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Managerial Effort, Agency, and Industrial Evolution*

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Abstract

This paper develops and estimates an industrial evolution model with endogenous managerial effort. Two versions of the model are considered: one in which ownership is separated from management (the agency model), and one in which managers are also owners (the proprietorship model). In the agency model, owners offer contracts to managers that elicit profit-maximizing effort levels, given information asymmetries. Both versions of the model are used to analyze managerial responses to heightened product market competition in a setting where managers lose rents if their firm exits.

The agency model is fit econometrically to plant-level panel data on the Colombian Malt Industry. Estimated parameters characterize the degree of risk aversion, the cost of effort, the rents that managers loose in the event that their firm exits, and productivity shocks. Parameters that govern industry dynamics, factor price shocks, and production technologies are also econometrically identified. The proprietorship model is inferred from the estimates of the agency model by assuming that managers own their firms.

Simulations of the estimated model characterize managers' effort choices in response to increased product market competition. In the agency model, heightened competitive pressures that cause managerial effort to increase by 23 percent for the lowest productivity firms, which are most likely to exit. However, among high productivity firms, managers decrease their effort levels by 2 percent. In the proprietorship model, managerial effort decreases with heightened competitive pressures for almost all firms, and it does so most dramatically for the low productivity firms. These findings reflect two forces. First, when loss of managerial rents is not an issue, heightened competitive pressures reduce the return to effort. Second, when owners do not internalize the loss of rents that managers suffer in the event of exit, managers use their effort level to try to control exit probabilities. The latter force is at work in the agency model but not the proprietorship model, and it dominates among low productivity firms, which are relatively likely to exit.

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1 Introduction:

Governments often view trade and antitrust policies as means to heighten competition within their own countries, and thereby to improve aggregate productivity. However, the effects of competition on efficiency are not well understood. Two basic types of linkages have been explored in the literature. First, even when firms' productivity is unaffected, competition may induce the least productive firms to exit, increase the market share of efficient incumbents, and set a higher standard for the productivity of new entrants. That is, competition can create selection effects. Second, intra-firm productivity may respond to competition because it changes the return to effort and/or innovation. This may occur because, by increasing demand elasticities, competition increases the sensitivity of firms' market shares to variation in efficiency. Alternatively, *given* firms' demand elasticities, reductions in their market share can reduce the payoff to efficiency improvements. And finally, when managers enjoy firm-specific rents, they may react to heightened competitive pressures by working harder to keep their firms from liquidating.

The empirical literature (described below) generally supports the notion that competition affects efficiency. But most of this literature is reduced-form, and does not isolate the quantitative importance of individual mechanisms. This paper generates new evidence on the importance of selection and shirking effects using a dynamic structural model. It has several key features. First, since managers are compensated by long term contracts rather than hired in spot markets, I characterize owner-manager relationships using the dynamic contracting problem developed by Phelan and Townsend (1991). Second, in order to incorporate selection effects, I embed the contracting problem in an industrial evolution model with monopolistically competitive, heterogeneous firms. The model exhibits aggregate uncertainty, endogenous effort, and endogenous entry and exit. Finally, to create a wedge between the objectives of owners and managers, I assume that managers lose some job-specific rents if their firm is liquidated. Owners place no weight on these potential rent losses when deciding whether to liquidate their firms, so managers choose their effort levels partly to influence owners' exit decisions.

I estimate this model using plant level panel data from the Colombian malt industry. This industry suits my purposes for several reasons. First, it has a large number of significant players. It is thus closer to monopolistic competition than to oligopoly, and not likely to reflect much strategic interactions between producers. Second, the industry is populated exclusively by corporations, so ownership and management are separated. Finally, the available plant-level panel data on this industry include information on managerial compensation, which helps to identify the parameters of agency problem.

Using the parameters estimated from the agency model, I perform counter-factual analysis concerning the effects of procompetitive policies. (This policy change is represented as a decrease in the mean fixed entry cost which sufficient to raise the mean entry rate nearly 8 percentage points.) Then, to isolate the effect of the agency problem on managerial behavior, I compare the predictions of this model with those of an otherwise identical model in which managers own their firms (the "proprietorship model").

My simulations show that heightened competitive pressure induce significant selectionbased productivity effects, as do earlier applied industrial evolution studies. But more interestingly, I find that effort levels respond dramatically to competitive pressure differently at certain firms. In the agency model, managers of the lowest productivity firms increase their efforts by 23 percent when competitive pressures rise, while managers of the highest productivity firms *reduce* their effort level by 2 percent. These differences in responses reflect the fact that low productivity firms face the greatest probability of failure, and their managers thus have the greatest incentive to improve their performance. In the proprietorship model, the effort choice of the owner/manager of the lowest productivity firm drops by 0.13 percent when competitive pressure rise, whereas it drops only by 0.06 percent for the highest productivity firm's owner/manager. Since the manager/owner incorporates all the losses that are incurred when the firm is liquidated, the risk of failure doesn't play any role in the incentive mechanism. Rather, standard Schumpeterian forces dominate in the proprietorship model, and managers work less as the return to effort decreases.

Related Literature

This paper is related to a handful of earlier theoretical papers concerning the effect of competition on managerial effort in the presence of agency problems. The basic message of these papers is that managers' incentives to work can go either way, depending on modeling assumptions. On one hand, as discussed in Hart (1983), competition may reduce managerial slack if marginal and total costs are positively correlated and the relative size of entrepreneurial firms to managerial firms is sufficient. On the other hand, as Scharfstein (1988) shows, Hart's results are reversed if managers' are highly responsive to income. These models don't treat entry and exit, so they do not capture managers' incentive to work harder when liquidation risk increases. However, several recent studies have done so. Schmidt (1997) shows owners' optimal contract offers induce managers to put higher effort as competition increases. Similarly, Raith (2003) incorporates liquidation risk into manager's optimization problem. However he abstracts from any positive profits by assuming free entry exit. This removes any changes to returns to effort due to loss of profits. Therefore, unambiguously, the manager increases effort with competitive pressure due to increased risk. The current paper extends this literature by considering the agency problem in the context of a dynamic industrial evolution model.

This paper is also related to a theoretical literature concerning the effect of competition on productivity in the absence of agency effects. One strand of this literature treats firms' productivity levels as exogenous, so that selection effects are the only source of industry-wide productivity gain (Hopenhayn (1992) and Melitz (2003)). Another strand combines selection effects with endogenous innovation or efforts. Boone (2000), Aghion,Harris and Vickers (1997) find that firms closer to the technological frontier innovate more with competitive pressure because they want to distance themselves from their close competitors. Also, consistent with standard Schumpeterian arguments, they find that firms far from the technological frontier decrease their innovative activities. Erickson and Pakes (1995), Pakes and McGuire (1994), Atkeson and Burstein (2006), and Constantini and Melitz (2007) study innovative behavior of heterogenous firms in an industrial evolution model. Most of these studies, too, find that Schumpeterian effects are important. My paper has both selection effects and endogenous effort, but it extends this literature by introducing an agency problem, and hence considers another channel through which competition affects productivity.

Finally, the present paper is related to an empirical literature on competition and productivity. Most of these studies which find a positive association between competition and performance (Blundell, Griffith, and Von Reenan (1995), Nickell (1996), Baily and Gersbach (1995)). Nickell (1996) also shows that if his data sample is divided into high and low rent firms, the firms with high-rent firms experience a lower productivity growth than low-rent firms. Griffith's (2001) paper is most closely related to the present study. She uses the introduction of the European Union Single Market Program (SMP) as an instrument to product market competition. She shows that increase in product market competition increases the overall levels of efficiency and growth rates. More interesting results are found when the firms are sorted according to their ownership. The increase in efficiency occurs in the group that consists of principal agent type firms. On the other hand, the firms, where ownership and management are closely linked, don't have efficiency gains even after the SMP. This paper discusses the same issue – how competition affects industry-wide productivity– but it extends the empirical literature by introducing a structural model that incorporates industry equilibrium. The structural approach allows me to conduct counter-factual analysis.

The rest of the paper is organized as follows. Section 2 details specifics of the model. Next section describes estimation methodology. Section 4 summarizes the findings. Section 5 concludes.

2 Model:

The model describes two types of infinitely lived agents: owners and managers. Owners create heterogeneous firms and contract with managers to run them. If the manager accepts the contract, he and the owner behave according to its terms for the duration of firm's life. Once active, the managers hire labor in a competitive factor market and compete with one another in a monopolistically competitive product market. Each firm's productivity depends upon the effort its manager puts into running it, the productivity it inherits from the previous period and an exogenous idiosyncratic shock.

At the beginning of each period, the owner of each active firm starts with the knowledge of the previous period's productivity. Next, taking last period's productivity level into consideration, the manager chooses an effort level. (Higher effort from the manager increases the chance of a high productivity realization.) Finally, once current productivity is realized, managers choose employment levels and prices so as to maximize current operating profits, given the market environment.

Owners cannot monitor either the effort exerted by their managers or the current idiosyncratic exogenous shocks their firms face every period. In order to reduce the agency problem, the owners offer their managers contracts which will be described fully below. The only aspect of the relationship not governed by the contract is the endogenous exit decision. Owners liquidate their firms when the scrap value they receive by doing so exceeds the expected present value of the future profit stream. In the event that a firm is liquidated, its manager suffers a loss of revenues and owners are not liable to pay the promised future expected utilities.

The model also allows for endogenous entry. Entering a market requires a sunk startup cost, F, paid by each potential entrant. If the expected value of a firm in the market is greater than the startup cost, a potential entrant pays that cost and draws an initial productivity from a commonly known distribution. The new entrant starts the next period as an incumbent.

Cross-firm heterogeneity in the return to effort occurs for two reasons. First, when competition increases, the probability of failure for low productivity firms increases relatively dramatically. Thus, managerial incentives to avoid the loss of rents are strongest among low productivity firms. Second, the sensitivity of profits to managerial effort differs across firms, with the highest sensitivity occurring at firms with large market shares. (This latter effect was first stressed by Schumpeter, and is present in many industrial evolution models.) Therefore, for each firm, the effect of competitive pressures on the return to managerial effort can be positive or negative.

Beginning-of-period productivity distributions, firm-specific shocks, exit decisions of incumbents, and entry decisions of potential entrepreneurs determine the distribution of firms every period. In equilibrium, agents' beliefs about the transition density for the distribution of firms must be consistent with the aggregation of optimal individual choices. Thus, the approximate law of motion for the market-wide price index used by the owners is consistent with the one generated in equilibrium by aggregating individual choices. The methodology for finding this equilibrium is taken from Utar (2007) who generalizes technology developed by Krusell and Smith (1998).[1]

2.1 Demand:

Demand is determined by the Dixit-Stiglitz (1977) constant elasticity of substitution (CES) utility function. Consumer preferences are defined over the N differentiated products currently available.

$$U = \left(\sum_{i=1}^{N} q_i^{\rho} \right)^{1/\rho}, \tag{1}$$

where q_i is the consumption of variety i. The elasticity of substitution between products is $\sigma = \frac{1}{1-\rho} > 1$. The CES utility function implies that demand for the i^{th} product is

$$q_i = \frac{R}{\widetilde{P}^{1-\sigma}} p_i^{-\sigma}, \tag{2}$$

where R denotes aggregate expenditure, and $\widetilde{P}$ is the exact price index for U:

$$\widetilde{P} = \left(\sum_{i=1}^{N} p_i^{1-\sigma} \right)^{1/(1-\sigma)}. \tag{3}$$

2.2 Production:

Labor is the only factor of production. Firms differ in their productivity, but share a common technology:

$$q_{it} = e^{\varphi_{it}} l_{it}^{\theta}, \qquad 0 < \theta \leq 1, \tag{4}$$

here l_{it} denotes the labor input of firm i at time t, and φ_{it} is the productivity of firm i at time t. Current productivity is dependent on the current effort choice of the manager, $a_{it} \in A$,

[1] In Krusell and Smith (1998) owners are farsighted and that estimation of the Markov process of the mean of the wealth distribution is enough to approximate the distribution of wealth. In Utar (2007) farsighted firms approximate the distribution of firms productivities with an industry-wide price index and the number of firms in the industry. The transition function that maps the distribution of current firm productivities to tomorrow's is approximated as Markov chain on price index and number of firms.

previous period's productivity, and an idiosyncratic productivity shock. More precisely, it follows a first order AR(1) process:

$$\varphi_{it} = b_1 \log(a_{it}) + b_2\varphi_{it-1} + b_3 + \varepsilon_\varphi \qquad \varepsilon_\varphi \tilde{} N(0, \sigma_\varepsilon^2). \tag{5}$$

The associated transition density will hereafter be denoted as $g(\varphi_{it}|\varphi_{it-1}, a_{it})$.

2.3 Aggregate states:

Wage rates are common across workers and exogenous to the model. They evolve according to the transition density $\Theta(w_{t+1}|w_t)$. The distribution of firms over productivities,φ, and future expected utilities promised to the manager, v_t (to be discussed below) are also common to all firms. This distribution will hereafter be denoted Γ_t, and its transition function, conditional on wages, will be denoted $\Gamma_{t+1} = H(\Gamma_t, w_t)$.

2.4 Characterization of the contract:Manager's problem:

When an owner creates a new firm, he makes a contract offer to a member of the pool of potential managers, all of whom are identical. The contract specifies a promised payment to the manager $c_t \in C$ in each period t that the firm is active, where C is a finite set. These payments are contingent upon the firm's previous productivity realizations, $h_t = \{\varphi_0, \varphi_2, \varphi_3, ...\varphi_{t-1}\}$, as well as its current productivity, φ_t. However, they are not contingent on the manager's current or previous effort levels, which the owner cannot observe.

Managers have no prior information about the value of firms, so they accept any offer that delivers expected utility greater than their outside option.[2] If managers reject the

[2] The outside option is assumed to be zero. With this assumption, if a manager receives a contract that delivers him a positive expected future utility, he accepts the offer.

offer, they are removed from the pool of potential managers and receive their outside option thereafter. If they accept, they commit to the contract as long as their firm is alive. Once employed, managers choose their effort level $a_t \in A$, each period, where A is a discrete set of values. After managers exert the chosen effort and an idiosyncratic productivity shock is realized, they determine the optimal employment level and price of the product.

The period t utility of a manager is a separable function of consumption and effort, $u(c_t, a_t) : A \times C \to \mathbb{R}_+ :$

$$u(c_t, a_t) = \begin{cases} c_t^{\mu} - (e^{\eta a_t} - 1) & \text{If the firm is in the market} \\ c_t^{\mu} - K & \text{If the firm exits that period} \\ c_0^{\mu} & \text{If manager worked for a firm before} \end{cases} \qquad \mu \in (0,1),\ \eta > 1.$$

Here, μ is the manager's degree of risk aversion of the manager, η is the cost of effort parameter. K is the one time loss of rents the manager loses in the event that the firm is liquidated, and c_0 is the per-period payment that former manager receives after their firm is liquidated. Hence, three considerations affect managerial effort choices. First, if the manager exerts more effort, he increases the probability of a high productivity realization, which in turn increases the probability of a high compensation. Second, effort is costly, so the manager has an incentive to shirk. Finally, effort reduces the risk of liquidation and the associated loss of income.

If we compare two different competitive environment, in a competitive environment firms' expected future profits decrease, and the return to cost-reducing activity may decrease for the owner.[3] This reduction in earnings is partly passed backed to managers as reduced compensation, hence it reduces the benefit of extra effort. On the other hand, heightened competitive pressure increases the risk of failure, which induces changes in the effort level of managers at firms susceptible to liquidation.

2.4.1 Owner's problem:

The moral hazard problem in this model arises from the owner's inability to observe the effort choices of the manager or the firm-specific productivity shocks, ε_{φ}. The owner must therefore design a contract that indirectly gives the manager the incentive to take the recommended action and the contract must be a function of entire history realizations which is t dimensional. A standard result in the dynamic contract literature is that there is a one-dimensional sufficient statistic for this history of productivity realizations (Phelan and Townsend, 1991). More precisely, the expected discounted future utility of the manager of participating in the contract from this point forward summarizes the relevant information in h_t. This recursive formulation will be used here, with v_{t+1} denoting managers expected discounted future utility.

Expressed this way, a contract specifies a recommended effort level, a_t, a current compensation, c_t, a promised discounted future utility, v_{t+1} as a function of the current promised utility level, v_t and current productivity realization φ_t. For reasons of computational tractability discussed by Phelan and Townsend (1991), lotteries are considered over (a_t, c_t, v_{t+1}) as well

[3] In this context, the return to a cost-reducing activity decreases as firm's profit decreases. In Boone (2001), the incentives to innovate and increase productivity increases for firms which are on the technology frontier as competition increases.

as deterministic values. Despite this apparently stochastic formulation computation always results in an optimal contract that is deterministic[4] . Therefore, the model is explained with deterministic contracts, and the details of the lottery contracts are described in Appendix.

An important economic constraint on the contract is that it must be incentive compatible. Incentive compatibility means that the manager prefers the recommended effort level a_t over all alternative effort levels $\widehat{a}_t$[5],

$$E[(u(a_t, c_t|v_t, \varphi_t) + \beta v_{t+1})|\varphi_{t-1}] = \max E_\lambda[u(\widehat{a}_t, c_t|v_t, \varphi_t) + \beta v_{t+1}|\varphi_{t-1}]$$

I now describe the timing of events. At the beginning of each period, the worker's wage and the distribution of firms over their productivities (w_t, Γ_t) are observed. The owner has already observed the last period's productivity, φ_{t-1} and he has dictated v_t by the contract to the manager in previous period. With those in mind, the owner recommends an effort level, a_t, specified by the contract. By incentive compatibility, the manager is willing to exert the recommended effort level as the owner has specified before observing the firm-specific productivity shock, ε_t. For a given action, a_t and previous period's productivity φ_{t-1}, current productivity is determined by the exogenous technology shock. After the manager observes the current productivity, he makes employment decisions. Since there are no firing or hiring costs, the employment problem is static. Finally production takes place and the profit-cash flow is observed by the owner. Knowing the aggregate state, the owner can also derive the value of current productivity. Conditional on productivity and the recommended action

[4] The risk taking behavior of the owner and the manager, in particular a risk neutral owner and a risk averse manager, guarantees that the optimal contract is deterministic.

[5] The expected utility of obeying the recomendation is greater than that of each possible deviations from the recomended effort level.

a_t, compensation is determined according to the compensation schedule $\mathbf{c}_t(\varphi_t|a_t, v_t)$. Also, in keeping with the contract, v_{t+1} is determined according to $\mathbf{v}_{t+1}(\varphi_t|c_t, a_t, v_t)$. At the end of the period, before observing tomorrow's macro state, the owner makes his exit or stay decision and the period ends.

For every owner who observed φ_{t-1} as last periods productivity, promised v_t to his manager and realized the aggregate state of the world as (Γ_t, w_t), the contract can be expressed as recommended actions, a_t, a compensation schedule $\mathbf{c}_t(\varphi_t|a_t, v_t)$ and promised utility schedule, $\mathbf{v}_{t+1}(\varphi_t|a_t, c_t, v_t)$ that satisfy the following constraints.

First, the discounted expected future utility of the manager must be equal to the promised value,v_t. So, the *continuation of utility constraint* is

$$v_t = \sum_{\Psi}(u(\mathbf{c}_t(\varphi_t|a_t, v_t), a_t) + \beta \mathbf{v}_{t+1}(\varphi_t|a_t, c_t, v_t))g(\varphi_t|\varphi_{t-1}, a_t). \tag{6}$$

Second, the contract must be incentive compatible for all assigned and alternative action pairs, $a, \widehat{a} \in A \times A$. The *incentive compatibility constraint* explained earlier can be rewritten as:

$$\sum_{\Psi}(u(c_t, a_t) + \beta v_{t+1})g(\varphi_t|\varphi_{t-1}, a_t) > \sum_{\Psi}(u(c_t, \widehat{a}_t) + \beta v_{t+1})g(\varphi_t|\varphi_{t-1}, \widehat{a}_t) \tag{7}$$

Lastly; the contract must deliver at least the managers outside option[6] .

$$v_t > \frac{1}{1-\beta}(c_0)^{\mu}$$

In a dynamic setting, the owner's problem is to construct a sequence of recommended

[6] Manager's outside option is assumed to be zero.

action levels, compensation and future utility functions $\{a_t, \mathbf{c}_t(), \mathbf{v}_{t+1}()\}_{t=1}^{\infty}$ as functions of observables; his firm's current productivity realization, and industry states, (w_t, Γ_t).

For an incumbent firm's owner, the current state is his firms's previous period productivity level,$\varphi_{t-1,}$ the value promised to the manager last period v_t, and the aggregate industry state (w_t, Γ_t). He finds the optimal contract among all contracts that satisfies the above constraints. The optimal contract maximizes the owner's expected discounted return given H, g, Θ. One can define the owner's problem as:

$$U_t(\varphi_{t-1}, v_t; \Gamma_t, w_t) = \max_{a_t, \mathbf{c}_t(), \mathbf{v}_{t+1}()} \sum_{\Psi} [\pi_t(\varphi_t | \Gamma_t, w_t) - c_t)$$

$$+\beta \max\{m, E_{\Gamma_{t+1}, w_{t+1}} U_{t+1}(\varphi_{t,} v_{t+1}; \Gamma_{t+1}, w_{t+1} | \Gamma_t, w_t)\}] \, g(\varphi_t | a_t, \varphi_{t-1})$$

subject to

$$\begin{aligned} v_t &= \sum_{(\varphi \geq \varphi_t^*) \in \Psi} (u_t(c_t, a_t) + \beta v_{t+1}) g(\varphi_t | a_t, \varphi_{t-1}) \\ &\quad + \sum_{(\varphi < \varphi_t^*) \in \Psi} (u_t(c_t, a_t) - K) g(\varphi_t | a_t, \varphi_{t-1}) \end{aligned}$$

$$\begin{aligned} v_t &> \sum_{(\varphi \geq \varphi_t^*) \in \Psi} (u_t(\mathbf{c}_t(\varphi_t | a_t, v_t), \widehat{a}_t) + \beta \mathbf{v}_{t+1}(\varphi_t | a_t, c_t, v_t)) g_t(\varphi_t | \varphi_{t-1}, \widehat{a}_t) \\ &\quad + \sum_{(\varphi < \varphi_t^*) \in \Psi} (u_t(\mathbf{c}_t(\varphi_t | a_t, v_t), \widehat{a}_t) - K) g_t(\varphi_t | \varphi_{t-1}, \widehat{a}_t) \end{aligned}$$

$$\begin{aligned} v_t &> \frac{1}{1-\beta} (c_0)^{\mu} \\ c_t &= \mathbf{c}_t(\varphi_t | a_t, v_t) \\ v_{t+1} &= \mathbf{v}_{t+1}(\varphi_t | a_t, c_t, v_t) \\ & \quad \textit{and} \\ \Gamma_{t+1} &= H(\Gamma_t, w_t) \end{aligned}$$

The owner exits the market if the expected value of his continuation utility is less than the scrap value, m of the firm. So the above dynamic problem gives an exit decision.

$$\chi(\varphi_{t-1}, v_t; \Gamma_t, w_t) = \begin{cases} 1 \text{ if } EV < m \\ 0 \text{ elsewhere} \end{cases}$$

For each state $(\varphi_{t-1}, v_t; \Gamma_t, w_t)$, there exists a cutoff level φ_t^* such that all firms at productivity levels above φ_t^* stays in the market and all others exit.

2.4.2 Potential entrant's problem

In each period, there is a pool of potential entrants. Ex-ante, owners are identical. Therefore, each potential entrant faces the same ex-ante problem: he draws a fixed entry cost from a common distribution which is assumed to be uniform over $[0, F_H]$. If the expected value of entering the market and being an owner of a firm exceeds the fixed entry cost, the potential entrant pays the fixed cost and enters the market. Then, entrants draw their initial productivity level from a common distribution, $F(\varphi)$. If ex-post, the expected value of the firm at the initial productivity draw is negative, the owner exits the market immediately. Otherwise, he hires a manager and starts production. Note that the new entrants choose to promise $v_1(\varphi_0)$ that maximizes their expected return: $v_1(\varphi_0) = \arg\max_{v_i} U(\varphi_0, v_i(\varphi_0); \Gamma_t, w_t)$. Thus, a potential entrant's problem, given the incumbent firm owner's value function U and $F(\varphi)$ is:

$$U^E(\Gamma_t, w_t | F(\varphi)) = E_{\varphi_0} U(\varphi_0, v_1(\varphi_0); \Gamma_t, w_t | F(\varphi)). \tag{8}$$

The potential entrant will create a new firm if

$$U^E(\Gamma_t, w_t | F(\varphi)) > fe, \tag{9}$$

and he will stay in the market if $U(\varphi_0, v_1(\varphi_0); \Gamma_t, w_t) > m$.

2.5 Equilibrium:

The equilibrium is a pair of value functions U and U^E for incumbents and potential entrants respectively and a corresponding contract,and exit rule χ, given H, Θ, g, F.

1-Given H, Θ, g, the owner solves his problem and the value function gives the contract and corresponding recommended action a_t, the compensation function $\mathbf{c}_t()$, and the promised utility function $\mathbf{v}_{t+1}()$.

2- Given U and H, U^E characterizes the problem of potential entrants.

3- Firms' optimal decisions are consistent with H.

Solution of the equilibrium

The solution of the problem requires the computation of the law of motion of the distribution of firms and promised utilities, which immediately creates a dimensionality problem. In order to solve the problem Utar's (2007) version of the Krusell-Smith (1998) algorithm is used[7] . The main assumptions behind this algorithm are that agents have a limited ability to predict the evolution of the distribution and individual agents take the market aggregates as exogenous. Therefore, one can use $\widetilde{P}$ as aggregates of the distribution to approximate the equilibrium. Define $\widetilde{P}_{t+1} = \overline{H}(\widetilde{P}_t, w_t)$ to be the Markov process for $\widetilde{P}_{t.}$

The solution proposed in the previous paragraph requires the knowledge of $\widetilde{P}_{t,}w_t$ and the

[7] Khan and Thomas(2003) used Krusell-Smith algorithm to decrease the infinite dimension of the distribution of firms over capital holdings by a finite number of moments. They simply divide the distribution into equal measure parts and use the mean of each partition as one moment. Recently, Utar(2007) analyzes the effect of openness on employment dynamics in a dynamic industrial evolution model. She uses the number of domestic firms and average price as two aggregates of the distribution to approximate the equilibrium. She also uses an unconstrained first order markov process instead of a switching AR(1).

Markov process defined on $\widetilde{P}_t$ to solve the owner's optimization problem. Although these information is sufficient to find the policy functions, we need to keep track of the distribution of firms over their productivities and promised utilities. The distribution itself gives pricing decision rules of firms,which gives the endogenous aggregates, $\Gamma_{t+1} = j(\Gamma_t, w_t, \widetilde{P}_t, \overline{H})$. The Markov process also maps current aggregates to tomorrow's aggregates; $\widetilde{P}_{t+1} = \overline{H}(\widetilde{P}_t, w_t)$. In equilibrium, the Markov process must be consistent with individual firms' decisions.

The algorithm to solve the approximate equilibrium is described as follows.

1- Start with an initial guess on the Markov Process $\overline{H}$.

2- Given $\overline{H}$, Θ, g solve for the value functions of incumbents and entrants.

3- Simulate the environment over a long period of time, solving for the spot market equilibrium each period.

4- Update $\overline{H}$ by calculating the number of times the market switches from $[\widetilde{P}_k]$ to $[\widetilde{P}_m]$.

5- If updated $\overline{H}$ is sufficiently close to the previous $\overline{H}$, stop. Otherwise, use the updated $\overline{H}$ and go back to step 2.

2.6 Proprietorship Model

Owner's problem:

The proprietorship version of the model shuts down agency problems and reexamines the effect of competitive pressures on aggregate productivity. In this model, the manager is the owner. He makes entry-exit decisions, he exerts effort, and he employs the workers as well. His preferences, however, remain the same as in the agency model: he is still risk averse, and he still incurs a disutility K if the firm exits the market.

The sequence of actions is as follows. After observing the aggregate state of the world, wage rate for workers, w_t, and the distribution of firm productivities, Γ_t, the manager exerts effort. Then, the firm realizes its idiosyncratic shock. Together with the effort choice and previous periods productivity, this shock determines the current productivity level. Once the manager observes the productivity level, he makes the employment decision. Finally production takes place and the current period profit-cash flow is realized. At the end of the period, before observing tomorrows aggregate state, the manager himself makes exit or stay decision and the period ends. In the meantime, potential entrants also pay the fixed cost of entry, draw their initial productivity levels and enters the market if the expected value of a firm is positive.

For an incumbent firm's manager, the current state is his firms's previous period productivity level, $\varphi_{t-1,}$ and aggregate state (w_t, Γ_t). He chooses his effort level to maximize his own expected discounted return, given H, g, Θ. His problem is:

$$U_t(\varphi_{t-1}; \Gamma_t, w_t) = \max_{a_t} \sum_{\Psi} \left[u(\pi_t(\varphi_t | \Gamma_t, w_t), a_{it}) - I(\varphi_t) K \right.$$

$$\left. + \, \beta \max\{u(m), E_{\Gamma_{t+1}, w_{t+1}} U_{t+1}(\varphi_t; \Gamma_{t+1}, w_{t+1} | \Gamma_t, w_t)\} \right] g(\varphi_t | \varphi_{t-1}, a_t)$$

subject to

$$\Gamma_{t+1} = H(\Gamma_t, w_t)$$

$$I(\varphi_t) = \begin{cases} 1 \text{ if } \varphi_t < \varphi^* \\ 0 \text{ if } \varphi_t > \varphi^* \end{cases},$$

The manager exits the market if the expected value of his continuation utility is less than the scrap value, m of the firm. So the above dynamic problem gives an exit rule.

$$\chi(\varphi_{t-1};\Gamma_t,w_t) = \begin{cases} 1 \text{ if } EV < U(m) \\ 0 \text{ elsewhere} \end{cases}$$

For each state $(\varphi_{t-1};\Gamma_t,w_t)$, there exists a cutoff productivity level φ_t^* such that all firms at productivity above φ_t^* stay in the market and the ones below the cutoff productivity exits.

Potential entrant's problem

In each period, there is a pool of potential entrants. The potential entrants' problem is similar to their problem in the model with agency. They draw a fixed entry cost from a common distribution which is assumed to be uniform over $[0, F_H]$. Those for whom the expected utility gain from entering the market exceeds the utility loss from the fixed entry cost, pays the entry cost and creates a new firm. Then, they draw their initial productivity level from a common distribution, $F(\varphi)$. Those for whom, the expected value of the firm at the initial productivity draw is negative exit the market immediately; the rest begin production and become incumbents the next period.

We can define the potential entrant's problem, given the incumbent firm owner's value function U and $F(\varphi)$:

$$U^E(\Gamma_t, w_t|F(\varphi)) = E_\varphi U(\varphi;\Gamma_t,w_t|F(\varphi)) \tag{10}$$

Potential entrants create new firms where:

$$U^E(\Gamma_t, w_t|F(\varphi)) > fe, \tag{11}$$

and they stay in the market when $U(\varphi;\Gamma_t,w_t) > 0$.

Equilibrium:

Equilibrium is characterized by a pair of value functions U and U^E for incumbents and potential entrants, respectively. These imply the policy function for the owners effort choice, $k(a)$, and the exit rule χ for given H, Θ, g, F.

1-Given H, Θ, g, the owner solves his problem and the value function gives policy functions, k and χ

2- Given U and H, U^E characterizes the problem of potential entrant.

3- Firms' optimal decisions are consistent with H.

The solution to the equilibrium is the same as explained in the model with the agency problem.

3 Estimation Approach:

Several parameters can be estimated before solving the structural model. First, I estimate the Markov process for the wage rate as an AR(1) fit to the cross-firm average wage for blue-collar workers (obreros):

$$w_t = \underset{(0.175)}{0.485} w_{t-1} + \underset{(9.847)}{29.576}$$

Second, I measure the level of aggregate expenditures, R, as the average of yearly industry revenues over the period 1977 through 1991 which amounts to $1,062,089,951$ (2005 US Dollars). Finally, following the standard parametrization in the literature, I set $\beta = 0.9$.

The remaining parameters to be estimated are:

$$\Omega = (\theta, \quad b_1, \quad b_2, \quad b_3, \quad \sigma_\varepsilon, \quad z, \quad \rho, \quad \mu, \quad \eta, \quad K, \quad F_H, \quad f, \quad m)$$

where θ is the production function parameter, the vector $(b_1, b_2, b_3, \sigma_\varepsilon)$ characterizes the AR(1) process of plant level productivity evolution, ρ is the demand parameter, the vector (μ, λ, K) parameterizes the utility of manager. Finally, (F_H, f, m) are the cost parameters to be estimated. f is the fixed cost per period, m is the scrap value of the firm if the firm is ever liquidated, and F_H is the upper bound on the fixed entry cost distribution. I start the structural estimation by making some distributional assumptions. First, fixed costs are drawn from a uniform distribution with support $[0, F_H]$. Second, the distribution of initial productivity levels for entrants is normal with mean; z and standard deviation $\left(\frac{\sigma_\varepsilon^2}{1-b_2^2}\right)$. This allows the new entrants to draw from a different distribution than the incumbents'.

The vector Ω is estimated using a simulated method of moments procedure. The procedure is as follows. For a candidate value of Ω, the value functions and the policy functions are calculated for incumbents and new entrants. (These functions depend upon the AR(1) for wage rates, and they reflect beliefs that are consistent with the productivity evolution as described in Krusell-Smith algorithm.) Then these policy functions are used to simulate a set of moments, M_s, including mean entry rates, mean firm sizes, ... (See table 1 for a complete list). Theses simulations require randomly drawn innovations in w_t, and firm-level productivity shocks, ε_{it}, and entry costs fe. I simulate the model N_T time periods and S times. The shocks, and fixed cost draws (call them Λ) are kept constant so that changes in simulated moments are a result of changes in parameters. Finally, the distance between the simulated moments and data counterparts is calculated. The estimated parameters values, $\widehat{\Omega}$, are the ones that create simulated moments as close to data moments as possible. Formally, the below problem is solved:

$$\widehat{\Omega}(W) = \arg\min_{\Omega}(M_D - M_s(\Omega, \Lambda))W(M_D - M_s(\Omega, \Lambda))'$$

and W is the weighing matrix.

The Colombian Malt Industry Data

I used the Colombian malt industry (SIC code 3133) for the period 1977 through 1990. As mentioned earlier, this industry suits my purposes because the industry is composed of corporations. Thus, the data were generated by an industry with agency problems. The mean number of firms in the market is around 21. There is a large number of firms in the market supporting the monopolistic competition assumption rather that a strategic oligopoly setup. The firms in the market do not export, this is also consistent with my non-tradable good economy assumption. The mean entry rate is 3.8 percent and the mean exit rate is 3.2 percent.

Finally, the available plant-level panel data on this industry reports information on employment, cost , firm types and managerial compensations. The panel data, not only allows us to link producer heterogeneity and productivity dynamics, with firm types and managerial compensations, it also allows us to calculate moments to pin down the manager's utility parameters; risk aversion, the disutility paid when the firm exits, and cost of effort. I include mean and variance of firm entry, exit and number of firms as general industry characteristics to identify costs of entry and exit. Managerial compensation and its covariance with firm characteristics help to identify managers' utility parameters. Intertemporal covariances help to identify parameters that govern the dynamic features of the model. In the structural model, the productivity of the firms is related to the employment level of the firm. Therefore, the employment and employment growth moments are used. Below is the full list of the moments.

Table 1: Data Moments

Mean Entry Rate	Mean Log Employment	Mean log Compensation
Variance of Entry Rate	Variance Log Employment	Variance of log Compensation
Mean Exit Rate	Mean log(revenue/cost)	Cov LogCOMP and logEMP
Variance of Exit Rate	Variance log(revenue/cost)	Cov LogEMP at t and t-1
Mean Number of Firms	Mean Employment Growth	Cov logCOMP at t and t-1
Variance of Number of Firms	Variance employment Growth	Cov of logRev/Cost and logEMP

A number of issues arise when constructing the simulations. First, all variables must be discretized in order to use standard techniques to calculate the value functions. For this, I use Tauchen's (1991) method. Second, I cannot observe the potential entrants in the market. Therefore, I arbitrarily fix, the number of potential entrants to $N_{pe} = 3$. This number exceeds the maximum number of entrants in one year. Finally, given the potential for discontinuities in the model and the discretization of the state space, a simulated annealing algorithm is used to perform the minimization.

4 Preliminary estimates

Table (2) reports the estimation results for the set of parameters, Ω.

The estimated value of the mean entry cost is about 2652 (billion 2005 Us dollars) or about a thousand times the average revenue,R, firms make in one period. Because of a high support on the fixed entry cost, only the firms, which can draw relatively low entry costs can enter the market. These simulated results match what we see in the data: low level of entry to the market. The sunk entry costs should be considered as any expenditure prior to entry that does not add to the value of firm or the product.

The scrap value of a firm is about 51.5 (million 2005 Us dollars) which is quite low when compared to the revenue made per period. The relatively low magnitude of the scrap value of firms is probably traceable to the fact that it is identified by entry and exit patterns. The exit rate is relatively low when compared to the total number of firms in the market. The fixed cost paid by firms each period is about 16.01 (milion 2005 Us dollars) which amounts to approximately 20 percent of average total sales.

Now I turn to the parameters of interest, which are the manager's utility parameters. The estimated value of his disutility payment, K, is about $11,178$ (2005 Us dollars) which is almost one third of the mean manager compensation. One can think of the disutility parameter as the loss of wages during unemployment, loss of rents associated to being a manager, or loss of reputation. The risk aversion parameter, μ, is 0.974, suggesting that managers are almost risk neutral.

The simulated moments are reported in table (3). The model does a good job of matching the data moments in sign. However, it does a poor job matching most compensation and employment moments. The main reason is the model's complexity. The contract in the model creates a computational limitations which limit me to using only a few grid points for the state variables. Therefore, the simulated moments,mainly the variances, do not match the actual data moments well.

4.1 Preliminary simulation results:

Given all the parameter estimates, I want to quantify the effects of heightened competition on endogenous effort choice when either the ownership and management are separated and there exists agency problems between the manager and the owner, or the management and ownership of the firms are one in the same. To do so, I increase competitive pressures by decreasing the mean fixed entry cost by a factor of 10^5, holding all other parameters constant. As a government policy, this can be thought of as diminishing the bureaucratic burdens to enter a market.

Given the simulated path for wage rates and that owners have rational expectations, the agency model is simulated for 400 years and 10 times. The figures in Table(4) are calculated by taking the average of these 10 sets of results. Similarly, with the estimated parameters of agency model, the proprietorship model is simulated assuming the manager owns the firm. The results of this version of the model is presented in Table (5).

The reduction in mean entry costs increases the number of firms in the market by allowing more firms to enter. With more firms and a lower aggregate price index, incumbents face more competition. As a result, aggregate productivity increases in both models (Table 6 and Table 7). There are three sources of this productivity gain. The first is market selection. With more competition, the exit rate increases, and the average productivity among survivors is higher. This result is consistent with Hopenhayn (1992) and Melitz (2003). The second is the market reallocation of resources. With competition, the output share of high productivity firms increases (Table 6 and Table 7) increasing the covariance between productivity and market shares. This effect is also predicted by Hopenhayn (1992) and Melitz (2003), and can found in earlier empirical studies (e.g. Olley and Pakes (1996), Pavnick (2002))

Both of the effects described above are present n the agency model and the proprietorship model. The third source of increase in aggregate productivity is the change in the managerial effort choices. Although, markets respond to heightened competition in the same direction in both models, the magnitude of these responses differ. In the agency model, lowest productivity firm's manager increases his effort level by 23 percent. On the other hand, the manager of the highest productivity firm decreases his effort by 2 percent (1). When firms face heightened competition, in this model, exit occurs disproportionately among the lower productivity firms. A manager, who pays disutility when his firm exits, works harder when he faces higher risk of failure. By doing so, he indirectly affects the owners decision on exit. Moreover, probability of exit diminishes as firms become more productive. Therefore, the positive effect of risk on managerial incentives diminishes as firms become more productive. In addition, competition reduces market shares of firms and therefore profits. Lower profits is reflected as lower compensations to the managers which reduces the incentives to exert higher effort. As productivity increases, the weight of risk on managerial incentives decreases and the reduced compensations are still in effect. Eventually two effects almost offset each other and results in a decrease in managerial effort of 2 percent. The change in managerial responses reflect as changes in industry mix. Consequently, low productivity firms experience higher productivity growth compared to high productivity firms. Therefore, the mean employment growth of firms jumps from 0.0151 to 0.1541 (Table (6)).

In proprietorship model, the managerial responses are opposite. The change in the ownership structure of the firm changes how risk and reduced profits affect the incentives. In this version of the model, the risk of failure doesn't play a role among the firms, as managers already incorporate the loss of rents when they are making their exit decision. With competitive pressure, reduced profits decrease the firm values. Therefore, it becomes optimal for manager/owners to decrease effort and exit if the utility of keeping the firm is less than the utility equivalence of scrap value. As a result, lowest productivity firm's manager/owner decrease his effort level by 0.13 percent with competitive pressure. Similarly, the manager of highest productivity firm decreases his effort level by 0.06 percent (Figure(2)). The decrease in the change of managerial effort as productivity increases can be explained with the market reallocation effect. Although, with competition firm profits decrease, the production also shifts towards more productive firms. Therefore, the decrease in effort level for high productivity firms is less than the decrease in lower productivity firms. Moreover, relatively smaller changes in effort levels also creates relatively less employment growth (0.01307 to 0.03905) compared to agency model (Table (5)). This, as well, shows that the market doesn't experience productivity growth among low productivity firms.

5 Conclusion

In this paper, I develop and estimate a dynamic industrial evolution model with monopolistically competitive heterogenous firms and aggregate uncertainty using the Colombian Malt industry panel data from 1977 to 1990. The firms' ownership and management are separated, and owners cannot observe the amount of effort exerted by managers. This creates a principal-agent problem between the owners and the managers. The problem is solved using the dynamic contract framework developed by Phelan and Townsend (1991).

The simulated GMM estimation method is used to estimate the model parameters. The low turnover rate in the industry can be explained by big difference between the scrap value of firms and mean entry costs in the market In addition, the disutility managers incur if firm exits is about one fifth of the mean yearly managerial compensation.

To explore the effects of competitive pressure on managerial behavior, I re-simulate the agency model with lower average entry costs, holding other estimated parameters fixed. Also, to determine how agency problems interact with competitive pressures, I simulate a low-competition and a high-competition scenario for a variant of the model in which managers own their firms, receive all profits, and make the entry and exit decisions (the proprietorship model).

Three sources of industrial efficiency are observed in the simulations results. Common to both versions of the model, the turnover rates increase with competitive pressure. As a result, the unproductive firms exit the market. Second, with competition, the covariance between firm productivity and market share increases. Higher covariance is due to the reallocation of resources towards more productive firms.

The third source of efficiency is the change in endogenous managerial incentives. In contrast to selection effect and reallocation of resources effects, the third source is not acting in the same direction in the two versions of the model. In the agency model, competitive pressure increases the effort level of lowest productivity firms' managers and the change in effort declines with productivity. Moreover, the highest productivity firms' manager drops his effort level. On the other hand, in the proprietorship model, all the managers/ owners decrease their managerial effort mostly among the lower productivity firms mainly due to reallocation of resources.

One area for future work is to link foreign competition to endogenous managerial effort choice and industrial efficiency. This will involve adapting the demand system to incorporate imported foreign goods, and it mean estimating the parameters with data on a tradeable-goods industry.

References

Aghion,P. and P.Howitt (1992), "Research and Development in the Growth Process", Journal of Economic Growth, Vol. 1, 49:73

Aghion P, C.Harris and J.Vickers (1997), "Competition and Growth with Step-by-Step Innovation; An Example", European Economic Review Vol. 41: 771-782.

Aghion,P.,M. Dewatripont, and P. Rey, (1997) " Corporate Governance, Competition Policy and Industrial Policy", European Economic Review, Vol. 41, 797:805.

Aghion P, Bloom N, Blundell R, Griffith R and Howitt P (2005), "Competition and Innovation: An Inverted U Relationship", Quarterly Journal of Economics, May, 701:728

Atkeson A. and A. Burstein (2007), "Innovation, Firm Dynamics, and International Trade", UCLA working paper.

Baily, M., H. Gersbach (1995) "Efficiency in manufacturing and the need for global competition", Brookings Paper on Economic Activity: Microeconomics, 307;347.

Bernard, A. B., J. Eaton, J. B. Jensen and S. Kortum (2003), "Plants and Productivity in International Trade", American Economic Review, Vol. 93, 1268:1290.

Blundell,R., Griffith, R., and Van Reenen, J. (1995) "Dynamic Count Data Models of Techological Innovation", Economic Journal Vol. 105, 333:344.

Boone, J.(2000), "Competitive Pressure: the Effects on Investments in Product and Process Innovation", RAND Journal of Economics Vol. 31(3), 549:569.

Costantini, J.A. and M.Melitz (2007), "The Dynamics of Firm-Level Adjustment to Trade Liberalization", working paper

Dixit, A. and J. E. Stiglitz (1977), "Monopolistic Competition and Optimal Product Diversity", American Economic Review, Vol. 67, 297:308.

Ericson, R and A. Pakes (1995), "Markov-Perfect Industry Dynamics: A Framework for Empirical Work", The Review of Economic Studies, Vol. 62(1) 53:82.

Griffith, R. (2001), "Product market competition, efficiency and agency costs: an empirical analysis", Institute for Fiscal Studies Working Papers, no WP 01/12.

Hart, O. (1983), "The Market Mechanism as an Incentive Scheme", Bell Journal of Economics, Vol. 14, 366:382.

Hopenhayn, H. (1992),"Entry, Exit and Firm Dynamics in Long Run Equilibrium", Econometrica Vol. 60(2), 1127:1150.

Khan, A. and J. Thomas (2003), "Nonconvex factor Adjustments in Equilibrium Business Cycles Models: Do Nonlinearities Matter?", Journal of Monetary Economics Vol. 50, 331:360.

Krusell, P. and A. Smith (1998), "Income and Wealth Heterogeneity in the Macroeconomy", Journal of Political Economy Vol. 106, 867:896.

Melitz, M. and G. Ottaviano (2005), "Market Size, Trade and Productivity", NBER Working Paper # 11393

Melitz, M. (2003), "The impact of trade on intra-industry reallocations and aggregate industry productivity", Econometrica Vol. 71, 1695:1725.

Nickell, S.J. (1996) "Competition and corporate performance", Journal of Political Economy, Vol.104, 724:746.

Olley, S. and A.Pakes (1996), "The Dynamics of Productivity in the Telecommunications Equipment Industry", Econometrica, Vol.64 (6), 1263:1297.

Pakes,A. and P.Mcguire (1994), "Computing Markov-Perfect Nash Equilibria: Numerical Implications of a Dynamic Differentiated Product Model", The RAND Journal of Economics, Vol. 25(4), 555:589.

Pavcnik, N. (2002), "Trade Liberalization, Exit and Productivity Improvements: Evidence from Chilean Plants", Review of Economic Studies, Vol.69, 245:76.

Phelan, C. and R.M.Townsend (1991), "Computing Multi-period,Information Constrained Optima", The Review of Economic Studies, Vol. 58(5), 853:881.

Raith, M. (2003), "Competition, Risk, and Managerial Incentives", American Economic Review, Vol. 93(4) 1425:1436.

Scharfstein, D. (1988), "Product Market Competition and Managerial Slack", RAND Journal of Economics Vol.19, 147:155.

Schmidt,K.M. (1997),"Managerial Incentives and Product Market Competition",Review of Economic Studies. Vol. 64, 191:213.

Tauchen, G. and R. Hussey (1991),"Quadrature-Based Methods for Obtaining Approximate Solutions to Nonlinear Asset Pricing Models," Econometrica, Vol. 59, 371:396.

Utar,H. (2007), "Employment Dynamics and Import Competition", University of Colorado, Boulder, mimeo.

6 Appendix

The formal description of the lottery contract is below:

A contract specifies a recommended effort level, $a_t \in A$, a current compensation, $c_t \in C$, a promised discounted future utility, $v_{t+1} \in V$ as a function of the current promised utility level, v_t and current productivity realization φ_t. For reasons of computational tractability discussed by Phelan and Townsend (1991), lotteries are considered over (a_t, c_t, v_{t+1}) as well as deterministic values.

Finally, the contract with lotteries is a joint probability measure of $\lambda(a_t, c_t, v_{t+1}|v_t, \varphi_t)$. In this notation, a deterministic contract is represented by a triple of degenerate lotteries, each of which assigns probability 1 to some single alternative. An important economic constraint on the contract is that it must be incentive compatible. Incentive compatibility means that the manager prefers the recommended effort level a_t over all alternative effort levels $\widehat{a}_t$[8],

$$E_\lambda[(u(a_t, c_t|v_t, \varphi_t) + \beta v_{t+1})|\varphi_{t-1}] = \max E_\lambda[(u(\widehat{a}_t, c_t|v_t, \varphi_t) + \beta v_{t+1})|\varphi_{t-1}]$$

I now describe the timing of events. At the beginning of each period, the worker's wage and the distribution of firms over their productivities are observed. The owner has already observed the last period's productivity, φ_{t-1} and he has promised, v_t to the manager in previous period. With those in mind, the owner offers the joint probability of $(a_t, c_t, v_{t+1}, \varphi_t)$ specified by the contract. By incentive compatibility, the manager is willing to randomize over effort levels as the owner has specified, before observing the firm-specific productivity

[8] Expected utility of obeying the recomendation is greater than that of each possible deviations from the recomended effort level.

shock, ε_t. For a given action,a_t and previous period's productivity φ_{t-1}, current productivity is determined by the exogenous technology shock. After the manager observes the current productivity, he makes employment decisions. Since there are no firing or hiring costs, the employment problem is static. Finally production takes place and the profit-cash flow is observed by the owner. Knowing the aggregate state, the owner can also derive the value of current productivity. Conditional on productivity and the recommended action a_t, compensation is determined according to conditional probability measure $\lambda(c_t|a_t, \varphi_t)$. Finally, v_{t+1} is promised according to $\lambda(v_{t+1}|a_t, c_t, \varphi_t)$. At the end of the period, before observing tomorrow's macro state, the owner makes his exit or stay decision and the period ends.

At this point, the problem is not a linear programming problem. To make the problem a linear programming problem, restate the joint distribution $\lambda()$ as a product of marginal and conditional distributions:[9]

$$\lambda(a_t, c_t, \varphi_t, v_{t+1}) = \lambda(v_{t+1}|a_t, c_t, \varphi_t)\lambda(c_t|a_t, \varphi_t)g(\varphi_t|\varphi_{t-1}, a_t)\lambda(a_t) \tag{12}$$

and make the joint distribution $\lambda(a_t, c_t, \varphi_t, v_{t+1})$ be the contract that is offered by the owner. If the owner chooses $\lambda(a_t, c_t, \varphi_t, v_{t+1})$ that satisfies the technology constraint; eq(12), that means he has implicitly chosen $\lambda(a_t), \lambda(c_t|a_t, \varphi_t)$, and $\lambda(v_{t+1}|a_t, c_t, \varphi_t)$.

For every owner who observed φ_{t-1} as last periods productivity, promised v_t to his manager and the aggregate state of the world,Γ_t, w_t , the contract is defined as such a probability

[9] The detailed explanation of the linearization of the owner's problem is explained in Prescott (2001). Application of this theorem here is sound not withstanding the fact that random variables are involved our endogenous ones.

measure that satisfies the following constraints.

First, the contract implies the conditional probabilities of productivities given the effort level which are the choice variables. These implied probabilities must coincide with the conditional probabilities of productivities imposed by the exogenous technology, $g(\varphi_t|\varphi_{t-1}, a_t)$. Therefore, for every $\overline{a}, \overline{\varphi} \in A \times \Psi$, the *technology constraint* has to be satisfied.

$$\sum_{C,V} \lambda(\overline{a}_t, c_t, \overline{\varphi}_t, v_{t+1}) = g(\overline{\varphi}_t|\varphi_{t-1}, \overline{a}_t) \sum_{C,V,\Psi} \lambda(\overline{a}_t, c_t, \varphi_t, v_{t+1}) \tag{13}$$

Second, the discounted expected future utility of the manager must be equal to the promised value,v_t. So, the *continuation of utility constraint* is

$$v_t = \sum_{A,\Psi,C,V} (u(c_t, a_t) + \beta v_{t+1})\lambda(a_t, c_t, \varphi_t, v_{t+1}). \tag{14}$$

Third, the joint distribution has to represent a valid probability measure,

$$\begin{aligned} \sum_{A,\Psi,C,V} \lambda(a_t, c_t, \varphi_t, v_{t+1}) &= 1 \text{ and } \lambda(a_t, c_t, \varphi_t, v_{t+1}) \geq 0 \\ \text{for all } a, c, \varphi, v &\in Q, \Psi, C, V \end{aligned} \tag{15}$$

Lastly; the contract must be incentive compatible for all assigned and alternative action pairs, $a, \widehat{a} \in A \times A$. So given the way the contract has been linearized, the *incentive compatibility constraint* explained earlier can be rewritten as:

$$\sum_{\Psi,C,V} (u(c_t, a_t)+\beta v_{t+1})\lambda(a_t, c_t, \varphi_t, v_{t+1}) \geq \sum_{\Psi,C,V} (u(c_t, \widehat{a}_t)+\beta v_{t+1})\frac{g(\varphi_t|\varphi_{t-1}, \widehat{a}_t)}{g(\varphi_t|\varphi_{t-1}, a_t)}\lambda(\widehat{a}_t, c_t, \varphi_t, v_{t+1}) \tag{16}$$

In a dynamic setting, the owner's problem is to construct sequence of probability measures $\{\lambda_t(a_t, \varphi_t, c_t, v_{t+1})\}_{t=1}^{\infty}\}$.

For an incumbent firm's owner, the current state is his firms's previous period productivity level,$\varphi_{t-1,}$ the value promised to the manager last period v_t, and the aggregate states w_t and Γ_t. He finds the optimal contract among all contracts that satisfies the above constraints. The optimal contract maximizes the owner's expected discounted return given H, g, Θ. One can define the owner's problem as:

$$U_t(\varphi_{t-1}, v_t; \Gamma_t, w_t) = \max_{\lambda} \sum_{A,\Psi,C,V} [\pi_t(\varphi_t|\Gamma_t, w_t) - c_t$$

$$+\beta \max\{m, E_{\Gamma_{t+1},w_{t+1}} U_{t+1}(\varphi_{t,} v_{t+1}; \Gamma_{t+1}, w_{t+1}|\Gamma_t, w_t)\}] \, \lambda(a_t, \varphi_t, c_t, v_{t+1})$$

subject to

$$\sum_{C,V} \lambda(\overline{a}, c_t, \overline{\varphi}, v_{t+1}) = g(\overline{\varphi}|\varphi_{t-1}, \overline{a}) \sum_{C,V,\Psi} \lambda(\overline{a}, c_t, \varphi_t, v_{t+1}) \qquad \text{for all } \overline{a}, \overline{\varphi} \in A \times \Psi,$$

$$\begin{aligned} v_t &= \sum_{A,C,V} \sum_{(\varphi \geq \varphi_t^*) \in \Psi} (u_t(c_t, a_t) + \beta v_{t+1}) \lambda(a_t, \varphi_t, c_t, v_{t+1}) \\ &\quad + \sum_{A,C,V} \sum_{(\varphi < \varphi_t^*) \in \Psi} (\frac{1}{1-\beta} u(c_t, a_t) - K) \lambda(a_t, \varphi_t, c_t, v_{t+1}) \end{aligned}$$

$$\sum_{A,\Psi,C,V} \lambda(a_t, \varphi_t, c_t, v_{t+1}) = 1 \quad \text{and} \quad \lambda(a_t, \varphi_t, c_t, v_{t+1}) \geq 0 \text{ for all } a_t, \varphi_t, c_t, v_{t+1}$$

$$\begin{aligned} v_t &> \sum_{A,C,V} \sum_{(\varphi \geq \varphi_t^*) \in \Psi} (u_t(c_t, \widehat{a}_t) + \beta v_{t+1}) \frac{g_t(\varphi_t|\varphi_{t-1}, \widehat{a}_t)}{g_t(\varphi_t|\varphi_{t-1}, a_t)} \lambda(a_t, \varphi_t, c_t, v_{t+1}) \\ &\quad + \sum_{A,C,V} \sum_{(\varphi < \varphi_t^*) \in \Psi} (\frac{1}{1-\beta} u(c_t, \widehat{a}_t) - K) \frac{g_t(\varphi_t|\varphi_{t-1}, \widehat{a}_t)}{g_t(\varphi_t|\varphi_{t-1}, a_t)} \lambda(a_t, \varphi_t, c_t, v_{t+1}) \end{aligned}$$

$$v_t > outside\_option$$

$$and$$

$$\Gamma_{t+1} = H(\Gamma_t, w_t)$$

Table 2: Estimated Model parameters for Agency Model for Colombian Malt Industry

	Parameters	Standard Errors
Manager's utility function parameter, μ	0.974	$n.a$
Cost of effort parameter, η	1.855	$n.a$
Manager's disutility parameter, K	$11,178.49$	$n.a$
Incumbent's productivity process, intercept, $b3$	1.997	$n.a$
Incumbent's productivity process, root, $b2$	0.231	$n.a$
Incumbent's productivity process, effort, $b1$	0.124	$n.a$
Incumbent's productivity process, variance σ_ε	0.095	$n.a$
production function parameter, θ	0.733	$n.a$
Elasticity of substitution between goods, σ	2.316	$n.a$
Mean entry cost, $\frac{FH}{2}$ (billion 2005 US dollars)	2652	$n.a$
Fixed Cost, f (million 2005 US dollars)	16.01	$n.a$
Scrap Value, m (million 2005 US dollars	51.5	$n.a$
Entrants initial productivity draw distribution,mean, z	-0.486	$n.a$

Table 3: Model Fit - Model with Agency Problem

	Simulated Moments	Data Moments
Mean Entry Rate	$1.2316e-05$	$3.8295e-02$
Variance of Entry Rate	$3.6225e-07$	$0.2787e-02$
Mean Exit Rate	$6.6746e-04$	$3.2176e-02$
Variance of Exit Rate	$1.9608e-05$	$1.6014e-03$
Mean Number of Firms	1.4259	1.0583
Variance of Number of Firms	0.0208	0.0026
Mean Log Employment	8.6668	5.4340
Variance Log Employment	0.0239	0.6863
Mean log(revenue/cost)	0.3863	0.6478
Variance log(revenue/cost)	0.0026	0.1622
Mean Employment Growth	0.0151	0.0221
Variance employment Growth	0.0320	0.0145
Mean log Compensation	2.8982	6.4541
Variance of log Compensation	2.1536	0.2534
Cov LogCOMP and logEMP	0.0124	0.0657
Cov LogEMP at t and t-1	0.0087	0.6565
Cov of logRev/Cost and logEMP	0.0076	0.0414
Cov of logRev/Cost at t and t-1	0.0009	0.07132

Table 4: Experiment: in a principal-agent(benchmark) model

	$When\ \frac{FH}{2} = 2.652e12$	$When\ \frac{FH}{2} = 2.652e7$
Mean Entry Rate	$1.2316e-05$	$1.38182e-02$
Variance of Entry Rate	$3.6225e-07$	$1.09671e-02$
Mean Exit Rate	$6.6746e-04$	$8.24316e-02$
Variance of Exit Rate	$1.9608e-05$	$4.17595e-02$
Mean (Number of Firms/20)	1.4259	7.77435
Variance of (Number of Firms/20)	0.0208	2.16776
Mean Log Employment	8.6668	8.6572
Variance Log Employment	0.0239	0.0332
Mean log(revenue/cost)	0.3863	0.3804
Variance log(revenue/cost)	0.0026	0.0041
Mean Employment Growth	0.0151	0.1541
Variance employment Growth	0.0320	0.0426
Mean log Compensation	2.8982	2.6535
Variance of log Compensation	2.1536	1.7268
Cov LogCOMP and logEMP	0.0124	0.0009
Cov LogEMP at t and t-1	0.0087	0.0080
Cov of logRev/Cost and logEMP	0.0076	0.0113
Cov of logRev/Cost at t and t-1	0.0009	0.0008

Table 5: Comparison with the benchmark economy, single agent model

	$When\ \frac{F_H}{2} = 2.652e12$	$When\ \frac{F_H}{2} = 2.652e7$
Mean Entry Rate	0.	$1.28826e-01$
Variance of Entry Rate	0.	$2.65282e-02$
Mean Exit Rate	$2.51256e-04$	$4.69849e-02$
Variance of Exit Rate	$2.51257e-04$	$3.96992e-02$
Mean (Number of Firms/20)	1.1328	5.35190
Variance of (Number of Firms/20)	0.018975	1.08536
Mean Log Employment	8.36921	8.39869
Variance Log Employment	0.02129	0.02952
Mean log(revenue/cost)	0.26097	0.27181
Variance log(revenue/cost)	0.00313	0.00467
Mean Employment Growth	0.01307	0.03905
Variance employment Growth	0.02988	0.04072
Cov LogEMP at t and t-1	0.00679	0.01029
Cov of logRev/Cost and logEMP	0.00768	0.01122
Cov of logRev/Cost at t and t-1	0.00080	0.00137

Table 6: Aggregate Productivity-When there is Agency Problem

	When competition is low	When competition is high
Aggregate Productivity	2.29083	2.69801
Mean Productivity	2.26652	2.66671
Covariance between market shares and productivity	$2.431e-02$	$3.130e-02$

Table 7: Aggregate Productivity-When there is no Agency Problem

	When competition is low	When competition is high
Aggregate Productivity	2.02951	2.81969
Mean Productivity	2.01288	2.79040
Covariance between market shares and productivity	$1.662e-02$	$2.929e-02$

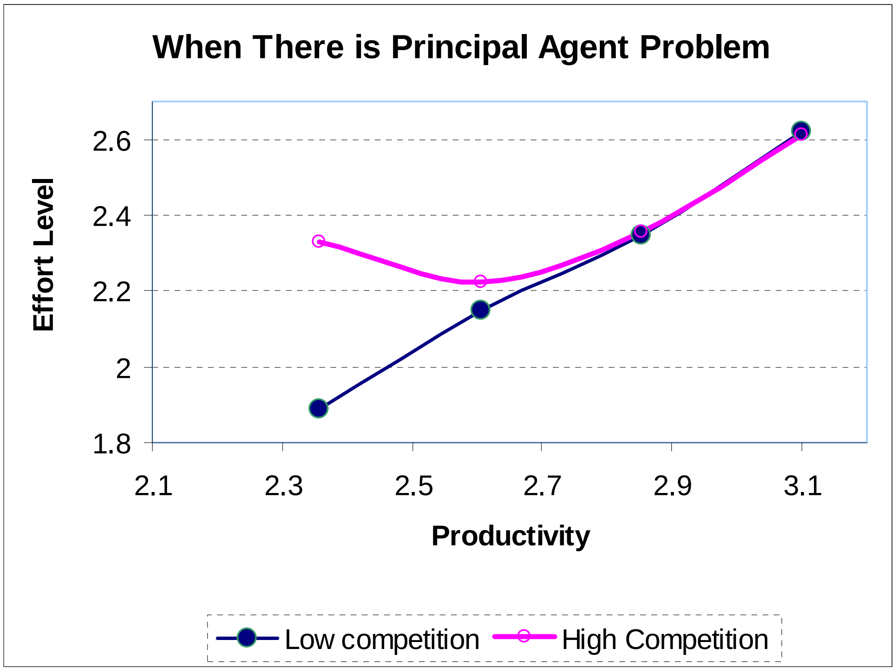

Figure 1: The Effort Responses of Managers in Agency Model

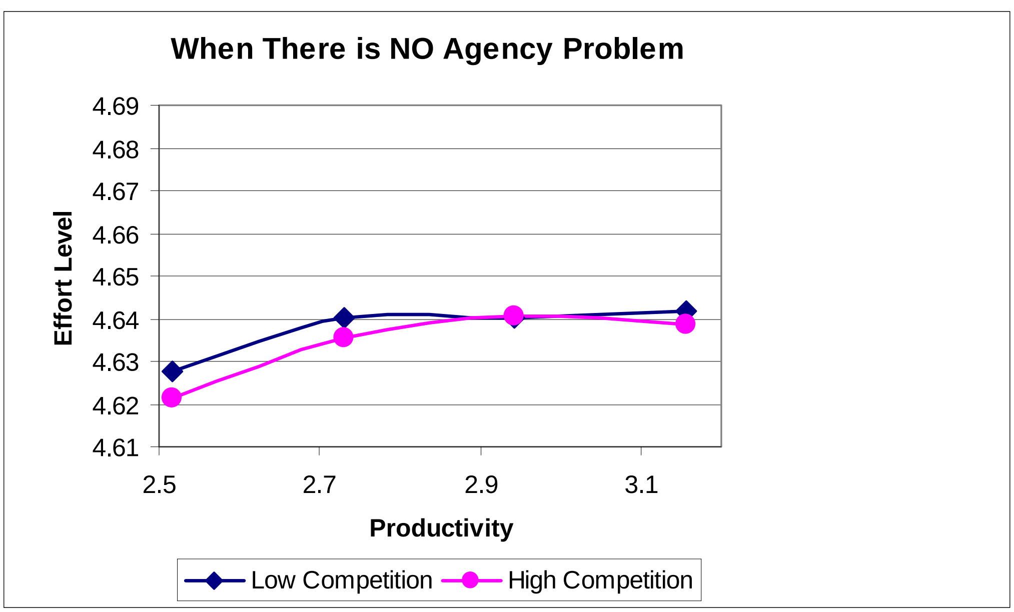

Figure 2: The Effort Responses of Managers in Proprietorship Model