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The Effects of Competition on Executive Behavior

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Key words: Principal-agent problems, organizational strategy, competitive strategy

Abstract

Economists presume that competition spurs a firm to be more efficient by forcing it to reduce its agency problems. This article investigates this presumption. It finds that the effects of competition on executive behavior can be decomposed into four effects, each of which is of potentially ambiguous sign. Theory, thus, offers no definitive defense of this presumption. This article also derives sets of conditions under which increased competition has the presumed effect of reducing agency problems. In some sets, important conditions are that increased competition reduce the executive's expected income and that agency goods (e.g., shirking) be normal goods for the executive. The article shows that an increase in the shareholders' bargaining strength can both reduce the agency problem and make it more sensitive to competition.

THE EFFECTS OF COMPETITION ON EXECUTIVE BEHAVIOR[1]

1. Introduction

The best of all monopoly profits is the quiet life. — Hicks (1935, p. 8).

A common belief is that competition drives firms to perform better. In particular, competition is believed to help correct a firm's agency problems. Recent work by Hart (1983), Nalebuff and Stiglitz (1983), and Scharfstein (1988a) on product market competition, and related work by Scharfstein (1988b) on competition for control, provides some theoretical support for these beliefs.

These articles focus on one potential effect of competition: By changing the information structure of the problem, competition can help a principal to make better inferences about her agent's actions. In Hart (1983), for instance, price competition allows the principal to make inferences about common shocks to factor prices (which otherwise conceal the agent's choice of action). In Nalebuff and Stiglitz (1983), the performance of competitors allows the principal to make inferences about common shocks. In Scharfstein (1988b), a raider's bid serves as an *ex post* signal about "shocks".

This focus, despite its many insights, is somewhat narrow. In particular, what other effects might competition have on a firm's agency problems? What is the relation among these effects? And how do they relate to the change-in-information effect? To answer these questions, I attempt a "Slutsky-like" decomposition of the effects of competition on a firm's agency problems. I begin with a model (Sections 2-4) in which changes in competition do not change the information structure of the problem. With this model, I show that competition can still encourage the executive (the agent) to consume fewer "agency goods" (e.g., slacking, perquisites, empire building, and other forms of at-the-expense-of-shareholders behavior).

This result holds under a number of different assumptions. Of particular interest,

however, is that it holds when (a) agency goods are normal goods; and (b) the executive's expected utility varies across different competitive environments. The second assumption is met by dropping the standard assumption that the shareholders offer the executive a compensation contract on a take-it-or-leave-it basis. Here, instead, the (arguably more realistic) assumption is made that it is the executive who offers a contract on a take-it-or-leave-it basis.[2] Although this may seem a rather inconsequential change, it can lead to quite striking results as Section 7 shows. Given this bargaining structure, the executive effectively "buys" agency goods from the shareholders in exchange for a lower expected income. Moreover, for a given amount of agency goods, the executive's *expected* income varies on the margin dollar-for-dollar with the firm's *expected* profit (gross of the executive's salary). Hence, an increase in competition, which lowers expected profit, also lowers the executive's expected income. Because agency goods are normal goods, the executive responds to increased competition by "buying" fewer agency goods.

This income effect is just one of three effects I identify; the other two are a risk-adjustment effect and a change-in-the-relative-value-of-actions effect. The former effect refers to the possibility that competition changes the executive's choice of action — consumption of agency goods — by changing the riskiness inherent in implementing different actions. The sign of this effect is *a priori* ambiguous. The latter effect refers to the possibility that competition can change the difference in expected profit between two actions, so the *relative* profitability of the better action (e.g., consuming fewer agency goods) can be "enhanced" or "diminished" by an increase in competition. An enhancement effect works with the income effect to lead the executive to consume fewer agency goods, while a diminishment effect works against the income effect. I derive conditions under which the income effect is the dominant effect (Proposition 2).

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In Sections 6 and 7, I explore the interactions between the effects of competition on executive behavior and the bargaining game that sets the executive's compensation contract. I show that an increase in the shareholders' bargaining strength can lead directly to the executive consuming fewer agency goods. Moreover, it can have an indirect effect on the executive by making him more willing to respond to competition by reducing his consumption of agency goods. I also contrast my model with the "classic" principal-agent model in which the shareholders make a take-it-or-leave-it offer to the executive. The contrast can be quite stark: For certain parameter values, competition leads to less consumption of agency goods in my model, but to *more* consumption of agency goods in the classic model.

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As a consequence of these assumptions, I can let $\mathbf{p}$ denote both the executive's action and the density that action determines. A density is a vector: $\mathbf{p} = (p_1, \ldots, p_N)'$, where p_n is the probability that c_n is realized.[3] From the first assumption, every state is possible (i.e., $p_n > 0$, for all n). I assume that $\mathbf{P}$, the set of possible actions, is finite and indexed by j, $j = 0, \ldots, J$. The executive's choice of action is *not* observable by the shareholders.

Assume that the order of the N profit levels is independent of the level of competition. In particular, index the profit levels so that if $n > m$, then $\pi(c_n, \phi) > \pi(c_m, \phi)$ for all ϕ. Assume that the J actions can be ordered by first-degree stochastic dominance. In particular, index the actions so that if $j > i$, then

$$\sum_{n=1}^{N} p_n^j \pi(c_n, \phi) > \sum_{n=1}^{N} p_n^i \pi(c_n, \phi).$$

For much of the analysis, how $\pi(\bullet, \bullet)$ is derived from a structural model of product-market competition does not matter. On the other hand, unless I show that derivations exist, there is a danger that the analysis is vacuous. To eliminate this danger, consider the following (admittedly simple) models of product-market competition:

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Cournot competition with overhead costs. Let c_n denote the firm's overhead (fixed) costs. Assume the firm and its T rivals have constant marginal cost, C. Assume market demand is linear, with slope equal to -1 and an intercept equal to A. Then the firm's profit in state n is

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The more competition there is — the lower is the rival's cost — the lower is the firm's profit. Notice that the marginal increase in profit from a reduction in marginal cost is $\frac{4}{9}(A + C/\phi - 2c_n)$. Notice too that this marginal increase in profit is diminishing in the level of competition. For a profit function with this property (i.e., $\pi_{c\phi} > 0$), *increased competition leads to a diminishing return to cost reduction.*

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Price-cap regulation with marginal costs.[4,5] Let c_n denote a utility's constant marginal cost and let γ be the binding price cap (i.e., a ceiling above which the utility is not allow to charge). Let the demand at the price cap be $D(\gamma)$. The utility's profit is $D(\gamma)(\gamma - c_n)$. Since the cap is binding, lowering it further will reduce the utility's profit (a lower price cap is analogous to increased competition here). Notice that the marginal increase in profit from a reduction in marginal cost is $D(\gamma)$. Notice too that this marginal increase in profit increases if the price cap is lowered (i.e., $dD(\gamma)/d(-\gamma) = -D'(\gamma) > 0$). For a profit function with this property (i.e., $\pi_{c\phi} < 0$), *increased competition leads to an increasing return to cost reduction.*

Assume that the shareholders are so well diversified that they are risk neutral. Let $U(s,\mathbf{p})$ be the executive's utility over salary, s, and action. As is typical in this literature, assume $U(s,\mathbf{p})$ to be additively separable in money and action; i.e., $U(s,\mathbf{p}) = v(s) - k(\mathbf{p})$. Assume that $v(\bullet)$ is twice-differentiable, strictly increasing, concave, and has an unbounded range. Hence, the inverse function $v^{-1}(\bullet)$ exists and is defined for all $u \in \mathbf{R}$.

Consistent with the notion that the consumption of fewer agency goods increases expected profit but decreases the executive's utility, assume that an action's disutility, $k(\mathbf{p})$, is increasing with its index; i.e., $j > i \Rightarrow k(\mathbf{p}^j) > k(\mathbf{p}^i)$. As a shorthand for this notion, $\mathbf{p}^j$ is a *harder* action than $\mathbf{p}^i$ if $j > i$. The executive may find some actions harder (i.e., provide less utility) than others because they, for example, represent less perquisite taking or less empire building. Alternatively, they may be unpleasant tasks (e.g., shutting plants) or they may simply represent less leisure.

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will reject the contract (possibly by selling the firm, or through a proxy fight to replace management). Thus, if s_n denotes the executive's salary in state n, then any contract $\mathbf{s} \equiv (s_1, \ldots, s_N)'$ must satisfy

$$\sum_{n=1}^{N} p_n \big(\pi(c_n, \phi) - s_n \big) \geq \pi_R, \tag{1}$$

where $\mathbf{p}$ is the action that the shareholders anticipate the executive will take.

To keep the model as straightforward as possible, I assume that the shareholders' reservation profit level, π_R, is invariant with respect to changes in competition. A possible justification for this assumption is that if the expected return is below π_R, then the firm can neither retain, nor attract capital, and would be compelled to shutdown. This minimum acceptable return, π_R, is, in turn, a function of the returns investors can earn from other securities (including government securities, foreign securities, and the securities of firms in other industries). Since the changes in the competitive environment of one firm or industry will have, at most, a negligible effect on the world-wide financial markets, it may be reasonable to treat π_R as independent of the firm's competitive environment. A case could, however, be made for a π_R that varies with the firm's competitive environment. Allowing π_R to vary does not change the analysis in any fundamental way, provided the change in π_R is not so large that the shareholders absorb *all* the financial effects of a change in the competitive environment.

Since $v(\bullet)$ is invertible, an alternative to specifying a contract as a vector of monetary payments, $\mathbf{s}$, is to specify it as a vector of utilities over money, $\mathbf{u}$, where the two vectors are related by $s_n = v^{-1}(u_n)$.

3. Basic Analysis

The shareholders' decision to accept a contract depends on which action they anticipate it will induce; hence, the $\mathbf{p}$ in (1) must be the executive's best response to the contract $\mathbf{s}$:

$$\sum_{n=1}^{N} p_n v(s_n) - k(p) \geq \sum_{n=1}^{N} \hat{p}_n v(s_n) - k(\hat{p}), \quad \forall \hat{p} \in P. \tag{2}$$

If (2) did not hold, then, given the contract, the executive would choose another action and, anticipating this, the shareholders would calculate their expected profit using this other action instead of **p**. If there exists an s such that (2) is met, then **p** is *implementable*. Let $\mathbf{P^I}$ denote the set of all *implementable* actions.

The executive seeks to maximize his expected utility subject to (1) and (2). Imagine he does so as follows. First, he derives for each implementable action the contract that maximizes his expected utility given that the contract is incentive compatible with that action and acceptable to the shareholders. Then, he chooses from the set of all such contracts the one that maximizes his expected utility overall. Thus, the first step is to solve, for *each* $\mathbf{p^j} \in \mathbf{P^I}$,

$$\max_{u} p^{j\prime}u \tag{3}$$

subject to

$$p^{j\prime}u - k(p^j) \geq p\prime u - k(p), \quad \forall p \in P, \tag{3a}$$

and

$$\sum_{n=1}^{N} p_n^j v^{-1}(u_n) \leq \sum_{n=1}^{N} p_n^j \pi(c_n, \phi) - \pi_R. \tag{3b}$$

The shareholder acceptance constraint, (3b), must be binding in equilibrium: If it were not and u were the "equilibrium" contract, then there would exist an $\epsilon > 0$ such that the contract $(u_1 + \epsilon, ..., u_N + \epsilon)\prime$ satisfied both (3a) and (3b) and gave the executive a greater expected

8

utility. Define $\mathbf{u}^j$ (alternatively, $\mathbf{s}^j$) as the solution to (3). Since (3b) is binding, harder actions yield the executive a greater expected income (i.e., $\mathbf{p}^{j\prime}\mathbf{s}^j$ is increasing in j). Define EU^j by $EU^j = \mathbf{p}^{j\prime}\mathbf{u}^j - k(\mathbf{p}^j)$.

The second step is to maximize EU^j; i.e., solve

$$\max_{\{j \mid \mathbf{p}^j \in \mathbf{P}^{\mathbf{I}}\}} EU^j. \tag{4}$$

If i is the solution to (4), then the executive offers $\mathbf{u}^i$.

4. Increased Competition in the Product Market

Different levels of competition yield different equilibria. The goal of this section is to find conditions under which an increase in competition can lead the executive to take harder actions in equilibrium.

Additive Profit Functions

To facilitate intuition, I first consider additive profit functions, $\pi(c_n,\phi) = -\phi - c_n$, where ϕ is increasing in the level of competition (see, e.g., the model of Cournot competition with overhead costs above).

If $dEU^j/d\phi$ is an increasing function of the index j for all values of π_R and ϕ, then an increase in competition as measured by an increase in ϕ (weakly) leads to the executive's implementing harder actions. For an additive profit function,

$$\frac{dEU^j}{d\phi} = -\mu^j,$$

where μ^j is the Lagrange multiplier on (3b). Hence, competition leads to harder actions if μ^j is decreasing in j for all π_R and ϕ.

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Since $v(\bullet)$ is invertible, an alternative to specifying a contract as a vector of monetary payments, $\mathbf{s}$, is to specify it as a vector of utilities over money, $\mathbf{u}$, where the two vectors are related by $s_n = v^{-1}(u_n)$.

3. Basic Analysis

The shareholders' decision to accept a contract depends on which action they anticipate it will induce; hence, the $\mathbf{p}$ in (1) must be the executive's best response to the contract $\mathbf{s}$:

$$\sum_{n=1}^{N} p_n v(s_n) - k(p) \geq \sum_{n=1}^{N} \hat{p}_n v(s_n) - k(\hat{p}), \quad \forall \hat{p} \in P. \qquad (2)$$

If (2) did not hold, then, given the contract, the executive would choose another action and, anticipating this, the shareholders would calculate their expected profit using this other action instead of **p**. If there exists an s such that (2) is met, then **p** is *implementable*. Let $\mathbf{P^I}$ denote the set of all *implementable* actions.

The executive seeks to maximize his expected utility subject to (1) and (2). Imagine he does so as follows. First, he derives for each implementable action the contract that maximizes his expected utility given that the contract is incentive compatible with that action and acceptable to the shareholders. Then, he chooses from the set of all such contracts the one that maximizes his expected utility overall. Thus, the first step is to solve, for *each* $\mathbf{p^j} \in \mathbf{P^I}$,

$$\max_{u} \, p^{j\prime} u \qquad (3)$$

subject to

$$p^{j\prime}u - k(p^j) \geq p'u - k(p), \quad \forall p \in P, \qquad (3a)$$

and

$$\sum_{n=1}^{N} p_n^j v^{-1}(u_n) \leq \sum_{n=1}^{N} p_n^j \pi(c_n, \phi) - \pi_R. \qquad (3b)$$

The shareholder acceptance constraint, (3b), must be binding in equilibrium: If it were not and u were the "equilibrium" contract, then there would exist an $\epsilon > 0$ such that the contract $(u_1 + \epsilon, \ldots, u_N + \epsilon)'$ satisfied both (3a) and (3b) and gave the executive a greater expected

8

utility. Define $\mathbf{u}^j$ (alternatively, $\mathbf{s}^j$) as the solution to (3). Since (3b) is binding, harder actions yield the executive a greater expected income (i.e., $\mathbf{p}^{j\prime}\mathbf{s}^j$ is increasing in j). Define EU^j by $EU^j = \mathbf{p}^{j\prime}\mathbf{u}^j - k(\mathbf{p}^j)$.

The second step is to maximize EU^j; i.e., solve

$$\max_{\{j \mid \mathbf{p}^j \in \mathbf{P}^I\}} EU^j. \tag{4}$$

If i is the solution to (4), then the executive offers $\mathbf{u}^i$.

4. Increased Competition in the Product Market

Different levels of competition yield different equilibria. The goal of this section is to find conditions under which an increase in competition can lead the executive to take harder actions in equilibrium.

Additive Profit Functions

To facilitate intuition, I first consider additive profit functions, $\pi(c_n, \phi) = -\phi - c_n$, where ϕ is increasing in the level of competition (see, e.g., the model of Cournot competition with overhead costs above).

If $dEU^j/d\phi$ is an increasing function of the index j for all values of π_R and ϕ, then an increase in competition as measured by an increase in ϕ (weakly) leads to the executive's implementing harder actions. For an additive profit function,

$$\frac{dEU^j}{d\phi} = -\mu^j,$$

where μ^j is the Lagrange multiplier on (3b). Hence, competition leads to harder actions if μ^j is decreasing in j for all π_R and ϕ.

9

Lemma 1:[6] *The Lagrange multiplier on constraint (3b) in program (3), μ^j, is*

$$\mu^j = \left(\sum_{n=1}^{N} p_n^j \frac{1}{v'(s_n^j)} \right)^{-1}. \tag{5}$$

Moreover, if <u>either</u> *of the following sets of conditions is met, then μ^j is decreasing in* j.

(i) $v(s) = \alpha log(s + \beta) + \delta$, where $\alpha > 0$, β, and δ are constants.

(ii) $[v'(\bullet)]^{-1}$ is convex and only two actions are implementable.

A consequence of this lemma and the preceding discussion is

Proposition 1: *Suppose the firm has an additive profit function. Moreover, suppose the level of competition increases. Then the executive works at least as hard in the new equilibrium as the old one if* <u>either</u> *of the conditions in Lemma 1 is satisfied.*

It should be noted that the two sets of conditions in Lemma 1 are merely sufficient conditions. As the discussion below will show, it is reasonable to expect that the executive works at least as hard, if not harder, following an increase in competition in many settings; not just in those covered by the conditions of Lemma 1. Nonetheless, it is worth asking how stringent are the two sets of conditions in Lemma 1? The log utility function is a fairly flexible functional form — arguably as flexible as other utility functions employed by this literature.[7] The function $[v'(\bullet)]^{-1}$ is convex if $v(\bullet)$ exhibits increasing, constant, or modestly decreasing

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[6] Proofs are in the appendix.

[7] For instance, Hart (1983) considers the utility function $U(V(s) - k(p))$, where $-U''(\bullet)/U'(\bullet) = \infty$ and $V(s)$ is restricted to two values: $-\infty$ if $s < \bar{s}$ and $\bar{v} > 0$ if $s \geq \bar{s}$. Scharfstein (1988a) makes the same assumptions about $U(\bullet)$, but assumes $V(s)$ is linear.

absolute risk aversion.[8] There will obviously be only two *implementable* actions if there are only two actions (e.g., the executive can choose to undertake a project or not to undertake it). Even when there are more than two actions, there may only be two implementable actions: Specifically, it is possible that the executive can do better mixing over the least costly action, $\mathbf{p}^0$, and the most costly action, $\mathbf{p}^J$, than he can do by playing any intermediate action, $\mathbf{p}^j$. This possibility will occur if there exists an $\eta_j \in (0,1)$ such that $\eta_j \mathbf{p}^J + (1-\eta_j)\mathbf{p}^0 = \mathbf{p}^j$ and $\eta_j k(\mathbf{p}^K) + (1-\eta_j)k(\mathbf{p}^0) < k(\mathbf{p}^j)$ for all j, $0 < j < J$.[9] For example, suppose the executive's action is a level of effort, e, where $e_j \in (0,1)$ for j not equal to 0 or J, $e_0 = 0$, and $e_J = 1$; the cost of effort e is just e; and $\mathbf{p}^j = (\bar{\mathbf{p}} - \underline{\mathbf{p}})e_j^\xi + \underline{\mathbf{p}}$, where $\xi > 1$ and $\bar{\mathbf{p}}$ first-degree stochastically dominates $\underline{\mathbf{p}}$ (i.e., where there are increasing returns to effort).

For the sake of intuition, consider momentarily the situation in which the shareholders could perfectly observe the executive's choice of action (i.e., the situation without moral hazard). The executive could, then, implement any action $\mathbf{p}$ by offering a contract that paid him

$$-\phi - \mathbf{p}'\mathbf{c} - \pi_R$$

if he undertook $\mathbf{p}$, where $\mathbf{c} = (c_1, ..., c_N)'$, and which paid him some arbitrarily small amount if he undertook any other action. In this case, he would choose the $\mathbf{p}$ that maximized

$$v(-\phi - \mathbf{p}'\mathbf{c} - \pi_R) - k(\mathbf{p}) .$$

Since his marginal utility of income is diminishing, if ϕ increased, the executive would never switch to an easier action, although he might switch to a harder action: Absent incentive effects, easier actions are normal goods.

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[8] If $A(\bullet)$ is the Arrow-Pratt measure of absolute risk aversion, then "modestly decreasing" means $A'(s) \geq -[A(s)]^2$. In Rogerson's (1985) examination of repeated moral hazard, the convexity of $1/v'(\bullet)$ is also important, in that it determines whether the agent's expected income is increasing or decreasing over time. This similarity, however, is best seen as arising from similarities in the mathematics (his paper also makes use of an expression similar to (5)) than from the underlying economic principles.

[9] For a proof, see Hermalin and Katz (1991), Proposition 2.

Although this income effect arises, here, from the assumptions of a diminishing marginal utility of income and additive separability between income and action, these are not necessary conditions: Agency goods (e.g., leisure and perquisites) are normal goods under other utility functions as well. That is, the normality of agency goods is not specific to the assumption of additively separable utility.[10]

With moral hazard, the executive implements the $\mathbf{p}^j$ that maximizes

$$v\left(-\phi - \mathbf{p}^{j\prime}c - \pi_R - RP^j(\phi)\right) - k(\mathbf{p}^j), \tag{6}$$

where $RP^j(\phi)$ is the risk premium associated with the optimal contract for implementing $\mathbf{p}^j$. One can interpret $RP^j(\phi)$ as the "agency wedge" created by the moral hazard problem. From (6), an increase in ϕ has two effects: an income effect and a "risk-adjustment" effect. This second effect arises because the riskiness of the optimal contract for implementing $\mathbf{p}^j$ may vary as that contract is "rewritten" to accommodate increased competition. If the change in the agency wedge due to increased competition is smaller the harder is the action (i.e., $dRP^j/d\phi$ is decreasing in j), then the risk-adjustment effect goes in the same direction as the income effect. In this case, an increase in competition cannot induce the executive to implement an easier action. Even if the risk-adjustment effect goes the other way, there is no reason in general to expect it to dominate the income effect.[11]

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[10] For instance, if $e \in \mathbf{R}$ is effort (i.e., negative leisure), then leisure will be a normal good under any twice-differentiable utility function $U(s,e)$ if the executive's problem (absent moral hazard) has a finite solution for e at all levels of competition; if the executive has a diminishing marginal utility of income; and if the marginal utility of income is non-increasing with the level of effort.

[11] Mathematically, $dv/d\phi = -v'(-\phi - \mathbf{p}'c - \pi_R - RP^j) \times (1 + dRP^j/d\phi)$. The first term is increasing in j — this is the income effect — so the second term can be increasing slightly in j without it dominating the first term.

Non-additive Profit Functions

Now consider a general profit function $\pi(c_n, \phi)$. An increase in competition, as measured by an increase in ϕ, causes the executive to work (weakly) harder if

$$\frac{dEU^j}{d\phi} = \mu^j \sum_{n=1}^{N} p_n^j \frac{\partial \pi(c_n, \phi)}{\partial \phi} \tag{7}$$

is increasing in j. Rather than concentrate on a general analysis of the non-additive function case, which offers few insights, I will consider the two "extremes": (1) Increased competition leads to increasing returns to cost reduction (i.e., $\pi_{c\phi} < 0$); and (2) Increased competition leads to diminishing returns to cost reduction (i.e., $\pi_{c\phi} > 0$).

For the first extreme

$$\sum_{n=1}^{N} p_n^j \frac{\partial \pi(c_n, \phi)}{\partial \phi} \tag{8}$$

is *increasing* in j: $\partial \pi(c_n, \phi)/\partial \phi$, like $\pi(c_n, \phi)$, is increasing in n, so the sum must be increasing in j by first-degree stochastic dominance. The sum itself is negative — an increase in competition lowers profit in each state — so a sum that is increasing in j (which is becoming less negative) works in concert with a μ^j that is decreasing in j to make the executive prefer harder actions as competition increases. In other words, if increased competition always led to harder actions in the additive-profit-function case (i.e., if μ^j is decreasing in j), then increased competition always leads to harder actions when increased competition leads to increasing returns to cost reduction. Economically, this should not be surprising: Increased competition makes harder actions relatively more attractive *ceteris paribus*. This "enhancement" effect augments the income effect, thereby further encouraging the executive to work harder.

The results are, however, ambiguous if increased competition leads to diminishing returns to cost reduction. For this second extreme, expression (8) is *decreasing* in j. A decreasing sum

13

(one which is becoming more negative) works against a decreasing μ^j. Economically, as ϕ increases, the desirability of a harder action relative to an easier action diminishes. The question is whether this "diminishment" effect dominates or is it dominated by the income effect. The answer is *a priori* ambiguous. For example, the diminishment effect would dominate if the executive were close to risk neutral, since, then, μ^j would be approximately a constant across j (see expressions (5) and (7)). On the other hand, if $\partial \pi(c_n, \phi)/\partial \phi$ is proportional to $-\pi(c_n, \phi)$ — i.e., $\partial \pi(c_n, \phi)/\partial \phi = -\zeta \pi(c_n, \phi)$, $\zeta > 0$ — then the income effect can dominate:[12]

Lemma 2: *If* $v(s) = \alpha log(s + \beta) + \delta$, *where* $\alpha > 0$, $\beta \leq \pi_R$, *and* δ *are constants, and* $\partial \pi(c_n, \phi)/\partial \phi$ *is proportional to* $-\pi(c_n, \phi)$, *then* $dEU^j/d\phi$ *is an increasing function of* j.

From this lemma and preceding discussion, the following proposition is a consequence:

Proposition 2: *Suppose the firm has a non-additive profit function. Moreover, suppose the level of competition increases. Then the executive works at least as hard in the new equilibrium as in the old one*

> *if* <u>either</u> *of the conditions in Lemma 1 is satisfied and an increase in competition leads to increasing returns to cost reduction (i.e.,* $\pi_{c\phi}(c_n, \phi) < 0$*);*

or

> *if the conditions in Lemma 2 are met.*

5. Changes in the Information Structure

Increased competition in this model has so far not been allowed to change the information structure underlying the principal-agent problem. In this section, I relax that assumption to gain

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[12] A model of product market competition that would yield a $\pi(c_n, \phi)$ satisfying this condition is the following. Suppose there are T firms in an oligopoly, which engages in tacit collusion. Assume the firms "agree" to a price, which is independent of T, and they divide the market demand at that price in equal portions. Suppose that the executive's firm has constant marginal cost equal to c_n in state n. It is straightforward to show that, in this model, $\partial \pi/\partial T$ is proportional to $-\pi(c_n, \phi)$.

an understanding of the role of the information structure. In doing so, I isolate changes in the information structure from changes in the profitability of the actions. In particular, the expected profit of a given action will be assumed to be unchanged by competition; all competition will do is affect how informative the realized profit level is about the action taken.[13]

Generalizing from equation (6), under this isolated effect of competition, the executive's expected utility from implementing action j is

$$v(E\Pi^j - \pi_R - RP^j(\phi)) - k(\mathbf{p}^j) , \qquad (9)$$

where $E\Pi^j$ is the expected profit if the chosen action is $\mathbf{p}^j$. From this expression, it follows that here competition affects only the agency wedge. In particular, if increased competition improved the shareholders' information about the executive's action (as is typically assumed), then the agency wedge should shrink. From (9), this would be equivalent to giving the executive more income. Since agency goods are normal goods, the executive would, thus, have a tendency to choose easier actions. On the other hand, this change-in-information effect would be likely to vary across different actions; in particular, it might be larger for harder actions than for easier actions, which means the executive would have a tendency to choose harder actions. To illustrate this ambiguity, consider the following examples. Note that in both examples care has been taken to isolate the "pure" change-in-information effect. In the first example, a change in the information structure leads the executive to switch to a harder action. In the second example, it leads the executive to switch to an easier action.

Example One. Let $\pi_R = 0$. Suppose $v(s) = \log(s)$. Suppose there are two actions. Consider two information structures: (1) $\mathbf{p}^0 = (3/4,1/4)'$, $\mathbf{p}^1 = (1/4,3/4)'$, $\pi(c_1,\phi) = 4$, and $\pi(c_2,\phi) = 33$; and (2) $\hat{\mathbf{p}}^0 = (1,0)'$, $\hat{\mathbf{p}}^1 = (0,1)'$, $\pi(c_1,\hat{\phi}) = 45/4$, and $\pi(c_2,\hat{\phi}) = 103/4$. Assume $k(\mathbf{p}^0) = k(\hat{\mathbf{p}}^0) = 0$ and $k(\mathbf{p}^1) = k(\hat{\mathbf{p}}^1) = \log(2)$. Note the only difference between the two

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[13] Admittedly real competition does not work this way. The objective, though, is to decompose the effects of a change in information from the other effects. In a way, it is analogous to supposing the consumer has received a compensating increase in income in order to identify the substitution effect when analyzing the effect of a price increase on a consumer's demand.

information structures is their informativeness about the executive's action; in particular, the expected gross profit of the two actions remain the same. It is straightforward to show that (3a) is binding when the executive implements $\mathbf{p}^1$. Solving that constraint yields $s_2^1 = 4s_1^1$. Hence, $s_2^1 = 412/13$ and $s_1^1 = 103/13$. So $EU^1 \approx 2.416$. Since $\mathbf{p}^0$ is the least-cost action, $s_1^0 = s_2^0 = 45/4$. So $EU^0 \approx 2.420$. Under the first information structure, the executive would implement the easier action. Since the second information structure perfectly reveals the executive's action, $EU^1 = \log(103/4) - \log(2) \approx 2.555$, which is greater than 2.420. Under the second, more informative, information structure, the executive would implement the harder action. Note that this is a general result *for two-action models*: An increase in the informativeness of the information structure cannot lead to the executive switching to the easier action, but it can lead to him switching to the harder action — the expected utility from implementing the harder action increases, while the expected utility from implementing the easier action is unchanged.

Example Two. Consider a three-action model. Assume that the *expected* gross profits from the three actions are $E\Pi^0 = 3$, $E\Pi^1 = 10$, and $E\Pi^2 = 14$. Let $\pi_R = 0$. Under the first information structure, $\mathbf{p}^0 = (1,0,0)'$, $\mathbf{p}^1 = (1/2,1/2,0)'$, and $\mathbf{p}^2 = (1/4,0,3/4)'$ (so, $\pi(c_1,\phi) = 3$, $\pi(c_2,\phi) = 17$, and $\pi(c_3,\phi) = 53/3$). Under the second information structure, $\hat{\mathbf{p}}^0 = (1,0,0)'$, $\hat{\mathbf{p}}^1 = (0,1,0)'$, and $\hat{\mathbf{p}}^2 = (0,0,1)'$. Assume $k(\mathbf{p}^0) = k(\hat{\mathbf{p}}^0) = 0$, $k(\mathbf{p}^1) = k(\hat{\mathbf{p}}^1) = \log(2)$, and $k(\mathbf{p}^2) = k(\hat{\mathbf{p}}^2) = \log(3)$. As shown in the appendix, under the first information structure, $EU^0 \approx 1.099$, $EU^1 \approx 1.386$, and $EU^2 \approx 1.388$; so the executive implements the hardest action given the less informative information structure. Under the second information structure, $EU^0 \approx 1.099$, $EU^1 \approx 1.609$, and $EU^2 \approx 1.540$; so the executive implements an easier action (the middle action) given the more informative information structure.

The ambiguous results of this section might seem surprising in light of the common belief that more information allows for better incentives (see, e.g., Nalebuff and Stiglitz (1983)). What must be kept in mind, however, is that one set of incentives is better than another if it allows actions to be implemented at lower cost; i.e., if the first set imposes less risk. This

reduction in risk applies not only to harder actions, but to easier actions as well (with the exception of the least-cost action, p^0). Since the cost of implementing *all* actions (except the least-cost action) has fallen, there is no *a priori* reason to expect a switch from easier actions to harder actions. It could be that the reduction is greatest for a harder action, which could lead to a switch from an easier action to the harder action. It could also be that the reduction is greatest for an easier action, which could lead to a switch from a harder action to the easier action. Note these ambiguous results do *not* depend on the bargaining game between the shareholders and the executive. When, however, the executive has the bargaining power, as here, there is also the influence of the income effect: Less risk is equivalent to more income, so even if the risk reduction is greater for harder actions, one could still see a switch from a harder action to an easier action.

Finally, as a digression, Example One can be used to show that although the executive's expected utility must decrease with an increase in competition, his expected income can nevertheless *increase*. Consider Example One under the *first* information structure only. Suppose the profit in *each* state falls by 1 due to increased competition. The executive will, then, switch from the easier action to the harder action (now, $EU^0 \approx 2.327$ and $EU^1 \approx 2.377$). His expected income will, consequently, go from 45/4 in the old equilibrium to 99/4 in the new equilibrium.

6. Changes in Bargaining Strength

The level of the shareholders' reservation profit, π_R, is a measure of the shareholders' bargaining strength. By considering changes in π_R, one can analyze how the shareholders' bargaining strength directly affects the executive's choice of action, as well as the sensitivity of the executive's choice of action to competition.

From (3b), an increase in π_R is equivalent to an increase in ϕ when the profit function is additive. From Proposition 1, then,

17

Corollary: *Suppose the shareholders' bargaining strength, as measured by π_R, increases. Then the executive works at least as hard in the new equilibrium as the old one if <u>either</u> of the conditions in Lemma 1 is satisfied.*

Next, how does the executive respond to changes in competition given different levels of the shareholders' bargaining strength? In particular, is he more or less responsive to changes in competition at greater levels of the shareholders' bargaining strength? As the following proposition demonstrates, the greater the shareholders' bargaining strength, the more responsive the executive is to increased competition.

Proposition 3: *Suppose that <u>either</u> of the conditions in Lemma 1 is satisfied. Consider two levels of bargaining strength for the shareholders: $\pi_R^0 < \pi_R^1$. Suppose initially the executive would implement the same action, $\mathbf{p}^\ell$, at <u>either</u> level of bargaining strength. Suppose the level of competition increases. If, at the lower level of bargaining strength, π_R^0, the executive would, now, (weakly) prefer to implement a harder action than $\mathbf{p}^\ell$, then, at the higher level of bargaining strength, π_R^1, the executive would, now, strictly prefer to implement a harder action than $\mathbf{p}^\ell$.*

Another way to view Proposition 3 is the following. Consider the relation between competition and the index of the equilibrium action. Under the assumptions of Proposition 1 or 2, this relation is a non-decreasing step function. An increase in the shareholders' bargaining power shifts (not necessarily uniformly) this function to the left, in the sense that the step from the jth action to the $j + 1$st action (if one exists) now occurs at a lower level of competition. It is in this sense, that an increase in the shareholders' bargaining strength might be said to "accelerate" the executive's response to increased competition.

18

7. Comparison with the Classic Principal-Agent Model

In the classic principal-agent model (e.g., Holmstrom (1979) or Shavell (1979)) the shareholders (principal) make a take-it-or-leave-it offer to the executive (agent) in the contract-negotiations stage. The executive accepts provided his expected equilibrium utility is at least as great as his reservation utility level, *which is independent of the level of competition.* The shareholders' cost of *optimally* implementing action **p** is, thus, independent of the level of competition. Denote this cost — the executive's expected income — by $K(\mathbf{p})$. The shareholders' choice problem is, therefore,

$$\max_{\mathbf{p} \in P^I} \sum_{n=1}^{N} p_n \pi(c_n, \phi) - K(\mathbf{p}).$$

Proposition 4: *Suppose that the shareholders make a take-it-or-leave-it offer to the executive in the contract negotiations. Consider two levels of competition, $\phi_L < \phi_H$. If it is optimal for the shareholders to implement $\mathbf{p}^L$ at the lower level of competition and $\mathbf{p}^H$ at the higher level of competition, then*

> $\mathbf{p}^L$ *is at least as hard an action as* $\mathbf{p}^H$ *if competition leads to a diminishing return to cost reduction (i.e., $\pi_{c\phi} > 0$);*

but

> $\mathbf{p}^L$ *is no harder an action than* $\mathbf{p}^H$ *if competition leads to an increasing return to cost reduction (i.e., $\pi_{c\phi} < 0$).*

In addition, if the profit function is additive, then an action that is optimal to implement at one level of competition is optimal to implement at all *levels of competition (i.e., the shareholders are never compelled to implement a different action by a change in the level of competition).*

The proof, which is by a revealed-preference argument, can be found in the appendix.

Comparing Proposition 4 with Propositions 1 and 2, it is apparent that the two models

19

have their similarities, but more noticeably their differences, when it comes to the effect of competition on executive behavior. In both models, if an increase in competition leads to increasing returns to cost reduction — i.e., competition increases the difference in value between a harder action and an easier action — then an increase in competition cannot lead to the executive choosing an easier action in equilibrium. On the other hand, if an increase in competition does *not* lead to increasing returns to cost reduction, then the two models can yield opposite predictions: In the classic model, an increase in competition *cannot* lead the executive to choose a harder action. In contrast, as shown by Propositions 1 and 2, in my model an increase in competition *can* lead him to choose a harder action.

These opposite predictions are a function, first, of the difference in bargaining structure, and, second, of differences in income effects. In my model, an increase in competition is fully absorbed by the executive, while the shareholders are unaffected. In the classic model, the opposite is true: The executive's expected utility is unaffected and only the shareholders' expected utility (profit) decreases. In my model, because the executive absorbs a change in competition, competition can affect the action he implements by the effect it has on his income. This income effect can dominate a negative effect of competition on the returns to cost reduction, which means the executive will not switch to easier actions. In the classic model, there is no income effect. Hence, nothing counteracts a negative effect of competition on the returns to cost reduction; so, the shareholders can prefer to implement an easier action.

8. Discussion and Conclusions

This article has decomposed the effect of competition on executive behavior into four possible effects: an income effect, a risk-adjustment effect, a change-in-information effect, and a change-in-the-relative-value-of-actions effect (i.e., $\pi_{c\phi} \gtrless 0$). All four effects have ambiguous signs (although not considered here, agency goods could be inferior goods), indicating that there is no definitive theoretical relationship between the level of competition and executive behavior. This article has, however, established sufficient conditions under which an increase in

competition has the commonly hypothesized effect of leading the executive to choose harder actions in equilibrium. Among these conditions is that agency goods be normal goods, in which case the income effect pushes the executive to choose harder actions as competition increases, and that this income effect be large relative to the other three effects (if they point in the opposite direction).

The idea that income effects are important in principal-agent relationships has long been understood. From one perspective, income risk aversion — a necessary condition for an agency problem to exist in many models — is really a statement that agency goods are normal goods for the agent (when, as typically assumed, utility functions are separable). Income effects also are important in settings with repeated moral hazard (see, e.g., Rogerson (1985) and Holmstrom and Milgrom (1987)); among other effects, the executive's preferences over income and agency goods determines whether his expected income rises or falls over time.

More generally, in the literature about the relation between competition and executive behavior, it has been understood since Scharfstein (1988a) that how competition will affect behavior is sensitive to what assumptions are made about the executive's preferences. This article extends Scharfstein's article in two ways: First, whereas Scharfstein considers the problem of hidden information, this article considers the complementary problem of hidden actions; second, this article more clearly identifies the importance of income effects and delineates the role of income effects vis-à-vis the other effects.

What, exactly, are the preferences of the executive — in particular, whether he considers agency goods to be normal goods or inferior goods — is an empirical question. One possible piece of indirect evidence is the Gibbons and Murphy (1990) finding that the sensitivity of CEO compensation to firm performance is greater for CEOs at the end of their careers than for other CEOs. Although there are a number of interpretations of this finding — including Gibbons and Murphy's that greater pay incentives are needed to replace diminished career-concern incentives — one is that older CEOs are wealthier (due to saving) than younger CEOs, and so are inclined to purchase more agency goods (holding pay incentives constant). Stronger pay incentives are,

21

therefore, required for older CEOs to make up for this inclination. In other words, the Gibbon and Murphy finding could be indirect evidence that agency goods are normal goods.[14]

The idea that competition has a change-in-the-relative-value-of-actions effect is well-known, and it appears in non-agency models, as well as agency models. For instance, Cabral and Riordan (1989) offer the following non-agency argument for why tightening the price cap can lead a utility to increase its efforts to reduce costs: As the cap tightens, demand increases, so the value of a reduction in unit cost also increases. This article offers a similar, complementary agency argument: Tightening the price cap lowers the executive's income, as well as enhancing the value of trying to lower costs (choosing a harder action), and both effects lead the executive to lower costs.[15]

Comparing the effect of an increase in competition on the relative value of different actions here and in the previous agency literature (e.g., Hart (1983) and Scharfstein (1988a)) is difficult because of differences in the models. Here, the executive's choice of action influences which state of nature arises, whereas in the previous literature the state of nature is known by the executive *prior* to his choosing his action. Hence, in that literature, it is more meaningful to talk about changes in relative value across states of nature. For example, in Scharfstein, the marginal revenue product of effort (action) is diminished more by competition in states where the firm is relatively productive than in states when it is relatively unproductive. For this type of model, that is analogous to the diminishment effect identified in Section 4. Since, in Scharfstein's model, there is essentially no income effect, his result that an increase in competition can lead to the executive choosing easier actions follows. In contrast, in Hart's model, where there is essentially a strong income effect, one can derive results in which an increase in competition can lead to the executive choosing harder actions.

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[14] I am grateful to a referee for this argument.

[15] Frantz and Naughton (1989) have also argued, although not in the context of a formal model, that changes in the regulatory environment (e.g., tightening the price cap) can affect the executive's consumption of agency goods.

This article has been concerned with whether competition causes the executive to consume fewer agency goods (work harder). One might also wonder whether competition causes the executive to work *better* in some welfare-economics sense. From one perspective, this is not a well-posed question: Since this a partial-equilibrium problem whose solution is always second-best optimal given the level of competition, it follows that executive's action is always "best". If one, however, takes a general-equilibrium perspective and one assumes that the problem with the executive's consumption of agency goods is that he purchases them at too low a price, then competition can be seen as causing the executive to work better.

A slightly different question is whether competition leads to a second-best action that is closer to the first-best action. The answer, in general, is ambiguous. An increase in competition changes both what the first-best action is and what the second-best action is. Although there are conditions under which the direction of change is the same (e.g., when the income effect dominates), it is difficult to compare the two rates of change due to the ambiguous sign of the risk-adjustment effect. Moreover, since the second-best action could be either harder or easier than the first-best action, it would be difficult to answer the question even if the rates of change were known.

A final point to make is that this article illustrates the importance of the bargaining game that determines the principal-agent contract. As the Corollary showed, changes in relative bargaining power can change the equilibrium action taken; and, as Proposition 3 showed, can also change how much the equilibrium action changes with an increase in the level of competition. Moreover, the comparison of a firm in which the executive has all the bargaining power with a firm in which the executive has no bargaining power shows that who has the bargaining power can change whether an increase in competition leads to harder or easier equilibrium actions (i.e., the comparison of Propositions 1 and 2 with Proposition 4).

Appendix

Proof of Lemma 1: To derive μ^j, consider the first-order condition for (3):[16]

$$p_n^j + \sum_{\forall i \neq j} \lambda^i (p_n^j - p_n^i) - \mu^j p_n^j \frac{1}{v'(s_n^j)} = 0 \qquad (A.1)$$

where λ^i is the Lagrange multiplier on (3a) for action $\mathbf{p}^i$. Summing (A.1) over n yields

$$1 = \mu^j \sum_{n=1}^{N} p_n^j \frac{1}{v'(s_n^j)}.$$

The first part of the lemma, then, follows.

Proof of the Sufficiency of Conditions (i): $1/v'(s) = (s + \beta)/\alpha$, so the result follows because (3b) is binding and $\Sigma_{n=1}^{N} p_n^j \pi(c_n, \phi)$ is increasing in j.

Proof of the Sufficiency of Conditions (ii): Since $\mathbf{p}^0$ is the least-cost action, it is implementable. Let $\mathbf{p}^*$ be the other implementable action. $\mathbf{p}^0$ is optimally implemented by a full-insurance contract. Hence,

$$\sum_{n=1}^{N} p_n^0 \frac{1}{v'(s_n^0)} = \frac{1}{v'\left(\sum_{n=1}^{N} p_n^0 s_n^0\right)}.$$

For $\mathbf{p}^*$, it follows from Jensen's inequality that

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[16] The maximand is weakly concave, while the constraints (3a) are weakly convex and the constraint (3b) is strictly convex. Thus, the first-order conditions are sufficient as well as necessary.

$$\sum_{n=1}^{N} p_n^* \frac{1}{v'(s_n^*)} \geq \frac{1}{v'\left(\sum_{n=1}^{N} p_n^* s_n^*\right)}.$$

Since $1/v'(\bullet)$ is an increasing function and (3b) is binding, the result follows. ∎

Proof of Lemma 2: Define $E\Pi^j = \sum_{n=1}^{N} p_n^j \pi(c_n, \phi)$. $1/v'(s) = (s + \beta)/\alpha$ and $\partial\pi/\partial\phi = -\zeta\pi$; hence, since (3b) is binding, expression (7) becomes

$$\frac{dEU^j}{d\phi} = -\left(\frac{\alpha}{E\Pi^j + \beta' - \pi_R}\right) E\Pi^j \zeta.$$

The result, then, follows because $x/(x+z)$, $z < 0$, is a decreasing function of x. ∎

Example Two: Under the first information structure, the only binding incentive compatibility constraint when implementing $\mathbf{p}^1$ or $\mathbf{p}^2$ is with respect to $\mathbf{p}^0$ (setting s_2 or s_3 equal to zero as appropriate ensures incentive compatibility between $\mathbf{p}^1$ and $\mathbf{p}^2$). Therefore, the optimal contract for implementing $\mathbf{p}^1$ is found by solving

$$\tfrac{1}{2}\log(s_2^1) - \tfrac{1}{2}\log(s_1^1) = \log(2)$$

and

$$\tfrac{1}{2}s_2^1 + \tfrac{1}{2}s_1^1 = 10.$$

Hence, $s_1^1 = 4$ and $s_2^1 = 16$. So $EU^1 = 1.386$. Similarly, for $\mathbf{p}^2$, solve

$$\tfrac{3}{4}\log(s_3^2) - \tfrac{3}{4}\log(s_1^2) = \log(3)$$

and

$$\tfrac{3}{4}s_3^2 + \tfrac{1}{4}s_1^2 = 14.$$

Hence, $s_1^2 \approx 4.006$ and $s_3^2 \approx 17.331$. So $EU^2 \approx 1.388$. Since $\mathbf{p}^0$ is the least-cost action, $EU^0 = \log(3) \approx 1.099$. Under the second information structure, the executive's action is

revealed, hence $\hat{s}^0 = (3,0,0)'$, $\hat{s}^1 = (0,10,0)'$, and $\hat{s}^2 = (0,0,14)'$ are optimal contracts. Plugging in yields $EU^0 \approx 1.099$, $EU^1 \approx 1.609$, and $EU^2 \approx 1.540$.

Proof of Proposition 3: Let $EU^j(\pi)$ denote the executive's expected utility from implementing action $\mathbf{p}^j$ at the *higher* level of competition when the shareholders' bargaining strength is π. By assumption, there is some harder action $\mathbf{p}^h$ such that $EU^h(\pi_R^0) \geq EU^\ell(\pi_R^0)$. The goal is to show that $EU^h(\pi_R^1) > EU^\ell(\pi_R^1)$, since then (at the very least) the executive would strictly prefer $\mathbf{p}^h$ to $\mathbf{p}^\ell$. To this end, consider the integral

$$\int_{\pi_R^0}^{\pi_R^1} \left(\frac{\partial EU^h(\pi)}{\partial \pi} - \frac{\partial EU^\ell(\pi)}{\partial \pi} \right) d\pi. \qquad (A.2)$$

Make the substitution $-\mu^j(\pi) = \partial EU^j(\pi)/\partial\pi$, so expression (A.2) becomes

$$\int_{\pi_R^0}^{\pi_R^1} (\mu^\ell(\pi) - \mu^h(\pi)) d\pi > 0,$$

since μ^j is decreasing in j. Therefore, integrating (A.2),

$$[EU^h(\pi_R^1) - EU^\ell(\pi_R^1)] - [EU^h(\pi_R^0) - EU^\ell(\pi_R^0)] > 0,$$

which, since the second term is non-negative, implies $EU^h(\pi_R^1) > EU^\ell(\pi_R^1)$. ∎

Proof of Proposition 4: Define $E\Pi^j(\phi) = \Sigma_{n=1}^N p_n^j \pi(c_n, \phi)$. By revealed preference:

$$E\Pi^H(\phi_H) - K(\mathbf{p}^H) \geq E\Pi^L(\phi_H) - K(\mathbf{p}^L)$$

and

$$E\Pi^L(\phi_L) - K(\mathbf{p}^L) \geq E\Pi^H(\phi_L) - K(\mathbf{p}^H) .$$

Combining these two expressions:

26

$$E\Pi^{H}(\phi_{H}) - E\Pi^{L}(\phi_{H}) \geq K(\mathbf{p}^{H}) - K(\mathbf{p}^{L}) \geq E\Pi^{H}(\phi_{L}) - E\Pi^{L}(\phi_{L}) \ . \qquad \text{(A.3)}$$

Suppose $\mathbf{p}^{H}$ is the strictly harder action. Then, if it is ever optimal to implement $\mathbf{p}^{L}$, it must be that $K(\mathbf{p}^{H}) > K(\mathbf{p}^{L})$. From (A.3), this means that there is non-diminishing returns to cost reduction. Hence, diminishing returns to cost reduction implies that $\mathbf{p}^{L}$ is at least as hard an action as $\mathbf{p}^{H}$.

Now, suppose that $\mathbf{p}^{L}$ is the strictly harder action. Then, by the previous reasoning, $K(\mathbf{p}^{L}) > K(\mathbf{p}^{H})$. With (A.3), this entails that

$$E\Pi^{L}(\phi_{L}) - E\Pi^{H}(\phi_{L}) \geq E\Pi^{L}(\phi_{H}) - E\Pi^{H}(\phi_{H}) \ ;$$

that is, that there is non-increasing returns to cost reduction. Hence, increasing returns to cost reduction imply that $\mathbf{p}^{L}$ is no harder an action than $\mathbf{p}^{H}$.

Finally, if the profit function is additive, the shareholders' optimization program is -

$$\max_{\mathbf{p} \in P^{I}} -\phi - \sum_{n=1}^{N} p_{n} c_{n} - K(\mathbf{p}).$$

Clearly, a change in ϕ does not change the solution(s) to this program. ∎

27

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