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A Note on Free Entry under Uncertainty: on the Role of Asymmetric Information

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In a model of competing managerial .rms I show that the equilibrium number of firms decreases with uncertainty if entry is relatively more costly than monitoring. The result adds to the earlier theoretical contributions and is consistent with the available evidence.

JEL Classification : D43, D81, L12.

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April 16, 2010

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1 Introduction

Models where risk-neutral firms compete in prices predict that greater uncertainty about marginal costs spurs entry. This is because profit functions are convex in prices, and (expected) prices are increasing with respect to cost volatility. Yet, the empirical evidence seems to support the opposite view. Using data on U.S. manufacturing industries over a 30-year period, Ghosal (1996) shows that greater uncertainty has a negative impact on the number of firms.

To explain this puzzle the existing literature has mainly focused on risk aversion: firms characterized by more risk aversion prefer not to operate in markets featuring high price uncertainty. But, these models are unable to provide unambiguous and easily testable predictions (e.g., Appelbaum and Katz, 1986, and Haruna, 1996), and even when they do provide clear-cut results, these are not in line with the evidence (e.g., Jellal and Wolff, 2005). Moreover, these models usually neglect agency issues and are mute on the interplay between managerial rents, corporate control and entry

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decisions. Modern firms, even small companies, usually feature agency problems that shape managerial incentives and, in turn, the industry structure. What are the drivers of managerial firms' entry and exit decisions? What is the impact of organizational and contractual rules on industry structure?

To address these issues, I analyze a simple managerial model linking entry decisions, corporate control and uncertainty. My purpose is to emphasize that, even under risk neutrality, a negative relationship between entry and uncertainty obtains when asymmetric information plagues the conflict between management and control. In a model where pricing, corporate control and entry decisions are determined endogenously, the effect of uncertainty on the equilibrium number of firms is shaped by the relative magnitude of monitoring and entry costs. Using a simple quadratic setting where managers are privately informed about marginal costs of production, I show that if monitoring costs are smaller than entry costs, the equilibrium number of firms is decreasing in a measure of uncertainty, and the converse obtains otherwise.

One main trade-off shapes this result. First, greater uncertainty increases the average market price and this spurs entry because sales profits are convex in prices: *a price effect*. Second, greater uncertainty spurs the information rent that shareholders need to give up in order to induce truthful information revelation. And the greater is this rent, the lower are total profits: *a rent effect*.

The net effect depends on the relative magnitude of entry and monitoring costs. If entry costs are larger than monitoring costs, the rent effect dominates: more uncertainty spurs information rents and entry becomes more costly because shareholders get lower returns from their initial investment. Conversely, if monitoring costs are larger than entry costs, the price effect dominates. When monitoring is very costly shareholders have little control on managers: the only way to reduce the costly information rents is to distort upward the price in bad technological states, so as to make mimicking less profitable. This distortion magnifies price dispersion and strengthens the positive effect of uncertainty on entry.

This result is novel in the theoretical debate on competition and incentives and offers simple testable predictions on the link between entry and uncertainty, whereby providing ready to use guidelines for future empirical work.

2 The model

Consider a Salop (1979) setting where n firms position themselves symmetrically around a circle, whose perimeter is normalized to 1. The cost of entry is F. Firms produce the same product and compete in prices. The circle is populated by a continuum of consumers with a uniform density of 1. Each consumer buys one unit of the good. If a consumer located at $x \in (z_i, z_{i+1})$ purchases from firm i located at z_i, his utility is

$$V_i(x) = v - p_i - tx,$$

where v is the reserve price of each consumer — i.e., the utility of consuming the most preferred variety x — and tx is the (linear) disutility associated with consuming this variety.

Following the literature (e.g., Hart, 1983, Schmidt, 1997, and Raith, 2003) I assume that each firm features separation between ownership and control. Shareholders (principals) own all productive assets but lack the required expertise in managing them, so they need to employ self-interested managers (agents) to run business in their behalf. Managers set prices and collect profits, which are then distributed to shareholders.

Production technologies are linear: marginal costs are determined by the realization of a random variable $\widetilde{\theta}_i \in \Theta = \{\overline{\theta}, \underline{\theta}\}$, with $\Pr(\underline{\theta}) = \nu$ and $\Delta\theta = \overline{\theta} - \underline{\theta} > 0$ for all i. Managers privately observe marginal costs and are protected by limited liability.

Shareholders hire managers before production occurs and uncertainty is resolved, they have full bargaining power and make take-it-or-leave-it offers. I use the Revelation Principle to characterize the set of incentive feasible allocations: once uncertainty is resolved, a message game takes place within each firm. A managerial contract C_i specifies an allocation rule determining: (i) the final price, p_i, (ii) the dividend to shareholders, D_i, and (iii) an auditing scheme, featuring a monitoring probability, ϕ_i, and and a (monetary) punishment, P_i, enforced in case a lie is detected. Auditing the manager is expensive and it costs $c(\phi_i)$ to shareholders. I shall interpret the probability of monitoring ϕ_i as a measure of monitoring (corporate control) intensity.

Shareholders can fully commit to a costly state verification policy, the contract C_i is a mechanism

$$C_i = \{p_i(m_i), D_i(m_i), \phi_i(m_i), P_i(\theta_i)\}_{(\theta_i, m_i) \in \Theta^2}$$

specifying a price, $p_i(m_i)$, a dividend, $D_i(m_i)$, and an auditing probability, $\phi_i(m_i)$, all contingent on manager i's report m_i. The contract also specifies a punishment $P_i(\theta_i)$, contingent on the realized state of nature, which is enforced whenever $\theta_i \neq m_i$. Upon receiving the message m_i, shareholders audit the manager with probability $\phi_i(m_i)$, discover the state θ_i and, if a lie is detected, the punishment $P_i(\theta_i)$ is inflicted to the manager.

The game unfolds as follows,

- **T = 0.** Shareholders decide whether to enter the market. If so, the entry cost F is paid.

- **T = 1.** Shareholders *secretly* propose contracts to managers. If an offer is rejected, both parties enjoy an outside option normalized to zero.

- **T = 2.** Uncertainty resolves and a communication game takes place within each firm: managers report their private information, set prices and product market competition takes place.

- **T=3.** Profits materialize, shareholders audit managers, dividends and punishments (if any) are collected.

Since contracts are secret, the equilibrium concept is Perfect Bayesian Equilibrium (PBE) with a "passive beliefs" refinement: given an equilibrium where shareholders of firm i offer the contract

C_i^e $(i = 1, ..n)$, when manager i is offered an unexpected contract, say $C_i' \neq C_i^e$, he believes that rivals are offered the same contracts — i.e., $C_j = C_j^e$ for every $j \neq i$. I shall look for symmetric fully separating equilibria: firms with the same cost charge the same final price — i.e., $p_i(\theta_i) = p_j(\theta_j)$ for $\theta_i = \theta_j$ — and prices are type-dependent — i.e., $p_i(\theta_i) \neq p_i(\theta_i')$ as long as $\theta_i \neq \theta_i'$.

Let $p^e(\theta_i)$ be firm i's equilibrium price in state θ_i. Consider then firm i setting p_i given that its neighbors charge the equilibrium prices $p^e(\theta_j)$, with $j \in \{i+1, i-1\}$. The location of the consumer that is indifferent between purchasing from firm i or its neighbor $i+1$, say $x(p_i, p^e(\widetilde{\theta}_{i+1}))$, is then defined by the indifference condition

$$v - p_i - tx = v - p^e(\theta_{i+1}) - t\left(\frac{1}{n} - x\right) \Rightarrow x(p_i, p^e(\theta_{i+1})) = \frac{p^e(\theta_{i+1}) - p_i + \frac{t}{n}}{t}.$$

By symmetry, firm i's expected demand is then

$$\sum_{j\in\{i+1,i-1\}} \mathrm{E}_{\widetilde{\theta}_j}[x(p_i, p^e(\widetilde{\theta}_j))] = \sum_{j\in\{i+1,i-1\}} \frac{\mathrm{E}_{\widetilde{\theta}_j}[p^e(\widetilde{\theta}_j)] - p_i + \frac{t}{n}}{2t} = \frac{\widehat{p}^e - p_i + \frac{t}{n}}{t},$$

where $\widehat{p}^e = \mathrm{E}_{\widetilde{\theta}_j}[p^e(\widetilde{\theta}_j)]$ is the average equilibrium price. Manager i's utility is linear in wealth:

$$U(\theta_i, m_i) = \mathrm{E}_{\widetilde{\theta}_{i+1},\widetilde{\theta}_{i-1}}[U_i(\theta_i, m_i|\theta_{i+1}, \theta_{i-1})] = Q^i(p_i(m_i), \widehat{p}^e)(p_i(m_i) - \theta_i) - D_i(m_i) - \phi_i(m_i) P_i(\theta_i),$$

given state θ_i and report m_i. Shareholders are risk-neutral and maximize the expected dividend $\mathrm{E}_{\widetilde{\theta}_i}[D_i(\widetilde{\theta}_i)]$.

I will make the following hypothesis:

A1 The random variable $\widetilde{\theta}_i$ takes values $\overline{\theta} = 1 + \sigma$ and $\underline{\theta} = 1 - \sigma$ with equal probability. It has standard deviation $\sigma \in [0, 1]$, expected value 1, and support $\Delta\theta = 2\sigma$. The monitoring cost is quadratic: $c(\phi) = \psi e^2/2$ with $\psi > 0$.

So that $\widetilde{\theta}_i$ reflects an idiosyncratic shock to each firm, while σ measures industry-wide uncertainty. Results will be derived for σ small to avoid corner solutions.

3 Complete information benchmark

When shareholders observe the cost realization of their own manager, but not those of the rivals' managers, the result is straightforward;

Lemma 1 *Assume **A1** and σ small. The equilibrium number of firms is*

$$n^*(\sigma) \simeq \frac{\sqrt{tF}}{F} + \frac{\sigma^2\sqrt{tF}}{4tF^2},$$

with $\frac{\partial n^*(\sigma)}{\partial \sigma^2} > 0$.

Since firms' sales profits are convex in prices, greater uncertainty makes entry more profitable.

4 Asymmetric information

Consider now asymmetric information. I look for a symmetric separating equilibrium of the game where: (i) shareholders offer contracts inducing truthful revelation by managers and that are best response one to another; (ii) managers participate the game and truthfully report their types; (iii) the equilibrium number of firms is determined by the shareholders' (expected) zero profit condition. This equilibrium outcome must satisfy few standard requirements.

First, manager i accepts contract C_i if and only its participation constraint is met:

$$U_i(\theta_i) = Q^i(p_i(\theta_i), \widehat{p}^e)(p_i(\theta_i) - \theta_i) - D_i(\theta_i) - \phi_i(\theta_i) P_i(\theta_i) \geq 0, \quad \forall\ \theta_i \in \Theta. \tag{1}$$

Moreover, he truthfully reports its type as long as C_i satisfies incentive compatibility, i.e.,

$$U_i(\theta_i) \geq Q^i(p_i(m_i), \widehat{p}^e)(p_i(m_i) - \theta_i) - D_i(m_i) - \phi_i(m_i) P_i(\theta_i), \quad \forall\ m_i \neq \theta_i. \tag{2}$$

Finally, since managers are protected by limited liability, the punishment $P_i(\theta_i)$ needs to satisfy the condition

$$D_i(m_i) + P_i(\theta_i) \leq Q^i(p_i(m_i), \widehat{p}^e)(p_i(m_i) - \theta_i), \quad \forall\ m_i \neq \theta_i, \tag{3}$$

implying that at the most the firm cash flow can be seized by shareholders when a lie is detected.

Then the equilibrium contract C^e solves:

$$C^e = \arg\max_{C_i} \begin{cases} \mathrm{E}_{\widetilde{\theta}_i}\left[Q^i(p_i(\widetilde{\theta}_i), \widehat{p}^e)(p_i(\widetilde{\theta}_i) - \widetilde{\theta}_i) - U_i(\widetilde{\theta}_i) - c(\phi_i(\widetilde{\theta}_i))\right], \\ \text{subject to (1)-(3).} \end{cases}$$

Standard techniques allow to show (see, e.g., Laffont and Martimort, 2000) that the relevant incentive constraint is that of efficient types, i.e.,

$$\underline{U}_i \geq \overline{U}_i + \Delta\theta Q^i(\overline{p}_i, \widehat{p}^e) - \overline{\phi}_i \underline{P}_i. \tag{4}$$

More efficient managers mimic inefficient ones simply because, by doing so, they save on production costs at the shareholders' expense. Hence, limited liability implies

$$\underline{P}_i \leq \overline{U}_i + \Delta\theta Q^i(\overline{p}_i, \widehat{p}^e). \tag{5}$$

Not that, in equilibrium there is no need to audit a manager who claims to be efficient — i.e., $\underline{\phi}_i = 0$. This is because the inefficient type's incentive constraint is slack and auditing is costly.

Finally, as standard, inefficient managers get no rents ($\overline{U}_i = 0$) so that the punishment $\overline{P}_i$ in the inefficient state is irrelevant. Differently, the punishment $\underline{P}_i$ in the efficient state is the largest possible given (5), i.e.,

$$\underline{P}_i = \Delta\theta Q^i \left(\overline{p}_i, \widehat{p}^e\right).$$

Hence,

$$\underline{U}_i \geq \left(1 - \overline{\phi}_i\right) \Delta\theta Q^i \left(\overline{p}_i, \widehat{p}^e\right).$$

This expression determines the information rent as a function of two endogenous variables: the monitoring intensity $\overline{\phi}_i$ and the price $\overline{p}_i$ charged in the inefficient state. The cost of inducing managers to tell the truth decreases the larger is the monitoring intensity (high $\overline{\phi}_i$) and the smaller is firm i's expected demand in state $\overline{\theta}$. To reduce this rent shareholders will: (i) monitor managers claiming to be inefficient with positive probability; (ii) distort upward relative to the complete information case the price $\overline{p}_i$.

Each principal's objective is therefore:

$$\max_{p_i(.),\overline{\phi}_i} \mathrm{E}_{\widetilde{\theta}_i}[Q^i(p_i(\widetilde{\theta}_i), \widehat{p}^e)(p_i(\widetilde{\theta}_i) - \widetilde{\theta}_i)] - \nu(1 - \overline{\phi}^e)\Delta\theta Q^i \left(\overline{p}_i, \widehat{p}^e\right) - (1 - \nu)\, c(\overline{\phi}_i).$$

Optimizing with respect to prices and monitoring intensity, a symmetric equilibrium is identified by the first-order conditions

$$\frac{\partial Q^i(\underline{p}^e, \widehat{p}^e)}{\partial p_i}(\underline{p}^e - \underline{\theta}) + Q^i(\underline{p}^e, \widehat{p}^e) = 0, \tag{6}$$

$$\frac{\partial Q^i \left(\overline{p}^e, \widehat{p}^e\right)}{\partial \overline{p}_i} \left(\overline{p}^e - \overline{\theta}\right) + Q^i \left(\overline{p}^e, \widehat{p}^e\right) - \frac{\nu}{1-\nu}(1 - \overline{\phi}^e)\Delta\theta \frac{\partial Q^i \left(\overline{p}^e, \widehat{p}^e\right)}{\partial \overline{p}_i} = 0, \tag{7}$$

$$\frac{\nu}{1-\nu}\Delta\theta Q^i \left(\overline{p}^e, \widehat{p}^e\right) = c'(\overline{\phi}^e). \tag{8}$$

As standard, low-cost managers price according to the efficient rule, (expected) marginal revenues equalize marginal costs as stated by equation (6). High cost managers, instead, are forced to set prices according to an inefficient rule as implied by equation (7): shareholders realize that the information rent of the efficient manager is larger the higher is demand when he mimics, so they request a larger price in the bad state to reduce this rent. Finally, equation (8) states that the monitoring intensity is chosen so as to equalize marginal costs to marginal benefits, which are captured by the negative impact of a tighter control on rents.

The free entry condition is:

$$\underbrace{\mathrm{E}_{\widetilde{\theta}_i}[Q^i(p^e(\widetilde{\theta}_i), \widehat{p}^e)(p^e(\widetilde{\theta}_i) - \widetilde{\theta}_i)]}_{\text{Sales profits}} = \underbrace{\nu(1 - \overline{\phi}^e)\Delta\theta Q^i \left(\overline{p}^e, \widehat{p}^e\right)}_{\text{Expected rents}} + \underbrace{(1-\nu)\, c(\overline{\phi}^e)}_{\text{Monitoring costs}} + \underbrace{F}_{\text{Entry costs}}. \tag{9}$$

This condition simply states that in a competitive equilibrium shareholders equalize sales profits to total costs, which include managerial rents, monitoring costs and entry costs.

Using the parametric specification in **A1** and taking σ small, the solution of the system of equations (6)-(9) implies:

Proposition 2 *Assume **A1** and σ small. The equilibrium number of firms with asymmetric information is*

$$n^e(\sigma) \simeq \frac{\sqrt{tF}}{F} + \frac{\sigma^2(\psi - F)\sqrt{tF}}{2\psi t F^2},$$

with

$$sign \frac{\partial n^e(\sigma)}{\partial \sigma^2} = sign(\psi - F).$$

For σ small there is an internal solution

$$\overline{\phi}^e(\sigma) \simeq \frac{2\sigma}{\psi}\left[\frac{F}{\sqrt{Ft}} - \frac{\sigma}{t}\right] < 1.$$

Larger cost volatility has two countervailing effects on entry. First, greater uncertainty increases the average price and this encourages entry because sales profits are convex in prices. Second, greater uncertainty spurs the information rents that owners need to give up in order to induce truthful information revelation. These greater rents stifle profits thereby making entry less profitable.

Which effect prevails depends on the relative magnitude of entry and monitoring costs. If the entry cost (F) is larger than the monitoring cost (ψ), the rent effect dominates, greater uncertainty spurs information rents and entry becomes more costly: shareholders get lower returns from their sunk investment. Conversely, if the monitoring cost is larger than the entry cost, the price effect dominates. This is because, when monitoring is very costly shareholders have little direct control on their managers: the only way to reduce the costly information rents is to distort upward the price in the bad state. This magnifies the equilibrium price dispersion and therefore strengthens the positive effect of uncertainty on entry.

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