_\ell(n, 0) - \underline{w}(u_0, b_0)$, so the average firm value may have decreased or stayed the same, rather than increased. ■

Proof of Proposition 5

From Proposition 3, we know that industry-level slack is weakly higher whenever b is higher. Further, from the definition of slack, the average quality of the product is inversely related to industry-level slack.

Now, from Lemma 1, it follows that $\Delta_u = u_h - u_\ell = \frac{1}{\Delta_e} \frac{b}{\Delta_q}$. Suppose $w_{\ell 1} < w_{\ell 2}$ and $w_{h1} > w_{h2}$. Then it follows that $\Delta_{u1} > \Delta_{u2}$, so that $\frac{b_1}{\Delta_{q1}} > \frac{b_2}{\Delta_{q2}}$. Further, from Proposition 3, $b_1 > b_2$ implies that $n_{\ell 1} \geq n_{\ell 2}$.

Now, suppose the good is a network good and $b_2 > b_1$. Then, $n_{\ell 2} \geq n_{\ell 1}$. For a network good, $q_h(k, n - k)$ is increasing in k. Further, in the multiplicative case $q_h = \theta q_\ell$ so that

$\Delta_q = \frac{\theta-1}{\theta} q_h$. In the high-quality only case, $q_\ell = 0$ so that $\Delta_q = q_h$. In each case, $\Delta_q(k, n-k)$ is increasing in k for a network good (or alternatively, decreasing in $n-k$). Therefore, if $n_{\ell 2} \geq n_{\ell 1}$, it follows that $\Delta_{q1} \equiv \Delta_q(n - n_{\ell 1}, n_{\ell 1}) \geq \Delta_q(n - n_{\ell 2}, n_{\ell 2}) \equiv \Delta_{q2}$. But then, $\frac{b_1}{\Delta_{q1}} < \frac{b_2}{\Delta_{q2}}$, which is a contradiction. Therefore, it must be that $b_1 > b_2$.

Next, suppose the good is a standard good. Now, in both the multiplicative and high-quality only cases, $\Delta_q(k, n-k)$ is decreasing in k (or alternatively increasing in $n-k$). Suppose $b_2 > b_1$. It now follows (since $n_{\ell 2} \geq n_{\ell 1}$) that $\Delta_{q1} \leq \Delta_{q2}$. If Δ_{q2} is sufficiently higher than Δ_{q1}, it is still possible that $\Delta_{u1} > \Delta_{u2}$. Similarly, if $b_1 < b_2$ and Δ_{q1} is not sufficiently larger than Δ_{q2}, we can have $\Delta_{u1} > \Delta_{u2}$. Therefore, on observing $w_{\ell 1} < w_{\ell 2}$ and $w_{h1} > w_{h2}$, no inference can be made on b, industry-level slack, or average quality. ■

Proof of Proposition 6

Let m be the mass of new entrants. Let $\hat{n}$ be the number of firms in the market such that if all firms provide low effort, each firm exactly breaks even. That is, $R_\ell(0, \hat{n}) = \underline{w}$. Since $\alpha > \underline{\alpha}$, it follows that $\hat{n} > \bar{n}$, where $\bar{n}$ is defined in equation (3).

Now, consider $m \in (\bar{n} - n, \hat{n} - n)$. Then, if the mass of entrants is m, in the new equilibrium all firms remain in the market and provide low effort.

■

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