Competition Reduces X-Inefficiency - A Note on a Limited Liability Mechanism

by

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Abstract

The study illustrates that a financial restriction may serve as a disciplining device on the internal efficiency of a firm, and that the disciplining power is higher the tougher the product market competition is. The financial restriction is modeled as a limited liability constraint, that is a non-negative profit constraint. Hence, this limited liability mechanism may, in part, account for the disciplining power of product market competition on firm efficiency, alleged by policy makers as well as economists.

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> "...the new competitive pressures brought about by the completion of the internal market can be expected to ...produce appreciable gains in internal efficiency...[which will] constitute much of what can be called the dynamic effects of the internal market..."
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> European Commission (1988, p. 126).

1 Introduction

In the absence of competition, production costs are higher than minimum production costs. In the absence of competition, employees exert low effort. Moreover, the low effort levels and high production cost, associated with lack of competition, are too low and too high respectively, from a social welfare point of view. These three notions are widespread among policy makers as well as economists. And indeed, the empirical evidence (although fragmentary) points in the same general direction: x-inefficiency (in the sense of high production costs) is more apt to be low when competitive pressures are strong than when firms enjoy insulated market positions, Scherer and Ross (1990 p. 672). Moreover, Scherer and Ross consider it plausible that x-inefficiencies attributable to monopoly power are at least as large as the welfare losses from resource misallocations.

The purpose of the present study is to illustrate that a financial restriction, functioning as a limited liability constraint (non-negative profit constraint), is a disciplining device which is more effective the tougher the product market competition is. Hence, this limited liability mechanism may, in part, account for the alleged disciplining power of product market competition on firm efficiency. The study contributes to the policy debate by pointing out that even if the decrease in x-inefficiency should be considered

as a welfare gain if competition is increased, for example by deregulation or liberalization of trade, the gain may be out-weighted by a welfare loss due to a more inefficient allocation of risk.

Consider a firm in which the owner (principal) must hire a manager (agent) to run the operations. The task of the manager is to organize production so as to minimize production cost. The cost of production depends partly on circumstances that are beyond the control of both the owner and the manager, and partly on the amount of effort the manager exerts in organizing production. The probability of a low marginal cost is increasing in managerial effort. It is presumed that internal efficiency requires the manager to exert high effort, that is the decrease in expected marginal cost is larger than the disutility of effort. The owner can observe the resulting marginal cost, but due to the separation of ownership from control, the principal can observe neither the exogenous circumstances that affect costs, nor the manager's effort level. Since the principal is unable to judge whether a high marginal cost is due to unfavorable external circumstances or to poor organization, the manager's effort must be induced by use of incentives in the executive compensation plan. Compensation must be contingent on the realized production cost. However, the agent is assumed to be more risk-averse than the principal, who is taken to be risk-neutral. Hence, optimal risk-sharing has the owner taking all the risk. To compensate for the risk-taking by the agent, the principal must offer the agent a higher expected wage, a risk-premium. If the risk-premium is high enough the principal may prefer not to induce effort, resulting in low managerial effort and high expected marginal cost. Consequently, lack of information and conflicting interests gives rise to an internal (x-) inefficiency.

The key insight in the present study is that the institution of limited

liability may affect the balance between incentives and insurance. A contract that requires more payment than the principal can afford is unenforceable, under limited liability. Hence, an agent dealing with such a principal must ensure that the contract *never* induces the principal to enter bankruptcy (in which case the agent looses part of his compensation). The only way to avoid bankruptcy is for the agent to accept a low compensation when other costs are high. (The contract will look *as if* the principal is risk-*averse*: as if the principal has extreme disutility from negative outcomes.) Consequently, limited liability will shift risk-taking from the principal to the agent. Hence, we may suspect that managers will have more incentives to exert effort to ensure more favorable outcomes, under the institution of limited liability.

One could argue that limited liability on the part of the manager would bind "before" the limited liability on the part of the owners of the firm. Although I agree, it is the effect of the latter that I am interested in, and to simplify I abstract from the former. There is however no difficulty to construct a model where both the principal and the agent have binding limited liability constraints, and generate the same kind of result as obtained here.

Subsections 2.1 and 2.2 introduce notation and state conditions for efficiency. In subsection 2.3 I replicate the classical inefficiency result. Further, it is shown that under full liability increased competition does not have any effect on the optimal, that is cost-minimizing, contract. In subsection 2.4, it is shown that the limited liability constraint on the principal induces limitations on the *minimum* penalty that can be imposed on a risk-averse agent. Increased competition reduce revenues and tend to make the limited liability constraint more binding. As a result the contract will stipulate more risk-bearing by the agent and hence also more incentives. Consequently, increased competition increases managerial effort and reduces expected marginal cost.

Finally, in the case managerial effort is too low from a social welfare point of view, increased competition reduces this internal (x-) inefficiency. Section 4 contains concluding remarks and section 3 contains a brief survey of related literature.

2 The Model

2.1 Preliminaries

Consider a firm where ownership and control are separated. The manager can exert high effort $e = 1$ or low effort $e = 0$. The marginal cost c is either high c_H or low $c_L < c_H$. The probability for a low marginal cost depends on effort $\Pr\{c_L \mid e\} \equiv p_e$. If effort is high then the probability of low marginal cost is high $p_1 > p_0$. The manager makes his effort choice *ex ante*, that is before he knows whether external conditions are good or bad. When more than one firm operates on the market it is assumed that the realization of marginal costs are independent across firms, so that the realization of costs and hence profit in one firm does not contain any information about the external conditions for other firms. Hereby, I abstract from information externalities between competing firms.[1] The manager receives a wage w. The wage contract (w_H, w_L) between the principal and the agent specifies a wage w_L to be paid in case of a low marginal cost, and a wage w_H to be paid in case of a high marginal cost. Total cost is the sum of variable cost $c \cdot q$

[1] Competition allows the principal to make inferences about common shocks, which otherwise conceal the agent's choice of action - an information effect of competition. Holmström (1982) and Nalebuff and Stiglitz (1983) argue that competition is beneficial because it enables firms to base compensation on *relative* performance. Hart (1983) and Scharfstein (1988) focus on how the market works as an implicit incentive scheme.

and the fixed cost of management consisting of the wage w

$$C = c \cdot q + w. \tag{1}$$

If the firm is active it produces one unit of the good $q = 1$. This restriction is used in order to abstract from the output effect.[2] Note that the restriction can be made endogenous by assuming that cost is constant only up to a capacity constraint $q_{\max} = 1$. Expected costs depend on the effort level and are given by

$$E\{C \mid e\} = [p_e c_L + (1 - p_e) c_H] + [p_e w_L + (1 - p_e) w_H]. \tag{2}$$

The firm's revenues are certain and given by $R(n, q) = P(n, q) \cdot q$ where $P(n, q)$ is the inverse residual demand function and n is the number of firms. The functions R and P are assumed to be differentiable. Since $q = 1$ revenues will normally be denoted $R(n)$ and it is assumed that R is decreasing in n. The expected profit to the firm is given by

$$E\{\Pi \mid e\} = R(n) - E\{C \mid e\}. \tag{3}$$

The manager's von Neumann - Morgenstern utility is additively separable in consumption and effort and it is given by

$$u = U(w) - D \cdot e \tag{4}$$

where U is a differentiable, increasing and concave function, and D is the disutility of effort. If the manager does not work for the firm he receives $\underline{u}$.

[2] Martin (1991) discusses demand effects of competition: The residual demand curve facing a single firm shifts inwards, and the equilibrium price-elasticity of residual demand goes up. The first of these demand effects has also been labeled the output effect of competition (see for example Horn *et al.* 1994): A given reduction in marginal cost saves more money for larger firms. Hence, the manager is willing to put more effort into cost-reduction in large firms than in small ones. Horn *et al.* (1994b) consider the effect of trade. Entry in a market reduce the size of firms and hence leads to increased marginal costs. Trade has three effects, two of which are variants of the output effect: the entry effect and a market-enlargement effect which operates in the opposite direction and dominate the former. A *general equilibrium effects* reinforce their result.

If the manager is to work for the owner and exert low effort, then the lowest (certain) wage that keeps the manager at utility level u is given by

$$w_0(u) = U^{-1}(u), \tag{5}$$

where U^{-1} denotes the inverse of U. In particular, to keep the manager on utility level $\underline{u}$ the lowest wage is $w_0(\underline{u})$. I frequently write just w_0 when it is obvious that $\underline{u}$ is assumed.

If the manager is to work for the owner and exert high effort, then the lowest (certain) wage that keeps the manager at utility level u is given by

$$w_1(u) = U^{-1}(u + D). \tag{6}$$

In particular, to keep the manager on utility level $\underline{u}$ the lowest wage is $w_1(\underline{u})$. I frequently write just w_1 when it is obvious that $\underline{u}$ is assumed. To simplify, let $w_e(u) = U^{-1}(u + D \cdot e)$. Note that $w_1 > w_0$ and define the monetary value of the disutility of effort as

$$\delta(u) \equiv w_1(u) - w_0(u) > 0. \tag{7}$$

I frequently write just δ when it is obvious that $\underline{u}$ is assumed. Note that δ is the lowest effort-premium at which the agent is willing to supply effort.

The timing is the following. At time $t = 1$, the firm proposes a wage contract (w_H, w_L). At time $t = 2$, the manager either accepts or rejects. Consequently the model presumes that the principal has all the bargaining power. Some authors argue that it is more realistic to assume that the agent has (all the) bargaining power. I use the present assumption to abstract from the income effect of competition.[3] If the manager rejects the offer he receives

[3]Hermalin (1992) considers a model where the agent has (all the) bargaining power, to establish an income effect of competition. Increased competition will decrease the "pie" over which the principal and agent bargain. Hence, increased competition will lower the

$\underline{u}$ and the firm receives zero profit. At time $t = 3$, the agent exerts high or low effort. At time $t = 4$, the cost level is realized to be either high or low. At time $t = 5$, production takes place. At time $t = 6$, the firm earns its revenue and the manager receives his wage.[4]

Note that if the cost turns out to be high, and if $w_H < w_0(\underline{u})$ then the manager would prefer to take his outside option, and to leave the principal. However, the above timing commits the manager to the contract, since effort is exerted before the manager knows if external conditions are good or bad. Moreover, at a high cost the principal might want to consider to cancel production. At time $t = 5$, the principal is already bound to pay w and the criterion for profitable production is $R(n) - c \geq 0$. However, this inequality is automatically satisfied, when limited liability is satisfied, for all cases when $w \geq 0$ as is ensured when $U(w) = \ln w$.

In order to maximize expected profits, the firm proposes the contract which minimizes the firm's expected total cost C. To determine which contract to propose, the principal first calculates what wage contract will minimize expected wage, both for the case that he wants to induce high effort, and for the case that he wants to induce low effort. Secondly the principal compares the minimal cost given high effort $E\{C \mid 1\}$ with the minimal cost given low effort $E\{C \mid 0\}$.

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agents income, and if "shirking" is a normal good, it will also be reduced. Another link between the competitive pressure and the internal conditions of the firm is that a larger number of firms may increase the demand for managers with the relevant experience, and hence increase the manager's reservation utility.

[4]Horn *et al.* (1994) discuss a strategic effect of competition: if the compensation scheme is chosen and made public information before product market competition, then the induced level of marginal cost will affect the second period equilibrium. They consider three different levels of competitiveness: Bertrand competition, Cournot competition and a cartel. They show that there is a negative relation between the competitiveness of the product market and the effort incentives provided by the optimal contract.

2.2 Efficiency

This section is used to define central concepts and to derive purely logical relations between them. First, I state a definition of Pareto efficiency, and I also define internal efficiency as the effort level which minimizes the social cost of production. Second, I show that Pareto efficiency requires (i) full insurance to the agent $w_H = w_L$, and (ii) that the firm is internally efficient.

As usual, a feasible allocation is said to be (Pareto) efficient if there exist no other feasible allocation that make all individuals at least as well-off, and at least one individual strictly better off, according to their own preferences. The efficiency criterion is here applied to the group of people consisting of the principal and the agent. An allocation is taken to be an effort level and a wage contract. Hence the effort level e and the wage contract (w_H, w_L) is *efficient* (at u) if they solve the following program:

$$\begin{array}{ll} \max\limits_{e,w_H,w_L} & R(n) - [p_e c_L + (1-p_e) c_H] - [p_e w_L + (1-p_e) w_H] \\ \text{subject to:} & p_e U(w_L) + (1-p_e) U(w_H) - D \cdot e \geq u \end{array} \tag{8}$$

The postscript "at u" to efficient, emphasizes that the requirements for efficiency may be different for different distributions of wealth (here measured by the manager's utility level u). However, I frequently make statements about efficiency, taking the distribution of wealth as given. That is, I refer to an allocation as efficient if it solves program (8) for $u = \underline{u}$.

The social cost of producing the unit of output q consists of costs incurred by the principal and costs incurred by the agent (there are no externalities). At a utility level u the cost of production to the agent is, in monetary terms $w_e(u)$. The principal is incurred the cost c. Hence, the social cost of production, in monetary terms is given by

$$S(c, e, u) = c + w_e(u). \tag{9}$$

The disutility of effort is independent of the state of the world. Hence, the expected social cost of production is given by

$$E\{S \mid e\} = [p_e c_L + (1 - p_e) c_H] + w_e(u). \tag{10}$$

A firm is said to be *internally efficient* (at u) if the effort level is such that the expected social cost of producing the unit of q is minimized. In that case, I also say that the effort level is internally efficient. Claim 1 establishes that internal efficiency, as defined here, is a necessary condition for Pareto-efficiency.

Claim 1 *An allocation is efficient (at u) only if:*

(i) The wage contract provides full insurance to the agent, that is $w_H = w_L$.

(ii) The effort level is internally efficient (at u).

Proof. The first statement is well known, and it follows immediately from the principal being risk-neutral and the agent being risk-averse. To prove the second statement, let $w_L = w_H = w$. The restriction in program (8), with equality, may be written $U(w) - D \cdot e = u$ that is $w = w_e(u)$. Substitute the restriction into the objective function to get $R(n) - E\{S \mid e\}$ which is maximized when the second term is minimized.

To get sufficient conditions, the conditions of the claim must be complemented by setting w so that the manager receives u.

Claim 2 *High effort is internally efficient (at u), that is $E\{S \mid 1\} < E\{S \mid 0\}$ if and only if*

$$(p_1 - p_0)(c_H - c_L) > \delta(u). \tag{11}$$

Hence, high effort minimizes the social cost of production if the decrease in expected marginal cost exceeds the monetary value of the disutility of effort. The inequality (11) is assumed to be fulfilled through out this study for $\underline{u}$.

It is well known that efficiency can be attained under some contracting technologies, namely when the contract can be made contingent on e.

2.3 Full Liability

As a benchmark, and to introduce some notation, assume that there are no limited liability constraints. Assume that the firm wants to induce low effort, $e = 0$. To ensure that the manager accepts the contract, the principal must propose a contract that satisfies the individual rationality constraint IR_e

$$p_e U(w_L) + (1 - p_e) U(w_H) - D \cdot e \geq \underline{u}, \tag{12}$$

for $e = 0$. To minimize expected wage, the constraint must hold with equality. Further, the principal must give the agent full insurance $(w_H, w_L) = (w_0, w_0)$. Expected total cost is accordingly

$$E\{C \mid 0\} = [p_0 c_L + (1 - p_0) c_H] + w_0. \tag{13}$$

If the firm induces high effort, $e = 1$, then both the incentive-compatibility constraint IC

$$p_1 U(w_L) + (1 - p_1) U(w_H) - D \geq p_0 U(w_L) + (1 - p_0) U(w_H) \tag{14}$$

and the individual rationality constraint IR_1 given by expression (12) for $e = 1$ must be satisfied. Actually, to minimize expected wage, both constraints hold with equality. The two constraints with equality can be used to solve for the optimal contract (w_H^*, w_L^*). The optimal contract does not give full insurance, that is

$$w_H^* < w_L^*. \tag{15}$$

Consequently, in order to induce effort, the firm must pay an expected wage bill that is higher than the wage w_1 (which is sufficient to induce effort when effort is contractible). That is, $[p_1 w_L^* + (1-p_1) w_H^*] > w_0 + \delta$. Moreover, let

$$\rho \equiv [p_1 w_L^* + (1-p_1) w_H^*] - (w_0 + \delta) > 0 \tag{16}$$

denote the risk-premium that the firm must pay in excess of the effort-premium, δ, to the manager, in order to induce high effort, when effort is not contractible.

The expected cost given high effort is given by

$$E\{C \mid 1\} = [p_1 c_L + (1-p_1) c_H] + (w_0 + \delta + \rho). \tag{17}$$

The firm prefers to induce high effort if and only if $E\{C \mid 1\} \leq E\{C \mid 0\}$, that is, if and only if

$$(p_1 - p_0)(c_H - c_L) \geq \delta + \rho. \tag{18}$$

This condition is more restrictive than the corresponding condition for efficiency, expression 11, since here the firm must pay a risk-premium ρ. The trade-off is between two kinds of inefficiencies, either the principal chooses internal efficiency, then he must not give full insurance but pay a risk premium, or he gives full insurance, but then he looses internal efficiency. In order to focus on the case where a firm, under soft competition, has internal inefficiency, the inequality (18) is presumed not to be fulfilled throughout this study.

Observation 1 *If effort is not contractible and the risk-premium is high enough, $\rho > (p_1 - p_0)(c_H - c_L) - \delta$, then the firm does not induce effort. Consequently, the expected production cost is high, that is $E\{c \mid 0\} > E\{c \mid 1\}$; the expected wage bill is low, that is $E\{w \mid 0\} = w_0$. Moreover, since $(p_1 - p_0)(c_H - c_L) - \delta > 0$ this outcome is internally inefficient.*

This is the classical inefficiency result (see for example Tirole 1988). Although the value of effort (the decrease in expected marginal cost) exceeds the disutility of effort, effort is not induced. Under other conditions the inefficiency may consist of too *much* effort.

It should be noted that the statement about internal efficiency compares the information-constrained optimum with the first best outcome, attainable when effort is contractible. One may doubt the value of making such a comparison, since it is hypothetical when information constraints are real. However, it gives a decomposition of the cost of production into two parts: The (idealized) minimum cost $E\{c \mid 1\} + w_0 + \delta$, and the inefficiency $(p_1 - p_0)(c_H - c_L) - \delta > 0$. Such a decomposition may be useful since strategies to lower the minimum cost are likely to be different from strategies to lower the inefficiency. The former may be lowered by for example technical progress, while the latter may be lowered by progress in social arrangements such as monitoring, motivation and so on.

For later reference note that

$$w_H^* < w_0 < w_L^*. \tag{19}$$

The first inequality is more interesting since it is not a priori obvious that it must hold. On the one hand w_H^* should indeed be low to induce effort. On the other hand w_H^* must be high in order to compensate for the disutility of effort, while w_0 is not constructed to induce effort. Further, it is this fact that may make it profitable to induce effort when limited liability rules out that w_0 can be paid in case of a high marginal cost.

The Effect of Competition To investigate the hypothesis that increased competition decreases internal inefficiency, the meaning of "increased competition" must be made clear. One possibility is to think of increased com-

petition as entry of new firms to one single market, for example due to some deregulation. Entry will decrease residual demand and hence revenues $R(n+1) < R(n)$. Another possibility is to think of increased competition as the integration of two formerly isolated markets. Such integration may, for example, be the result of a liberalization of trade between countries or the result of anti-trust policies toward exclusive territories. Now, increased competition, from the point of view of the firm, consists of two effects: First, there is entry on the "home" market. Second, a new market has opened (the market-enlargement effect). Now, increased competition cannot be described as a decrease in residual demand. Other measures of the intensity of competition includes whether firms compete in prices or quantities (Horn *et al.* 1994, 1994b) and the share of owner-managed firms (Hart 1983). Also characteristics such as the substitutability between products matter. However, normally firms should experience decreased revenues as competition becomes more intense, that is $R(n+1) < R(n)$. This is the way that increased competition is modeled in the present study.

If entry occurs, the firm will only be affected by a decrease in residual demand or revenues $R(n+1) < R(n)$. As long as production is continued, the optimal, that is cost-minimizing contract is not affected since expression (18) is left unchanged.

Observation 2 *Absent a limited liability constraint, increased competition does not affect the cost-minimizing contract.*

Implicit in the analysis has been that the firm's individual rationality constraint, that is the zero-expected-profit condition,

$$E\Pi = R(n) - [p_0 c_L + (1 - p_0) c_H] - w_0 \geq 0. \tag{20}$$

is satisfied for the monopolist $n = 1$. If entry occurs, the zero-expected-profit condition (20) is harder to satisfy, but it is assumed that it holds, also for $n = 2$. Note also that if n is increased so that the zero-profit condition is violated, then there are no possibilities to change the contract to ensure survival of the firm. The contract already minimizes private production cost, given the information constraints.

2.4 Limited Liability

A limited liability constraint LL_i requires that the firm must not earn a negative *ex post* profit in state $i = H, L$:

$$\Pi_i = R(n) - c_i - w_i \geq 0 \qquad i = H, L. \tag{21}$$

An interpretation of this restriction is that the principal has invested all his wealth, and that he cannot borrow any external funds. If profit would fall below zero, then the principal simply cannot pay the stipulated wage. However, the parties are rational and foresee this. Consequently, the agent will not accept an offer that does not satisfy the limited liability constraint (21). The limited liability constraint could alternatively be formulated as not allowing *ex post* profits below some negative number.

In the preceding section I considered the case when $\delta < (p_1 - p_0)(c_H - c_L) < \rho + \delta$, and the information-constrained firm there chose the inefficiently low level of effort $e = 0$. Hence, the firm pays the same wage w_0 to the manager, regardless of the realized cost level. Since the wage is independent of marginal cost, the critical limited liability constraint (21) is when marginal cost is high, $i = H$. When competition is soft, revenues $R(n)$ are high, and the limited liability constraint need not be binding. However, if competition is increased, revenues fall $R(n+1) < R(n)$ and the limited liability con-

straints tend to be harder to satisfy. In particular, it may well be that the limited liability constraint binds for $i = H$ but not for $i = L$, that is[5]

$$c_L + w_0 < R(n) < c_H + w_0. \tag{22}$$

Since the firm still can make a profit when $c = c_L$ the limited liability constraint may induce exit despite the fact that the firm could earn a positive profit in expectation. However, there is a chance to survive if the contract is redesigned in order to decrease the wage when marginal cost is high w_H and instead increase the wage when the marginal cost is low w_L. In particular, since $w_H^* < w_0 < w_L^*$, we may hypothesize that (w_H^*, w_L^*) and a high effort level will be chosen by the principal. The purpose of this section is to prove this conjecture.

The analysis will consider the case when (w_H^*, w_L^*) satisfies limited liability. Hence (w_H^*, w_L^*) minimizes the expected wage (when effort is high) subject to IR_1, IC and limited liability. The expected cost when effort is high $E\{C \mid 1\}$ is hence given by expression (17).

Let $\left(w_H^l(n), w_L^l(n)\right)$ be the wage contract that minimizes the expected (given low effort) wage subject to individual rationality IR_0, and limited liability LL_i. That is $\left(w_H^l(n), w_L^l(n)\right)$ solves:

$$\begin{aligned} &\min_{w_H, w_L} \quad p_0 w_L + (1 - p_0) w_H \\ &\text{subject to:} \\ &(IR_0) \qquad p_0 U(w_L) + (1 - p_0) U(w_H) \geq U(w_0) \\ &(LL_i) \qquad w_i \leq \overline{w}_i(n) \equiv R(n) - c_i \qquad i = H, L \end{aligned} \tag{23}$$

The limited liability restriction LL_i is simply (21) rewritten to be expressed

[5] A sufficient condition for this to happen for some n is that $R(1) \geq c_H + w_0$ and

$$R(n) - R(n+1) \leq c_H - c_L \qquad \forall n.$$

as a restriction on the contract wages. Note that since the limited liability restriction depends on the number of firms, so will also the optimal wage contract depend on the number of firms. For all small n such that the limited liability does not bind $R(n) \geq c_H + w_0$ we know that $\left(w_H^l(n), w_L^l(n)\right) = (w_0, w_0)$. When competition is intense $R(n) < c_H + w_0$, it turns out that w_H^l is the highest wage that can be paid that does not violate the LL_H constraint. Moreover, w_L^l is set so that IR_0 is satisfied with equality.

Claim 3 *The solution to program (23) is given by*

$$\left(w_H^l(n), w_L^l(n)\right) = \begin{cases} (w_0, w_0) & \forall n : R(n) \geq c_H + w_0 \\ \left(\overline{w}_H(n), w_L^l(n)\right) & \forall n : R(n) < c_H + w_0 \end{cases}$$

where $w_L^l(n)$ *is implicitly defined by* $p_0 U\left(w_L^l(n)\right) + (1-p_0) U\left(\overline{w}_H(n)\right) = U(w_0)$.

All proofs are relegated to Appendix A.

Claim 4 *If* $w_H^* < \overline{w}_H$ *then* $\left(w_H^l, w_L^l\right)$ *does not induce effort.*

So, despite the fact that $\left(w_H^l, w_L^l\right)$ does not induce effort, it does impose some risk on the manager. It is convenient to discuss in terms of a *limited liability premium*, defined as

$$\lambda(n) \equiv \left[p_0 w_L^l(n) + (1-p_0) w_H^l(n)\right] - w_0. \tag{24}$$

The limited liability premium measures in expectation, the additional wage relative to w_0, that must be paid to the agent to compensate him for taking the risk associated with $\left(w_H^l, w_L^l\right)$.

Claim 5 $\lambda(n) \left\{ \begin{array}{c} > \\ = \end{array} \right\} 0 \qquad \forall n : c_H + w_0 \left\{ \begin{array}{c} > \\ \leq \end{array} \right\} R(n)$.

If competition becomes more intense, then revenues fall and hence the limited liability constraint becomes more binding. Consequently, the amount of risk imposed on the manager must be increased.

Claim 6 $\lambda'(n) \left\{ \begin{array}{c} > \\ = \end{array} \right\} 0 \qquad \forall n : c_H + w_0 \left\{ \begin{array}{c} > \\ \leq \end{array} \right\} R(n)$.

The expected cost to the firm if it offers $\left(w_H^l, w_L^l\right)$ and no effort is induced, $e = 0$, is given by

$$E\{C \mid 0\} = [p_0 c_L + (1 - p_0) c_H] + (w_0 + \lambda(n)). \tag{25}$$

The expected cost to the firm if it offers (w_H^*, w_L^*) and effort is induced, $e = 1$, is given by expression (17). A comparison of these costs gives the condition for the principal to choose high or low effort.

Claim 7 *If $w_H^* < \overline{w}_H$, then the principal prefers to induce effort if and only if*

$$(p_1 - p_0)(c_H - c_L) > \delta + \rho - \lambda(n). \tag{26}$$

Now, if condition (26) is compared with condition (18) we see that the *additional* cost of inducing high effort is lower, when the limited liability constraint is binding, $\lambda > 0$, than when it is not. Further, increased competition will increase the limited liability premium, $\lambda' > 0$, and hence reduce the additional cost of inducing high effort. When $\lambda(n)$ is large enough condition (26) is satisfied and the principal prefers to induce effort. Hence, the main result of the present study is:

Observation 3 *Assume that increased competition reduces revenues and thereby makes the limited liability constraint more binding. Then increased competition will affect the optimal agency contract. In particular, contrasting*

a market with more competition to one with less:

(i) Managerial contracts impose more incentives.

(ii) Managers exert more effort.

(iii) Managers earn a higher expected wage.

(iv) Firms produce with a lower expected marginal cost.

(v) The firm is more internally (x-) efficient.

Since Observation (2) establishes that increased competition does not affect internal conditions when there are no limited liability constraints, it is the interplay between product market competition and financial restrictions that produce this result.

My main interest concerns the effect of competition on internal inefficiency, statement *(v)*. However, it is likely to be hard to measure internal efficiency for empirical investigation. As a consequence it may be valuable to state closely related implications of the model that may be subject to empirical testing. In this way it is possible to get indirect tests of the main statement. Among these statements *(i)*, *(iii)* and *(iv)* may "in principle" be subject to empirical testing. However, statement *(i)* presupposes the existence of some measure of the degree of incentives that are present in a wage contract. Without giving any general definition, it is clear that in the present model, the degree of incentives can be measured by the difference in expected wage, given high and low effort, that is $E\{w \mid 1\} - E\{w \mid 0\} = (p_1 - p_0)(w_L - w_H)$. Statement *(ii)* is more problematic since it presupposes that effort may be observable to the "econometrician," although it is not observable for contracting. Such data can hence not be collected from the firm's accounts, but could perhaps be attainable through for example interviews.

It should be noted that although competition reduces internal inefficiency,

the net welfare effect is negative in the present model. This is due to the fact that increased competition only will make the owner switch from internal inefficiency to an inefficiency in the form of imposing risk on the manager. So, in a sense, the conclusion in this study is a bit pessimistic: Although it may be true that increased competition reduces internal (x-) inefficiency, if the mechanism is the one presented here, this should not be considered as a social welfare gain.

One may however argue that the present model over-emphasizes the weight of a single manager in the social welfare function. Should the cost of managerial effort not be negligible compared to the potential reduction in production cost? If we interpret the manager as "the administration," however, proportions are restored. Recall that Radner (1992) estimates that a significant fraction, perhaps more than 40 percent of the labor force, is devoted to the activity of managing.

Another objection to the Observation is that firms with high revenues do not tend to pay their managers less than firms with low revenues. Rather, managers in large firms tend to earn more than managers in small firms. However, the Observation is concerned with changes in revenues for a given size of the firms as measured by total costs (disregarding the possible subsequent fall in marginal cost due to changed incentives). That is, a low mark-up $R-C$ should lead to a high w. However, again one needs to be careful, since there are other mechanisms that may give rise to a positive relation between $R-C$ and w. For example the manager may have some bargaining power, which enables him to capture some share of the expected profit.

One may again want to question the use of $(p_1 - p_0)(w_L - w_H) > \delta$ as a criterion for efficiency, since it is hypothetical when information problems and limited liability are real. However, again one may argue that such a

decomposition is useful since costs due to information problems ρ and costs due to limited liability λ are different in character. Their levels are given by quite different considerations, and programs to reduce them are likely to involve quite different strategies.

To verify that the assumptions of the above analysis are consistent and do not define the empty set (of possible applications): First, use the following functional forms: $U(w) = \ln w$ and $R(n) = a - b \cdot n$. Second, use the following values for the exogenous variables: $\underline{u} = 0$, $D = 1$, $p_0 = 0.2$, $p_1 = 0.5$, $c_L = 0$, $c_H = 19.4$, $a = 22$, $b = 1$. See Stennek (1994) for details.

3 Related Literature

There are a couple of other papers that have shown that financial restrictions may discipline the firm. Grossman and Hart (1982) show that the risk of bankruptcy can discipline the managers of a firm. Without the risk of bankruptcy, the managers will use the firm's funds for private consumption rather than to invest. Hence, the managers will be unable to raise any capital. With a bankruptcy-risk and if the firm goes bankrupt a receiver is able to recover all funds that are not invested, leaving the manager with no consumption. Under these circumstances the manager will use some of the funds to invest and hence reduce the risk of bankruptcy. A similar argument is Jensen's (1986) control hypothesis for debt creation. By issuing debt in exchange for stock, without retention of the proceeds of the issue, managers are bonding their promise to pay out future cash flows. Thus debt reduces the agency cost of free cash flow available for spending at the discretion of the manager. See also Schmidt (1994).

Apart from the contract models cited in connection with the presentation

of the model, Varian (1994) has studied the relation between the competitive pressure on the product market and firm efficiency in an evolutionary setting.

From a methodological point of view, the present study is related to other contract models that include limited liability constraints. To my knowledge there is only one study, Innes (1990), that includes a limited liability constraint on the principal. In Innes (1990) both the agent and the principal are risk-neutral, and hence the contract need not meet any risk-sharing requirements. The agent (who has all the bargaining power) maximizes his incentives to exert effort by signing a "live-or-die" contract, giving him all the profit in high-profit states of nature, and a constant share $\beta < 1$ of firm profits in low-profit states of nature. In some cases even $\beta = 0$ is insufficient to induce efficient effort. The significance of limited liability constraints, in this model, is that they limit the strength of incentives for effort. For example, the limited liability of the principal implies that the agent cannot be given more than all the profits when profit is high. The agent is at most residual claimant when profit is high. In the present study the limited liability constraint implies that the agent must at least be residual claimant when profit is low. So, in Innes (1990) limited liability means that there is an upper bound on the strength of incentives to a risk-neutral agent. Here, there is a lower bound on the risk-bearing for a risk-avert agent. Although it may be possible to derive effects of product market competition on effort also in an Innes type of model (which is constructed to study financial contracting), I consider my formulation more natural for the study of how competition disciplines managers. Other models of financial contracting have included limited liability constraint only on the agent. Brander and Spencer (1989) show that an owner/manager of a firm may exert sub-optimal effort because of limited liability. The reason is that the bank, and not the owner/manager is residual

claimant in high cost states. Moreover, they show that the effort level in monopoly firms is lower than the effort level in competitive firms. The main reason for this is however that effort affects output directly, and that the monopolist faces a downward sloping demand, implying that the monopolist will lower his price by increased effort. Sappington (1983) considers a model with a risk-neutral agent that can observe productivity before he acts, and shows that limited liability on the agent will make the optimal contract include less than full incentives and hence will lead the agent to take less effort than the efficient level. See also Kahn and Scheinkman (1985) and Farmer (1985) for an application to the issue of underemployment in recessions.

4 Concluding Remarks

A limited liability constraint on the principal induces limitations on the *minimum* penalty that can be imposed on a risk-averse agent, also when low effort is induced. Increased competition reduces revenues and tends to make the limited liability constraint more binding. As a result the contract will stipulate more risk-bearing by the agent and hence also a higher risk-premium. Consequently, the *additional* risk-premium cost of inducing high effort is reduced. When competition is intense enough, the owner of the firm switches from inducing low to inducing high effort. Hence, the main conclusion is that increased competition increases managerial effort and reduces expected marginal cost. Moreover, in the case managerial effort is too low from a social welfare point of view, increased competition reduces this internal (x-) inefficiency.

Intuitively, it may appear as if the mechanism behind the result is that limited liability forces the agent to bear some risk, that this increase in

risk-bearing automatically creates more incentives for effort, and hence automatically induce more effort. However, as the model is written this is not entirely correct, due to the fact that e is a discrete variable. Rather, it is shown that, in the presence of a limited liability constraint, the contract that does not induce effort $\left(w_H^l(n), w_L^l(n)\right)$ becomes more expensive with increased competition n, while the contract that induces effort (w_H^*, w_L^*) is left unchanged. At some point, competition is hard enough to make the second contract more attractive than the first. So, at some point competition makes the firm switch from a "boundary solution contract" to an "interior solution contract." There is however no gradual change in the "interior solution contract." However, I suppose that the initial intuition could be formalized more directly with a more smooth model.

Assume *low* effort to be socially efficient. Then, when competition is soft the firm may choose the socially efficient level of effort. Then the possibility may arise that increased competition leads to an internal inefficiency (as it is defined in the present study), in the form of too much effort.

A Proofs

Proof of Claim 3 Consider the case when $R(n) < c_H + w_0$. Suppose that limited liability is satisfied, but that IR_0 is not binding. Then the principal can reduce any wage, without breaking limited liability. Assume that IR_0 bind, but that limited liability when $i = H$ does not bind and contemplate a transfer of wage from state L to state H such that IR_0 is still binding: $p_0 U'\left(w_L^l\right) dw_L^l + (1-p_0) U'\left(w_H^l\right) dw_H^l = 0$. Then $p_0 dw_L^l + (1-p_0)\frac{U'\left(w_H^l\right)}{U'\left(w_L^l\right)} dw_H^l = 0$. Since $w_H^l < w_L^l$ we have $U'\left(w_H^l\right) > U'\left(w_L^l\right)$ and $\frac{U'\left(w_H^l\right)}{U'\left(w_L^l\right)} > 1$. Hence $p_0 dw_L^l + (1-p_0) dw_H^l < p_0 dw_L^l + (1-p_0)\frac{U'\left(w_H^l\right)}{U'\left(w_L^l\right)} dw_H^l = 0$, that is a decrease in expected wage.

Proof of Claim 4 From the construction of $\left(w_H^l, w_L^l\right)$ we know that $p_0 U\left(w_L^l\right) +$
$+ (1-p_0) U\left(w_H^l\right) = U(w_0)$. From the construction of (w_H^*, w_L^*) we also know that $p_0 U(w_L^*) + (1-p_0) U(w_H^*) = U(w_0)$. Hence $p_0 U\left(w_L^l\right) + (1-p_0) U\left(w_H^l\right) = p_0 U(w_L^*) + (1-p_0) U(w_H^*)$ that is

$$p_0\left[U\left(w_L^l\right) - U(w_L^*)\right] + (1-p_0)\left[U\left(w_H^l\right) - U(w_H^*)\right] = 0. \tag{27}$$

By assumption we have $w_H^* < \overline{w}_H(n) = w_H^l(n)$. Hence we must have $w_L^l < w_L^*$ for (27) to hold. IC holds only if $U(w_L) - U(w_H) \geq \frac{1}{p_1 - p_0} D$. By construction $U(w_L^*) - U(w_H^*) = \frac{1}{p_1 - p_0} D$. Since $w_H^* < w_H^l$ and $w_L^l < w_L^*$ we have $U\left(w_L^l\right) - U\left(w_H^l\right) < U(w_L^*) - U(w_H^*) = \frac{1}{p_1 - p_0} D$. Hence $\left(w_H^l, w_L^l\right)$ does not satisfy IC.

Proof of Claim 5 For all n such that $c_H + w_0 > R(n)$ we have

$$w_H^l(n) < w_0 < w_L^l(n). \tag{28}$$

The first inequality hold since $w_H^l = \overline{w}_H = R(n) - c_H < w_0$. Given the first inequality, the second inequality must hold in order to satisfy expression (12) for $e = 0$. Due to the concavity of U the inequalities (28) imply that $p_0 w_L^l + (1 - p_0) w_H^l > w_0$. Hence, $\lambda(n) > 0$.

Proof of Claim 6 Ignore the integer-problem and assume all functions to be differentiable. Then $\lambda'(n) = p_0 \frac{dw_L^l}{dn} + (1 - p_0) \frac{dw_H^l}{dn}$. Further, we have $\frac{dw_H^l}{dn} = R'(n)$ and $\frac{dw_L^l}{dn} = -\frac{1-p_0}{p_0} \frac{U'(w_H^l)}{U'(w_L^l)} R'(n)$. Hence $\lambda'(n) = (1 - p_0) R'(n) \left[1 - \frac{U'(w_H^l)}{U'(w_L^l)}\right]$. For all n such that $c_H + w_0 > R(n)$ we have $w_H^l(n) < w_L^l(n)$ and hence $\frac{U'(w_H^l)}{U'(w_L^l)} > 1$ and hence $\lambda'(n) > 0$.

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