Managerial Effort, Agency, and Industrial Evolution*
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Abstract
This paper demonstrates a new channel through which informational asymmetries between an owner and a manager affects aggregate productivity and industry dynamics. I build an industrial evolution model that exhibits endogenous effort choices which then affects the productivity evolution of firms and owners offering dynamic contracts to elicit profit maximizing effort choices of managers. An analysis of procompetitive counterfactual experiments shows that the model with agency problems results in drastically smaller increase in aggregate productivity, a decrease in mean productivity and mean employment as opposed to an alternative environment without agency problems. These dramatic differences are shown to be due to heterogenous responses of managers to heightened competition. In the presence of agency problems, managers’ higher incentives to avoid liquidation more dominantly among less productive firms work against the standard Schumpeterian forces and hence increase the survival probability of smaller firms.

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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 (also known as Schumpeterian forces). 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.

This paper proposes a new channel through which managers’ actions affect aggregate productivity. In an economy with agency problems between a firm owner and a manager, when managers enjoy firm-specific rents, they may react to heightened competitive pressures by working harder to keep their firms from liquidating. This effect is dominant among smaller firms which are more prone to liquidation. This heterogenous effect of competitive pressure on managerial actions work in the opposite direction of the selection effects and Schumpetarian forces. Thus the overall effect of competitive pressure on firms dynamics, firm turnover and aggregate productivity is dampened by the existence of agency problems. This is the first paper that demonstrates this channel and hence the importance of agency problems in evaluating procompetitive policy reforms.

First I build an industrial evolution model with monopolistically competitive heterogenous firms. The owner of the firm is the only decision maker. At each period in time, his effort choice affects the productivity level of his firm tomorrow. He also makes static employment and pricing decisions. At the end of each period, he decides on the continuation or the exit of the firm by comparing the value of his
firm with its scrap value. Thus the model exhibits both selection effects through endogenous exit decision of owners and Schumpeterian forces through endogenous effort choices. The model described above is called "family-owned" model. Then, I introduce "agency" model which is built upon the family-owned model. There are two decision makers in any firm, an owner and a manager. The owner continues to make stay or exit decision and the manager makes dynamic effort choice and static employment and pricing decisions. Informational asymmetry between the owner and the manager creates the agency problems in the model. Agency model has two key features. First, managers are compensated by long term contracts rather than hired in spot markets. Thus, owner-manager relationship is characterized using the dynamic contract developed by Phelan and Townsend (1991). Second, to create a wedge between the objectives of the owner and the manager, I assume that the manager loses job-specific rents if his 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 to influence owners’ exit decisions.

The parameters of the family-owned model is estimated using plant level panel data from the Colombian Ophtalmic Industry. The industry and the data set are ideal for the purposes of this paper. First, the industry 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, it is populated exclusively by proprietorships and limited partnerships, so ownership and management are not separated. Finally, the available plant-level panel data on other industries include information on managerial compensation and bonuses which make it possible to infer the parameters of the agency problem in the agency model.

Using parameters estimated from the family-owned model and parameters of the agency problem inferred from the data, I perform counterfactual analysis concerning the effects of procompetitive policies on aggregate productivity on two versions of the model. This policy change for both models is represented as a tenfold decrease in mean fixed entry costs. Then, to point out the effect of agency problems, I compare the predictions of both models.

Counterfactual simulation experiments show that with heightened competitive
pressure the increase in aggregate productivity in the family owned model is 15%. Mean productivity increases as well. Also there is a 5% increase in employment size. Threshold productivity for potential entrants and current incumbents also increases. All these findings are inline with the existing literature. When we compare the effects of an identical policy change on the agency model, we observe drastically different market dynamics. The increase in aggregate productivity is 2.7% and smaller than the family owned model. Threshold productivity doesn’t change, mean productivity declines and most importantly mean employment declines by 25%. These findings are all contrary to the findings of existing literature on the effects of competitive pressure on firm dynamics.

The difference between the two models is solely due to the existence of agency problems and heterogenous responses of effort choices of managers to heightened competition in agency model results in an increase in the probability of survival among lower productivity-smaller firms. In the agency model, managers of the surviving lowest productivity firms decrease their effort levels by 37%. The marginal benefit of an additional effort on the probability of survival and the probability of loss of job specific rents and hence on the marginal benefit of manager’s lifetime utility is lower than the marginal cost of effort. Thus, they decline their efforts drastically. This sharp decline is followed by a sharp increase in managerial effort level by 27%. Among the firms that are still at high risk of failure, their managers have the greatest incentive to improve their performance to avoid bankruptcy. This high incentive declines with productivity as probability of failure declines as well. Furthermore, with higher competition Schumpeterian forces decrease incentives to exert effort for all productivity levels and dominate the incentives to avoid bankruptcy for higher productivity firms. Finally effort levels decline by about 2% to 5% among relatively higher productivity firms along the productivity distribution. In the family owned model, since the owner already internalizes all the losses that are incurred when the firm is liquidated, the risk of failure doesn’t play any role in effort choices of owners. Rather, standard Schumpeterian forces dominate in the family owned model, and owners work less as the return to effort decreases. Among the surviving firms that have the lowest and highest productivity levels of the productivity distribution effort
levels decline by 13%.

The differential increase in aggregate productivity comes along with differential effects on threshold productivity and mean employment levels. When faced with higher competition the threshold level rises in the family owned model whereas it does not change in the agency model. Again, higher competition has minimal effect on potential entrants in industries composed of mainly corporations. These changes are accompanied by a drastic decline in mean employment in agency model compared to an increase in the family owned model. The differences between these observations come mainly from the fact that managers do not exert their first best effort choices in the existence of agency problems. Since there is room for improvement, with heightened competitive pressure, to avoid bankruptcy and managerial cost of liquidation, managers work harder. Note that this also allows relatively low productivity firms to survive in agency model compared to family owned model. Hence both the threshold productivity level is not effected and the average employment level declines when firms face competition. The risk of failure declines with productivity and hence managers of high productivity firms are harder to incentivize to exert more effort.

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 (Hart (1983) and Scharfstein (1988)). These models also 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. In this framework managers of heterogenous firms facing heterogenous liquidation risks respond to competitive pressure differently. For each firm, the effect of competitive pressures on the
return to managerial effort can be positive or negative. Cross-firm heterogeneity in 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 and declines with productivity. 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.) Furthermore, a structural industrial evolution model with heterogenous firms allows us to aggregate these heterogenous responses and quantify the changes in aggregate productivity.

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, in line with standard Schumpeterian arguments, but opposite to the findings of this paper, they find that firms far from the technological frontier decrease their innovative activities. More recently, 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 to better understand how productivity evolves. The key distinction between the above industrial evolution models with endogenous productivity growth is that I empirically characterize steady state of an industrial evolution model with endogenous effort choices in the presence of agency problems. Both versions of the model have endogenous effort choices affecting productivity levels of firms, thus contributing to the new developments in understanding how productivity evolves.

Finally, the present paper is related to an empirical literature on competition and productivity. The empirical literature generally supports the notion that com-
petition has positive effect on efficiency. But most of this literature is reduced-form, and does not isolate the quantitative importance of individual mechanisms (Blundell, Griffith, and Von Reenan (1995), Nickell (1996), Baily and Gersbach (1995)). Nickell (1996)). 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. Then she sorts firms according to their ownership. The increase in efficiency occurs in the group that consists of corporations. On the other hand, the firms, where ownership and management are closely linked, don’t have efficiency gains even after the SMP. However, she does not evaluate the overall effect on industry composition of firms and aggregate efficiency. This paper extends the empirical literature by introducing a structural model that allows me to conduct counter-factual analysis and quantify the channels through which the agency problems affect aggregate productivity. Furthermore and most importantly, the model allows us to understand how policy makers may overestimate the effect of competitive pressure on the aggregate productivity increase.

The rest of the paper is organized as follows. Section 2 details specifics of the model. Section 3 describes estimation methodology. Section 4 summarizes the findings. Section 5 concludes.

2 Model:

The model below describes the agency model in full detail for expositional purposes. The family owned model is described afterwards as a simplified version of the agency model.

The agency model has 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, firms compete with one another in a monopolistically competitive product market.
At the beginning of each period, each active firm starts with the knowledge of the previous period’s productivity level. Taking last period’s productivity level and his contract into consideration, the manager chooses an effort level. Each firm’s productivity depends upon the effort its manager puts into running it, the productivity it inherits from the previous period and an idiosyncratic shock. Finally, once current productivity is realized, managers hire labour in a competitive factor market and decide on 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 shocks their firms face each period. They can only observe profit flows. 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. At the end of each period owners may 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 productivity distribution. The new entrant starts next period as an incumbent.

Beginning-of-period distribution of firms, exit decisions of incumbents, and entry decisions of potential entrepreneurs determine the distribution of firms every period. In steady state 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.
2.1 Demand:

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

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

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

\[
q_i = \frac{R}{\bar{P}^{1-\sigma} p_i^{-\sigma}},
\]

where \( R \) denotes aggregate expenditure, \( \bar{P} \) is the exact price index for a unit of utility where \( p_i \) represents the price of product \( i \):

\[
\bar{P} = \left( \sum_{i=1}^{N} p_i^{1-\sigma} \right)^{1/(1-\sigma)}.
\]

2.2 Production:

Labor is the only factor of production. The factor market is perfectly competitive. The wage rate \( w \) is common to all workers and exogenous to the model. Firms differ in their productivity, but share a common technology:

\[
q_{it} = e^{\varphi_{it} l_{it}^\theta}, \quad 0 < \theta \leq 1,
\]

here \( l_{it} \) denotes the labor input of firm \( i \) at time \( t \), and \( \varphi_{it} \) is the productivity of firm \( i \) at time \( t \). \( \theta \) represents the degree of returns to scale. Current productivity is dependent on the current effort choice of the manager, \( a_{it} \in A \), previous period’s productivity \( \varphi_{it-1} \), and an idiosyncratic shock \( \varepsilon_{it} \). More precisely, it follows a first
order AR(1) process:

\[ \varphi_{it} = b_1 \log(a_{it}) + b_2 \varphi_{it-1} + b_3 + \varepsilon_\varphi \sim N(0, \sigma_\varepsilon^2). \]  

(5)

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

2.3 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, \( h_t = \{\varphi_0, \varphi_2, \varphi_3, \ldots \varphi_{t-1}\} \), as well as its current productivity, \( \varphi_t \). 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.\(^1\) If managers reject the 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 the idiosyncratic productivity shock is realized, they determine the optimal employment level and price of the product depending on the realized productivity.

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

\[
u(c_t, a_t) = \begin{cases} 
  c_t^\mu - (c_t^{\mu t} - 1) & \text{If the firm is in the market} \\
  c_t^\mu - K & \text{If the firm exits that period} \\
  c_0^\mu & \text{If the manager worked for a firm before} 
\end{cases} \]

\(\mu \in (0, 1), \eta > 1.\)

\(^1\) 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.
Here, $\mu$ is manager’s degree of risk aversion, and $\eta$ is the cost of effort parameter. $K$ is the onetime loss of rents by the manager 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 (as in Schmidt (1997)). 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.

Changes in competitive pressure effect the above mentioned factors of managerial effort choice in different directions. In a more competitive environment, decline in expected future profits may decrease the return to cost reducing activity for the owner. 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. Hence, the overall effect of competitive pressure on managerial performance is dependent on which effect dominates the other.

2.3.1 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. 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 of productivity realizations which is $t$ dimensional. A standard result in the dynamic contract literature is that there is a one-dimensional sufficient statistic

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2 K may include the opportunity cost of the time period for which the manager searches for a new job. K may also be the loss of firm specific human capital or else may be the stigma of being the former manager of a bankrupt firm. See Ryngaert (1988), Malatesta and Walking (1988) for empirical evidence.

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.
for this history of productivity realizations (Phelan and Townsend (1991), Spear and Srivasta (1987), Thomas and Wortall (1988), Abreu, Pearce, and Stacchetti (1990)). More precisely, the expected discounted future utility of the manager 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 current promised utility level, $v_t$ and current productivity realization $\varphi_t$. 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. Despite this apparently stochastic formulation computation always results in an optimal contract that is deterministic. Therefore, the model is explained with deterministic contracts, and the details of the lottery contracts are described in Appendix.

I now describe the timing of events. The owner has observed the last period’s productivity, $\varphi_{t-1}$ 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. The contract is designed such that the expected utility of obeying the recommendation is greater than that of each possible deviations from the recommended level. Thus, the manager is willing to exert the recommended effort level as the owner has specified. Later, he observes firm-specific productivity shock, $\varepsilon_t$. For a given action level, $a_t$ and previous period’s productivity $\varphi_{t-1}$, current productivity is determined by the productivity shock. After the realization of the current productivity, the manager 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. The owner can also derive the value of current productivity. Conditional on productivity and the recommended action $a_t$, compensation is determined according to the compensation schedule $c_t(\varphi_t|a_t, v_t)$.

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4 The risk taking behavior of the owner and the manager, in particular a risk neutral owner and a risk averse manager with a separable utility function guarantees that the optimal contract is deterministic. See Arnott and Stiglitz (1988)
Also, in keeping with the contract, $v_{t+1}$ is determined according to $v_{t+1}(\varphi_t|c_t, a_t, v_t)$. At the end of the period, the owner makes his exit or stay decision and the period ends.

For every owner who observed $\varphi_{t-1}$ as last periods productivity and promised $v_t$ to his manager, the contract can be expressed as recommended actions, $a_t$, a compensation schedule $c_t(\varphi_t|a_t, c_t, v_t)$ and promised utility schedule, $v_{t+1}(\varphi_t|a_t, c_t, v_t)$ 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

$$v_t = \int (u(c_t(\varphi_t|a_t, v_t), a_t) + \beta v_{t+1}(\varphi_t|a_t, c_t, v_t))g(d\varphi_t|\varphi_{t-1}, a_t).$$ (6)

Second, the contract must be incentive compatible for all assigned and alternative action pairs, $a, \tilde{a} \in A \times A$. The incentive compatibility means that the manager prefers the recommended effort level $a$ over all alternative effort levels $\tilde{a}$. That is, the expected utility of obeying the recommendation is greater than that of each possible deviations from the recommended effort level. The incentive compatibility constraint explained can be written as:

$$\int (u(c_t, a_t) + \beta v_{t+1})g(d\varphi_t|\varphi_{t-1}, a_t) > \int (u(c_t, \tilde{a}_t) + \beta v_{t+1})g(d\varphi_t|\varphi_{t-1}, \tilde{a}_t)$$ (7)

Lastly; the contract must deliver at least the managers outside option$^5$

$$v_t > \frac{1}{1 - \beta} (c_0)^{\mu}.$$ (8)

In a dynamic setting, the owner’s problem is to construct a sequence of recommended action levels, compensation and future utility functions \{$(a_t, c_t(), v_{t+1}())$\}$^\infty_{t=1}$ as functions of the observables; his firm’s productivity realizations.

The decision that is not governed by the contract is the owner’s exit decision. At the end of each period, he makes a "stay or exit" decision. If the expected value

$^5$ Manager’s outside option is assumed to be zero.
of his continuation utility is less than the scrap value, \( m \), of the firm, the firm is liquidated. Otherwise, it continues to operate in the market.

For an incumbent firm’s owner, the current state is his firm’s previous period productivity level, \( \varphi_{t-1} \), and the value promised to the manager in the last period \( v_t \). He finds the optimal contract among all feasible contracts i.e. contracts that satisfy the above constraints. The optimal contract maximizes the owner’s expected discounted return given \( g \), and \( w \). One can define the owner’s problem as:

\[
U_t(\varphi_{t-1}, v_t) = \max_{a_t,c_t} \int [\pi_t(\varphi_t) - c_t] + \beta \max\{m, U_{t+1}(\varphi_t, v_{t+1})\} g(d\varphi_t|a_t, \varphi_{t-1})
\]

subject to

\[
v_t = \int_{\varphi \geq \varphi_t^*} (u_t(c_t, a_t) + \beta v_{t+1}) g(d\varphi_t|a_t, \varphi_{t-1}) + \int_{\varphi < \varphi_t^*} (u_t(c_t, a_t) - K) g(d\varphi_t|a_t, \varphi_{t-1})
\]

\[
v_t > \int_{\varphi \geq \varphi_t^*} (u_t(c_t(\varphi_t|a_t), v_t), \tilde{a}_t) + \beta v_{t+1}(\varphi_t|a_t, c_t, v_t)) g_t(d\varphi_t|\varphi_{t-1}, \tilde{a}_t) + \int_{\varphi < \varphi_t^*} (u_t(c_t(\varphi_t|a_t), v_t), \tilde{a}_t) - K) g_t(d\varphi_t|\varphi_{t-1}, \tilde{a}_t)
\]

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

\[
c_t = c_t(\varphi_t|a_t, v_t)
\]

\[
v_{t+1} = v_{t+1}(\varphi_t|a_t, c_t, v_t)
\]
The above dynamic problem also gives an exit decision.

\[ \chi(\varphi_{t-1}, v_t) = \begin{cases} 
1 & \text{if } EV < m \\
0 & \text{elsewhere} 
\end{cases} \]

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

### 2.3.2 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, \(fe\), 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 less than the scrap value of the firm, the owner exits the market immediately. Otherwise, he offers a contract to a manager and starts production. Note that the new entrants choose to promise \(v_1(\varphi_0)\) that maximizes their expected return: 

\[ v_1(\varphi_0) = \arg\max_{v_i} U(\varphi_0, v_i(\varphi_0)) \]

Thus, a potential entrant’s problem, given the incumbent firm owner’s value function \(U\) and \(F(\varphi)\) is:

\[ U^E = E_{\varphi_0} U(\varphi_0, v_1(\varphi_0)|F(\varphi)). \] (8)

The potential entrant will create a new firm if

\[ U^E > fe, \] (9)

and he will stay in the market if \(U(\varphi_0, v_1(\varphi_0)) > m\).
2.4 Equilibrium:

The steady state equilibrium is a pair of value functions $U$ and $U^E$ for incumbents and potential entrants respectively and a corresponding contract, and exit rule $\chi$, given the transition density of productivities $g$, and the common initial productivity distribution that potential entrants draw from $F$ and wages for labour, $w$.

1- Given the distribution of firms over their productivities and promised future utilities, $w$ and $g$, the owner solves his problem and the value function gives exit rule $\chi$ and the contract: the recommended action $a_t$, the compensation function $c_t()$, and the promised utility function $v_{t+1}()$.

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

3- Firm’s optimal decisions are consistent with the distribution of firms over their productivities and promised future utilities i.e. the distribution of firms over their productivities and promised future utilities reproduce itself each period given $g$, $F$, and policy functions.

Solution of the equilibrium

The main assumption behind this algorithm is that individual agents take the market aggregates as exogenous. Therefore, one can use $\bar{P}$ as aggregates of the distribution to approximate the equilibrium. The solution proposed in the previous paragraph requires the knowledge of $\bar{P}$ to solve the owner’s optimization problem. Although this 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. In equilibrium, the aggregate price index $\bar{P}$ must be consistent with individual firms’ pricing decisions.

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

1- Start with an initial guess on the aggregate price index $\bar{P}$
2- Given $\bar{P}$, $w$, and $g$ 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 $\bar{P}$ by aggregating the pricing decisions of firms.
5. If updated $\tilde{P}$ is sufficiently close to the previous guess, $\tilde{P}$, stop. Otherwise, use the updated $\tilde{P}$ and go back to step 2.

2.5 Family Owned Model

Owner’s problem:

The family owned version of the model shuts down agency problems and reexamines the effect of competitive pressures on the behavior of decision makers and thus on the aggregate economy. In this model the owner also manages the firm. He makes entry-exit decisions, he exerts effort, and employs the workers as well.

The sequence of actions is as follows. Given the wage rate for labour and previous period’s productivity level of the firm, the owner exerts effort level $a_t \in A$, each period, where $A$ is a discrete set of values. 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 owner 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, the owner makes exit or stay decision and the period ends. In the meantime, at the beginning of each period, potential entrants pay the fixed cost of entry $fe$, draw their initial productivity levels $\varphi_0$, and enters the market if the expected value of the firm is positive.

For an incumbent firm’s owner, the current state is his firm’s previous period productivity level, $\varphi_{t-1}$. He chooses his effort level to maximize his own expected discounted return, given the wage rate $w$, and the productivity transition $g$. His problem is:

$$U_t(\varphi_{t-1}) = \max_{a_t} \int \left[ \pi_t(\varphi_t) - \text{cost}(a_t) \right] + \beta \max \{ m, U_{t+1}(\varphi_t) \} g(d\varphi_t|\varphi_{t-1}, a_t)$$

where $\text{cost}(a_{it})$ has the same functional form as the manager.

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
rule.
\[
\chi(\varphi_{t-1}) = \begin{cases} 
1 & \text{if } EV < m \\
0 & \text{elsewhere}
\end{cases}
\]

For each state \((\varphi_{t-1})\), there exists a cutoff productivity level \(\varphi^*_t\) such that all firms at productivity above \(\varphi^*_t\) 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 \(F(\varphi)\):

\[
U^E = E_{\varphi}U(\varphi|F(\varphi))
\]  

(11)

Potential entrants create new firms where:

\[
U^E > f e,
\]

(12)

and they stay in the market when \(U(\varphi) > m\).

**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 \(\chi\) for given wage rate \(w\) for labour, \(g\), and \(F\).

1-Given the distribution of firms over their productivities, the wage rate for labour, \(w\), and the transition density \(g\), the owner solves his problem and the value
function gives policy functions, \( k \) and \( \chi \)

2- Given \( U \) and \( f \), \( U^E \) characterizes the problem of potential entrant.

3- Firms’ optimal decisions are consistent with the distribution of firms over their productivities.

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

3 Description of the Data:

I used the Colombian "Ophthalmic Goods" industry with SIC code 3852 for the period 1981 and 1989. The data is collected by the Colombia’s Departamento Administrativo National de Estadistica (DANE). The data cleaning process is described by Roberts(1996). Annual plant level data covers all plants with 10 or more employees.

The industry suits my purposes because it is composed of only proprietorships and limited partnerships. Out of 23 firms observed during the sample period, 17 of them are limited partnerships, 5 of them are proprietorships and 1 of them is a joint partnership. Thus, the data is generated by profit maximizing decision makers who are sole owners of their firms and are fully liable for their debt and loss as well. The mean number of firms for each year is 13. The size distribution of the industry and the large number of firms supports the monopolistic competition assumption rather than a strategic oligopolistic setup.

The firms in the market do not export. Out of 23 firms observed throughout the sample period only one of them exports. Furthermore, firms received export subsidies throughout the sample period. However, average percentage of export subsidies to total sales is 0.001%. We also do not have micro/industry level data on import competition. We know that up until 1984/1985 Colombian commercial policy protected import competing firms with high tariff barriers which were reduced slightly.

\footnote{The data do not link plants with firms. So we treat each plant as a single firm decision making unit.}
after 1984. Quantitative restrictions continued to exist for high import competing industries. Furthermore, between 82 – 86 are the years when Colombian peso is very weak (experienced a real-exchange rate depreciation), stabilizes after 1986. All these information is consistent with the non-tradable good economy assumption. Therefore, the structural model doesn’t incorporate exporting decision of firms or any import competition

The mean entry rate is 6.95 percent and the mean exit rate is 9.2 percent during the sample period. If we exclude the first year where we observe an exceptionally high exit rate, the mean exit rate drops to 6.98 percent which supports steady state equilibrium.

We also have the small economy assumption where we assume that wages of blue collar workers is exogenous to firms. Finally, the total revenue generated by the industry is on average %1 percent of the GDP of Columbia generated during the sample period which supports the small economy assumption.

3.1 Fitting the Family Owned Model to the Data

There are parameters that cannot be identified by the model. I take these parameters from the plant-level data (if available) or from external sources.

First, I measure the level of aggregate expenditures, $R$, as the average of yearly industry revenues over the period 1981 through 1989 which amounts to 5,890,142 (in 2005 US Dollars). Second, wages for blue collar workers in the ophthalmic goods sector is calculated using plant -level data which have disaggregated wage and bonus information. Cross-firm average wage plus bonuses for blue collar workers (obreros) is 4697 (in 2005 US Dollars) which is set as the wage rate for labour in the model. Third, I cannot observe the potential entrants in the market. The model also doesn’t allow me to identify the mass of entrants along with the fixed entry cost. Therefore, I arbitrarily fix the number of potential entrants to $N_{pe} = 5$. This number exceeds the maximum number of entrants in any sample year which is 3. Finally, following

---

7 For further details on Columbia’s economy during the sample period, see Roberts (1996)
Bond et.al (2014) I set the discount factor, $\beta = 0.9$.\(^8\)

The remaining parameters to be estimated are:

$$\Omega = (\theta, \ b_1, \ b_2, \ b_3, \ \sigma_\varepsilon, \ \sigma, \ \eta, \ F_H, \ f, \ m)$$

where $\theta$ is the production function parameter which represents returns to scale, the vector $(b_1, b_2, b_3, \sigma_\varepsilon)$ characterizes the AR(1) process of plant level productivity evolution, $\sigma$ is the elasticity of substitution between goods, cost of effort is parameterized by $\eta$. 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; 0 and standard deviation $\left(\frac{\sigma^2}{1-b_2^2}\right)$. This allows the new entrants to draw from a distribution that has the same variance as the incumbents’. Finally, the set of effort levels, $A$, is set as a discrete set of values where values are discretized between 0 and $e$.

The vector $\Omega$ is estimated using a simulated method of moments procedure (Gourieroux and Monfort (1996)).\(^9\) The procedure is as follows. For a candidate value of $\Omega$, the value functions and the policy functions are calculated for incumbents and new entrants. Then these policy functions are used to simulate a set of sample moments, $M_s$ (See table 1 for a complete list). Theses simulations require randomly drawn innovations as firm-level productivity shocks, $\varepsilon_{it}$ and entry costs $fe$.

I simulate the model $N_T(=***$) time periods and $S(=....)$ times. The shocks, and fixed cost draws (call them $\Lambda$) are kept constant for each simulation trials 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 parameter values, $\widehat{\Omega}$, are the ones that create simulated moments as

---

\(^8\) Bond et.al.(2014) calibrate the discount factor using average interest rate implied by the self-exiting threshold autoregression process for Columbia during the same sample period.

close to data moments as possible. Formally, the below problem is solved:

$$\hat{\Omega}(W) = \arg \min_{\Omega} (M_D - M_s(\Omega, \Lambda))\hat{W}(M_D - M_s(\Omega, \Lambda)^t$$

and $\hat{W}$ is a bootstrapped estimate of $(var(M_s))^{-1}$.

A number of issues arise when constructing the simulations. First, productivities and promised future utilities must be discretized in order to use standard techniques to calculate the value functions. For this, I use Tauchen and Husseys (1991) method. Second, given the potential for discontinuities in the model and the discretization of the state space, following Rust (1994) I use a simulated annealing optimization algorithm to perform the minimization to avoid local minima of the equation.

**Sample Statistics and Identification:**

The sample statistics, $M_s$ are calculated using plant level data of Colombian Ophthalmic Goods industry. The available plant-level panel data reports information on employment, revenue, cost, and firm types. Most importantly the panel data allows us to link producer heterogeneity and productivity dynamics with firm types.

I use 13 moments to estimate 10 parameters. I include mean and variance of firm entry, exit and number of firms as general industry characteristics to identify costs of entry and exit and fixed cost of operation. I find the number of firms, entrants and exiters for each year in the data set.\(^\text{10}\)The fraction of exiters/entrants in year $t$ is averaged over the sample period to calculate mean exit/entry rates. The variance of exiters/entrants is constructed as the variance of the fraction of exiters/entrants over the sample period. The number of firms is normalized with 13 which is the average number of observed firms per year. The mean and variance number of firms (divided by 13) is the average and variance of firms over the sample period.

Employment statistics are used to capture the returns to scale parameter, $\theta$. Mean and variance of log of total blue collar workers is calculated over the pooled sample of plants. Similarly, log of revenue over cost is calculated as the log of total

\(^{10}\) An entrant is defined as the firm/plant which appears with a new plant level ID in the data set for the first time. Similarly, an exitter is defined as the firm/plant which doesn’t appear in the data set from time $t$ on. They are counted as exiters on the last year they are seen.
revenue of a plant divided by the total cost of production. The mean and variance of log of revenue over cost is calculated over the pooled sample of plants. The fixed cost parameter and cost of effort parameters affect the profit and hence revenue over cost statistics of firms. In the structural model, the productivity of firms is directly related to total labour employment. Therefore, along with revenue over cost, the intertemporal covariances help to identify parameters that govern the dynamic features of the model. Full set of moments and sample statistics are reported in Table (1)

<table>
<thead>
<tr>
<th>Mean Entry Rate</th>
<th>Variance Log Employment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variance of Entry Rate</td>
<td>Mean log(revenue/cost)</td>
</tr>
<tr>
<td>Mean Exit Rate</td>
<td>Variance log(revenue/cost)</td>
</tr>
<tr>
<td>Variance of Exit Rate</td>
<td>Cov LogEMP at t and t-1</td>
</tr>
<tr>
<td>Mean Number of Firms</td>
<td>Cov logRev/Cost at t and t-1</td>
</tr>
<tr>
<td>Variance of Number of Firms</td>
<td>Cov of logRev/Cost and logEMP</td>
</tr>
<tr>
<td>Mean Log Employment</td>
<td></td>
</tr>
</tbody>
</table>

### 4 Parameter estimates

The simulated moments are reported in table (3). The model fits the data reasonably well. In particular, it captures the mean and variance of both number and size distribution of firms. The mean entry and exit rates underestimated data targets but simulated variances are close to the data variances. There is only one moment that poorly targets its counter data moment is the persistence in revenue over cost. Table (2) reports the estimation results for the set of parameters, Ω.

The standard errors are calculated using the asymptotic variance-covariance matrix expression (see Gourieroux and Monfort (2002) for a detailed discussion). The expression for the asymptotic variance covariance matrix is $\text{inv}[D'\hat{W}D]$ where $D$ is the derivative of the sample moments with respect to parameters. $W = \text{inv}(\text{cov}(\hat{Q}))$, where $\hat{Q}$ is bootstrapped estimate of $\text{var}(M_s)$. $\text{var}(M_s)$ is bootstrapped
from the sample data. Since the sample period is short and the number of observations is low, the diagonal elements of bootstrapped variance is large by construction leading to higher standard errors. Nonetheless, the estimated standard errors show a good fit of the model except for the upper bound of the fixed entry cost distribution. Furthermore, the above asymptotic variance covariance expression is valid if the number of simulations goes to infinity. Following, Duffie and Singleton(1993) and Hall and Rust (2003), I limit the number of simulations to 10.\footnote{The asymptotic variance covariance matrix of the SMM estimator is \((1 + \frac{1}{S})\) times that of the GMM estimator. (Duffie and Singleton (1993)). Therefore as the number of simulations increase, the marginal benefit of running one additional simulations is lower than the cost of it. Thus, I limit the number of simulations to 10.}

The estimated value of the mean entry cost is about 2540 (thousands 2005 Us dollars) or almost the same as 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 298.2 (in thousands 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 40.16 (in thousands 2005 Us dollars) which amounts to approximately 0.6 percent of average total sales.

The elasticity of substitution between goods is estimated as 2.611. This implies a mark-up equivalent to 1.62 which is very much in line with the literature. Estimates of the elasticity of substitution vary widely. In their study for Slovenian manufacturing firms De Loecker and Warzyski (2012) estimate median mark-ups ranging from 1.10 to 1.28 and report a standard deviation around the mark-ups as 0.5. They also report the distribution of mark-ups between 0.95 and 2.5 for chemical products. Estimated mark-ups are even higher for traded goods but there is evidence that ex-
porters on average have higher mark-ups than non-exporters (Melitz and Ottaviano (2008), De Loecker and Warzyski (2012) and Broda and Weinstein (2006)).

Returns to scale parameter is estimated as 0.9 which implies a decreasing returns to scale technology. For the same period as our data set, Basu and Fernald (1997) reports that 2 digit industries in US have returns to scale that is either constant or slightly decreasing returns to scale. Tybout et al. (1991) estimated returns to scale for 2 digit Chilean industries ranging from 0.79 to 1.26.

The parameters that govern the productivity process merit some comment as well. One percent increase in effort level increases future productivity and hence output by 0.125 percent. Among two firms one that is one unit more productive today is expected to be 0.668 units more productive tomorrow. Along with the coefficients of current productivity and effort, the variance of the idiosyncratic shock gives us the variance of productivity of incumbent firms which is 0.75 units.

Finally, the cost of effort parameter is estimated to be 2.277. Since our owner is risk neutral and the cost of effort function is exponentially increasing, a unit increase in effort decreases the owner’s utility ranging from 0 to 460 dollars in utility depending on current effort level.\(^{12}\)

4.1 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 the management are separated or that of the firms are one in the same. To do so, I perform an identical experiment on two versions of the model and compare the results. The experiment is designed as increasing competitive pressure by decreasing the mean fixed entry cost by a factor of 10, holding all other parameters constant. As a government policy, this can be thought of as diminishing bureaucratic burdens to enter a market. With the estimated parameters of the family owned model, both models are simulated with both estimated fixed entry cost parameter and lower fixed entry costs. Given the

\(^{12}\) The derivative of owner’s utility with respect to effort is \(-2.27 * \exp(2.27a)\). Therefore, the decline in utility due to a one unit increase in effort increases with effort level.
policy functions evaluated for both models, exogenous path of idiosyncratic shocks and that owners have rational expectations, both models are simulated for 400 years and 8 times. The simulated data is calculated by taking the average of these 8 sets of results.

The agency problem is parametrized as follows. The average urban unemployment during the sample period is 11 months (see Coşar et al. (forthcoming AER) and Medina et al. (2013)). Furthermore, in the data the median managerial compensation including bonuses is 103 (thousand 2005 dollars). Therefore, I set the disutility parameter that the manager experiences when the firm is liquidated, $K$, as 96. The manager’s risk aversion parameter, $\mu$, is set at 0.8.  

The reduction in mean entry costs increases the number of firms in the market by allowing more firms to enter. With more firms and thus a lower aggregate price index, incumbents face more competition. As a result, aggregate productivity increases in both versions of the model. Aggregate productivity increases by only %2.3 in agency model and a lot higher, by %15, in family owned model (Table 6 and Table 7). If we decompose the increase in aggregate productivity as in Olley and Pakes (1996), the mean productivity decreases in the agency model whereas in the family owned model the direction of the change is in line with the literature. The main explanation of relatively lower increase in aggregate productivity and the decline in mean productivity with heightened competition in agency model is the existence of agency problems and managers loosing firm specific rents. With heightened competitive pressure managers have incentives to increase their effort levels to avoid liquidation risk more dominantly among low productivity firms.

13 The discussion is based on simulation results for risk aversion parameter, $\mu = 0.8$. The experiment is repeated for $\mu = 0.85$ and $\mu = 0.9$ as well.

14 So far, the literature argues that with heightened competition, turnover rate in the market increases and through the exit of low productivity firms, aggregate productivity increases (selection effect). Furthermore, resources are reallocated more efficiently. Hence, aggregate productivity increases further through giving more market shares to more productive firms (resource reallocation effect). These effects are the key explanations of aggregate productivity increase in the literature and are also predicted by Hopenhayn (1992) and Melitz (2003), and can be found in earlier empirical studies (e.g. Olley and Pakes (1996), Pavnick (2002)). However, in agency model, the selection effect is weakened with the existence of shirking effect.
There are two key differences between the family-owned model and the agency model. First, ownership and management is separated. Owners can only influence the firms’ productivity trajectories through the dynamic contracts they offer to their managers. Second, when firms are liquidated, managers loose firm specific rents. Thus, managers have an incentive to avoid liquidation. Hence, changes in competitive pressures affect contracts and as a result efforts and compensations differ at firms with different degrees of liquidation risk. In the agency model, the decline in effort choice among the lowest productivity surviving firm is %37. However this decline is reversed by a sharp increase in effort level by %27 among the next lowest productivity firms that are still at high risk of bankruptcy. Furthermore, as productivity increases the decline in effort choices ranges from 2% to 5 %. Thus, to manipulate owners’ exit decision, the managers of firms on the lower end of the productivity distribution exerts more effort and this allows less productive-smaller firms to survive (see table(8)) . On the contrary, the effect is absent in the family owned model. With heightened competition, among the surviving firms effort levels decline the most among the firms that have the lowest and highest productivity levels of the productivity distribution. The decline is around %13 percent but almost negligible among medium productivity firms.

In an industry with agency problems, heightened competitive pressure is expected to further improve productivities as managers were not exerting their first best efforts. However, because of the heterogenous liquidation risk, the responses of managers are also heterogenous. Among low productivity firms increased effort responses allows them to survive even in a more competitive environment. As a result, the effect of competitive pressure on managerial effort responses to avoid liquidation works in the opposite direction to the selection effect and Schumpeterian forces. Since this effect is not present in the family owned model, it is only the selection effect and Schumpeterian forces that operate. The simulation results also supports the above argument. Competitive pressure increases the cutoff productivity for surviving firms in family owned model whereas in agency model the cutoff productivity does not change. This can also be seen as a decrease by %25 in mean employment level in agency model. On average firms become smaller and hence less productive. On
the contrary but in line with the previous literature, in family owned model, both mean employment (by 5%) and mean productivity (by 65 %) increases with higher competition.

A further discussion is necessary to understand why we observe different responses by owners’/managers’ effort choices in both versions of the model. The main reason is the effect of the ownership structure of the firm on how risk and reduced profits affect the incentives. In both versions of the model, when firms face heightened competition, exit occurs disproportionately among the lower productivity firms. In the agency model the 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 are 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 for mid and high productivity firms. On the other hand, in family-owned model, the risk of failure doesn’t play a role among the firms, as owners 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 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, some of the low productivity firms who were active before exited the market with heightened competition (see table(8)). Owners of the surviving low productivity firms decrease their effort.

In addition to introducing a new channel which may dampen the strong selection effects and Schumpeterian forces for low productivity firms, the model also helps to understand why CEO’s of very large firms get very high bonuses/compensations even at times of high risk of liquidation (like the 2008 economic crisis). Figure 1 depicts a u-shaped relationship between wage per effort for all productivity levels of firms.
For mid and high productivity firms, compensations exhibit a linear relationship with firms profits and productivities. The existence of liquidation risk and owners’ incentive to pay more to motivate their managers further to avoid liquidation also increases the wage /effort levels for low productivity firms. Hence we observe high payments for surviving small firms and very high productivity firms but relatively lower compensations per effort for mid-level firms.

The more surprising observation is the change in wage per effort levels when competition increases (hence the risk of liquidation). Among the highest productivity firms wage per effort levels increases even though their effort choices decrease (Figure 1 and Table 5). Now, very productive companies are compensating more even though their managers are lazier. On the contrary high liquidation risk makes it cheaper to motivate the manager of the low productivity firm. Their wage per effort levels decline even though they are exerting more effort. This further makes it easier for low productive firms to survive. This also explains why we observe wage rises for CEO’s at times of high risk.

5 Conclusion

This paper tries to understand how competitive pressure effects individual firm productivity and aggregate industry productivity in an environment where there are agency problems at the firm level. The literature mostly emphasizes Schumpeterian forces and selection effects of competition on aggregate productivity. This paper introduces a new channel through which aggregate productivity is affected by competitive pressure.

I first introduce the family owned model which is an industrial evolution model with monopolisticaly competitive heterogenous firms. The model exhibits both selection effects and Schumpeterian forces. Unlike most of the earlier dynamic frameworks, owner’s endogenous effort choice enters into the productivity evolution of firms. I estimate the benchmark model using Colombian Ophthalmic Goods industry panel data from 1981 to 1989.

I then introduce the Agency model. I embed agency problems into the family
owned model by separating ownership and management and imposing informational asymmetries. To solve the dynamic contractual problem, I use the dynamic contract framework developed by Phelan and Townsend (1991). In this model, owners offer long term contracts at the beginning of their life and make exit or stay decisions at the end of each period. Managers exert effort and make employment and pricing decisions at each period. The parametrization of the agency model is based on estimated parameters of the family owned model that govern firm dynamics and productivity evolution. The parameters of the manager’s utility function are assigned.

The structural model allows to quantify the effects of agency problems on aggregate productivity when the industry becomes more competitive. To do so, I perform a counterfactual analysis on both versions of the model. The competitive pressure is weakened by decreasing the upper bound on the fixed cost of entry distribution. In other words, it becomes more likely to draw a fixed entry cost that is above the expected value of being in the market.

The simulation results show that the aggregate productivity increases in both versions of the model, more in the family owned model than in the agency model. Moreover, the mean productivity declines in the agency model as oppose to an increase in the family owned model. These three sources of industrial efficiency observed in the simulations can explain the differences. Through endogenous entry and exit decisions selection effects are present. Through the changes on the market shares, one can also observe the effects of Schumpeterian forces. These two effects are present in both versions of the model and in earlier industrial evolution models used in the literature.

In the agency model, managers are incentivized through higher payments. This incentive mechanism weakens with competition as market shares decline. They are also incentivized to exert more effort to avoid the payment of cost of liquidation in case their firm goes bankrupt. This mechanism has differential effects on firms as firms’ liquidation risks are higher as they are closer to the cutoff productivity. Thus competitive pressure increases the incentives to exert more effort more among managers who are closer to the cut-off productivity. As a result we observe low productivity firms’ managers increasing their effort levels while higher productivity
firms decreasing their efforts. On the contrary this effect is not present in the family owned model. Hence, effort levels decline for all but most dominantly among low productivity firms.

A central finding of the simulation exercise is that with agency problems managers of relatively smaller firms increase their efforts and hence their survival probability. As a result we observe no change in cut-off productivity in the agency model as oppose to an increase in the family owned model and as expected in the literature. The differential effect on the cutoff productivity is accompanied by a differential change in average firm size of the industry. Average firm size (in labour counts) decreases in agency model whereas it increases in the family-owned model and in earlier models in the literature. These findings also show us that the managerial incentives to avoid cost of liquidation works against the selection effects and Schumpeterian forces and dampens the positive effects of competition on aggregate productivity. Hence policy makers should incorporate the existence of agency problems when evaluating the benefits of competition enhancing policies in environments where firms with potential agency problems are dominant.

References


Appendix (For Online Publication)

6.1 The formal description of the lottery contract:

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 \( \varphi_t \). 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 \((a_t, c_t, v_{t+1}|v_t, \varphi_t)\). 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 \( \tilde{a}_t \),

\[
E_\lambda[(u(a_t, c_t|v_t, \varphi_t) + \beta v_{t+1})|\varphi_{t-1}] = \max E_\lambda[(u(\tilde{a}_t, c_t|v_t, \varphi_t) + \beta v_{t+1})|\varphi_{t-1}]
\] (13)

I now describe the timing of events. At the beginning of each period the distribution of firms over their productivities is observed. The owner has already observed the last period’s productivity, \( \varphi_{t-1} \) 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 shock, \( \varepsilon_t \). For a given action, \( a_t \) and previous period’s productivity \( \varphi_{t-1} \), and exogenous productivity shock \( \varepsilon_t \), current productivity is determined. 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 profit-cash flow is observed by the owner. The owner also derives the value of current productivity from observables. Conditional on

\footnote{Expected utility of obeying the recomendation is greater than that of each possible deviations from the recomended effort level.}
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 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, one has to restate the joint distribution as a product of marginal and conditional distributions:

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

(14)

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(14), 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 $\varphi_{t-1}$ as last periods productivity, promised $v_t$ to his manager, the contract is defined as such a probability 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 $\pi, \varphi \in A \times \Psi$, the technology constraint has to be satisfied.

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

(15)

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

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

(16)

16 The detailed explanation of the linearization of the owner’s problem is explained in Prescott (2001). Application of this theorem here is sound notwithstanding the fact that random variables involved are endogenous ones.
Third, the joint distribution has to represent a valid probability measure,

\[ \sum_{A,\Psi, C, V} \lambda(a_t, c_t, \varphi_t, v_{t+1}) = 1 \text{ and } \lambda(a_t, c_t, \varphi_t, v_{t+1}) \geq 0 \] (17)

for all \( a, c, \varphi, v \in Q, \Psi, C, V \)

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

\[ \sum_{\Psi, C, V} (u(c_t, a_t) + \beta v_{t+1}) \lambda(a_t, c_t, \varphi_t, v_{t+1}) \geq \sum_{\Psi, C, V} (u(c_t, \tilde{a}_t) + \beta v_{t+1}) \frac{g(\varphi_t | \varphi_{t-1}, \tilde{a}_t)}{g(\varphi_t | \varphi_{t-1}, a_t)} \lambda(\tilde{a}_t, c_t, \varphi_t, v_{t+1}) \] (18)

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 firm’s previous period productivity level, \( \varphi_{t-1} \), and the value promised to the manager last period \( v_t \). He finds the optimal contract among all contracts that satisfies the above constraints. The optimal contract maximizes the owner’s expected discounted return given \( g \) and \( w \). One can define the owner’s problem as:

\[ U_t(\varphi_{t-1}, v_t) = \max_{A, \Psi, C, V} \sum_{A, \Psi, C, V} [\pi_t(\varphi_t) - c_t] \] (19)

\[ + \beta \max \{ m, U_{t+1}(\varphi_t, v_{t+1}) \} \lambda(a_t, \varphi_t, c_t, v_{t+1}) \]

subject to

\[ \sum_{C, V} \lambda(\overline{a}, c_t, \overline{\varphi}, v_{t+1}) = g(\overline{\varphi} | \varphi_{t-1}, \overline{a}) \sum_{C, V, \Psi} \lambda(\overline{a}, c_t, \varphi_t, v_{t+1}) \] for all \( \overline{a}, \overline{\varphi} \in A \times \Psi \),
\[ v_t = \sum_{A,C,V} \sum_{(\varphi \geq \varphi_t^i) \in \Psi} (u_t(c_t, a_t) + \beta v_{t+1}) \lambda(a_t, \varphi_t, c_t, v_{t+1}) \]
\[ + \sum_{A,C,V} \sum_{(\varphi < \varphi_t^i) \in \Psi} \left( \frac{1}{1-\beta} u(c_t, a_t) - K \right) \lambda(a_t, \varphi_t, c_t, v_{t+1}) \]
\[ \sum_{A,\Psi,C,V} \lambda(a_t, \varphi_t, c_t, v_{t+1}) = 1 \quad \text{and} \quad \lambda(a_t, \varphi_t, c_t, v_{t+1}) \geq 0 \text{ for all } a_t, \varphi_t, c_t, v_{t+1} \]

\[ v_t > \sum_{A,C,V} \sum_{(\varphi \geq \varphi_t^i) \in \Psi} (u_t(c_t, \widehat{a}_t) + \beta v_{t+1}) \frac{g_t(\varphi_t \mid \varphi_{t-1}, \widehat{a}_t)}{g_t(\varphi_t \mid \varphi_{t-1}, a_t)} \lambda(a_t, \varphi_t, c_t, v_{t+1}) \]
\[ + \sum_{A,C,V} \sum_{(\varphi < \varphi_t^i) \in \Psi} \left( \frac{1}{1-\beta} u(c_t, \widehat{a}_t) - K \right) \frac{g_t(\varphi_t \mid \varphi_{t-1}, \widehat{a}_t)}{g_t(\varphi_t \mid \varphi_{t-1}, a_t)} \lambda(a_t, \varphi_t, c_t, v_{t+1}) \]
\[ v_t > \text{outside \_ option} \]
6.2 Algorithm for numerical solution

A- Family Owned model

Value function iteration:

Some of the parameters are acquired from the data set; aggregate expenditure level of consumers, \( R \), blue collar worker’s wage, \( w \). The productivity is discretized with the Tauchen’s method using 13 grid points. Effort choice set is discretized on a log scale using 40 grid points. The set of efforts is then \( (0, e] \). I also set the number of potential entrants to 5 which is greater than the maximum number of entry in any given year in the data.

For a given set of parameters, \( \Omega \), and above mentioned parametrization of the model, value function for proprietorship model is calculated as follows:

VFI.1. make an initial guess on the value function

VFI.2. Calculate the new value function using equation (10). Find the associated dynamic decision rules on effort choice, and exit decisions. Also calculate the static employment and pricing decisions.

VFI.3. If the value function doesn’t satisfy the convergence criteria, repeat step VFI.2. while updating the initial guess on the value function as the last value function calculated.

Iteration on price:

The distribution of firms on productivity can actually be summarized by a single statistics which is the aggregate price index. A steady state also implies a unique price index. Thus, the outerloop of the value function iteration is the aggregate price index iteration.

P.I.I.1 Make an initial guess on the aggregate price index, \( \tilde{P} \). Given the initial guess on aggregate price index, calculate the value function and the corresponding policy functions on effort and exit decisions of owners.

P.I.I.2. Given the policy functions and aggregate price index, simulate the data maximum 2500 times. After 1000 simulation iterations, simulation stops if the distribution of firms over their productivities satisfies the steady state criteria. Once the steady state is reached, aggregate price implied by the converged steady state
distribution of firms is calculated, $\tilde{P}_{\text{new}}$.

P.I.I.3. If $\tilde{P}_{\text{new}}$ is close enough to the initial guess $\tilde{P}$, equilibrium is reached. If not, update the initial guess on aggregate price index with $\tilde{P}_{\text{new}}$ and repeat step P.I.I.1, P.I.I.2, and P.I.I.3.

With iteration on price and value functions, we find an equilibrium for a given set of parameters, $\Omega$. Given the aggregate price index and policy functions implied by the value function, data moments are calculated. We implement 8 simulations with 400 iterations at each simulation round. The simulated moments are the average of these 8 simulation rounds. Finally, the minimization of the difference between data moments and simulated counterparts is done with the annealing algorithm to avoid the local minimas.

B- Agency Model:

Value function iteration:

Given the parametrization of the proprietorship model and setting the risk aversion of the manager as 0.85 and the disutility of the manager in case the firm goes bankrupt as 96 (in thousand 2005 dollars), the algorithm of finding the value function is as follows.

VFI.1 Make an initial guess on the value function.

VFI.2 Calculate the value function using equation (19). This allows us to find the optimal lottery contract offered to the manager and the exit decision.

VFI.3. If the value function doesn’t satisfy the convergence criteria, repeat step VFI.2 while updating the initial guess on the value function as the last value function calculated.

The value function iteration merits more discussion. The optimal lottery contract requires to determine the consumption and the future utility set. The consumption amount, $c$ is given from a finite set: $C = [0, c_{\text{max}}]$ where $c_{\text{max}}$ is determined as 500. Given the effort set, $A$, and the consumption set $C$, the promised expected utility offered to the manager must have the following upper and lower bounds. The lower bound, $v$, is receiving with certainty the lowest consumption at the highest effort exerted throughout firm’s lifetime. Similarly, the upper bound, $\bar{v}$ is receiving with certainty the highest consumption at the lowest effort level until the firm is
liquidated. Finally, the finite set $V=[y, \bar{y}]$ and $C$ are log normally discretized.

**Iteration on price:**

The iteration on price is exactly the same as the family owned model.

Table 2: Estimated Model Parameters for "Family Owned" Model

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Estimates</th>
<th>Standard Errors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of effort parameter, $\eta$</td>
<td>2.277</td>
<td>1.415</td>
</tr>
<tr>
<td>Productivity process, intercept, $b_3$</td>
<td>0.060</td>
<td>0.215</td>
</tr>
<tr>
<td>Productivity process, root, $b_2$</td>
<td>0.668</td>
<td>0.139</td>
</tr>
<tr>
<td>Productivity process, effort, $b_1$</td>
<td>0.125</td>
<td>0.059</td>
</tr>
<tr>
<td>Productivity process, variance $\sigma_e$</td>
<td>0.420</td>
<td>0.195</td>
</tr>
<tr>
<td>returns to scale, $\theta$</td>
<td>0.900</td>
<td>0.170</td>
</tr>
<tr>
<td>Elasticity of substitution between goods, $\sigma$</td>
<td>2.611</td>
<td>0.933</td>
</tr>
<tr>
<td>Mean entry cost, $\frac{F}{H}$ (thousands 2005 US dollars)</td>
<td>2540</td>
<td>11401</td>
</tr>
<tr>
<td>Fixed Cost, $f$ (thousands 2005 US dollars)</td>
<td>40.16</td>
<td>4.401</td>
</tr>
<tr>
<td>Scrap Value, $m$ (thousands 2005 US dollars)</td>
<td>298.227</td>
<td>21.940</td>
</tr>
</tbody>
</table>

Notes: The industry used is Columbian Ophthalmic Industry. Parameters are estimated using Simulated Method of Moments. See text for details.
Table 3: Model Fit

<table>
<thead>
<tr>
<th></th>
<th>Simulated Moments</th>
<th>Data Moments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Entry Rate</td>
<td>0.030</td>
<td>0.069</td>
</tr>
<tr>
<td>Variance of Entry Rate</td>
<td>0.003</td>
<td>0.005</td>
</tr>
<tr>
<td>Mean Exit Rate</td>
<td>0.028</td>
<td>0.069</td>
</tr>
<tr>
<td>Variance of Exit Rate</td>
<td>0.002</td>
<td>0.003</td>
</tr>
<tr>
<td>Mean (Number of Firms/13)</td>
<td>1.069</td>
<td>0.991</td>
</tr>
<tr>
<td>Variance of (Number of Firms/13)</td>
<td>0.075</td>
<td>0.015</td>
</tr>
<tr>
<td>Mean Log Employment</td>
<td>3.253</td>
<td>3.134</td>
</tr>
<tr>
<td>Variance Log Employment</td>
<td>0.600</td>
<td>0.421</td>
</tr>
<tr>
<td>Mean log(revenue/cost)</td>
<td>0.250</td>
<td>0.313</td>
</tr>
<tr>
<td>Variance log(revenue/cost)</td>
<td>0.041</td>
<td>0.042</td>
</tr>
<tr>
<td>Cov LogEMP at t and t-1</td>
<td>0.421</td>
<td>0.878</td>
</tr>
<tr>
<td>Cov of logRev/Cost and logEMP</td>
<td>0.148</td>
<td>0.334</td>
</tr>
<tr>
<td>Cov of logRev/Cost at t and t-1</td>
<td>0.030</td>
<td>0.376</td>
</tr>
</tbody>
</table>

Notes: Data Moments are constructed using Columbian Ophthalmic Industry during the period 1981-1989. These data is collected by the Columbian National Administrative Department of Statistics (DANE) which covers all plants with more than 10 workers.
Table 4: "Family Owned" Model

<table>
<thead>
<tr>
<th></th>
<th>Low Competition</th>
<th>High Competition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Entry Rate</td>
<td>0.030</td>
<td>0.111</td>
</tr>
<tr>
<td>Variance of Entry Rate</td>
<td>0.003</td>
<td>0.004</td>
</tr>
<tr>
<td>Mean Exit Rate</td>
<td>0.028</td>
<td>0.107</td>
</tr>
<tr>
<td>Variance of Exit Rate</td>
<td>0.002</td>
<td>0.005</td>
</tr>
<tr>
<td>Mean (Number of Firms/13)</td>
<td>1.069</td>
<td>1.600</td>
</tr>
<tr>
<td>Variance of (Number of Firms/13)</td>
<td>0.075</td>
<td>0.090</td>
</tr>
<tr>
<td>Mean Log Employment</td>
<td>3.253</td>
<td>3.307</td>
</tr>
<tr>
<td>Variance Log Employment</td>
<td>0.600</td>
<td>0.430</td>
</tr>
<tr>
<td>Mean log(revenue/cost)</td>
<td>0.250</td>
<td>0.281</td>
</tr>
<tr>
<td>Variance log(revenue/cost)</td>
<td>0.041</td>
<td>0.021</td>
</tr>
<tr>
<td>Cov LogEMP at t and t-1</td>
<td>0.421</td>
<td>0.302</td>
</tr>
<tr>
<td>Cov of logRev/Cost and logEMP</td>
<td>0.148</td>
<td>0.091</td>
</tr>
<tr>
<td>Cov of logRev/Cost at t and t-1</td>
<td>0.030</td>
<td>0.017</td>
</tr>
</tbody>
</table>

Notes: Table reports simulated moments under two competitive environments using the family owned model with parameters reported in table (2). Competition level is increased by decreasing mean fixed cost of entry by a factor of 10, holding all other parameters constant. See text for details.
Table 5: Agency Model

<table>
<thead>
<tr>
<th></th>
<th>Low Competition</th>
<th>High Competition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Entry Rate</td>
<td>0.040</td>
<td>0.039</td>
</tr>
<tr>
<td>Variance of Entry Rate</td>
<td>2.5e − 4</td>
<td>4.6e − 6</td>
</tr>
<tr>
<td>Mean Exit Rate</td>
<td>0.040</td>
<td>0.039</td>
</tr>
<tr>
<td>Variance of Exit Rate</td>
<td>5.5e − 4</td>
<td>3.0e − 4</td>
</tr>
<tr>
<td>Mean (Number of Firms/13)</td>
<td>5.549</td>
<td>9.690</td>
</tr>
<tr>
<td>Variance of (Number of Firms/13)</td>
<td>0.188</td>
<td>0.268</td>
</tr>
<tr>
<td>Mean Log Employment</td>
<td>2.566</td>
<td>2.272</td>
</tr>
<tr>
<td>Variance Log Employment</td>
<td>0.799</td>
<td>0.784</td>
</tr>
<tr>
<td>Mean log(revenue/cost)</td>
<td>−0.005</td>
<td>−0.133</td>
</tr>
<tr>
<td>Variance log(revenue/cost)</td>
<td>0.143</td>
<td>0.182</td>
</tr>
<tr>
<td>Mean log Compensation</td>
<td>−2.116</td>
<td>−2.432</td>
</tr>
<tr>
<td>Variance of log Compensation</td>
<td>12.365</td>
<td>10.493</td>
</tr>
<tr>
<td>Cov LogEMP at t and t-1</td>
<td>0.565</td>
<td>0.549</td>
</tr>
<tr>
<td>Cov of logRev/Cost and logEMP</td>
<td>0.322</td>
<td>0.364</td>
</tr>
<tr>
<td>Cov of logRev/Cost at t and t-1</td>
<td>0.099</td>
<td>0.126</td>
</tr>
</tbody>
</table>

Notes: Table reports simulated moments under two competitive environments using the agency model with parameters reported in table (2). Competition level is increased by decreasing mean fixed cost of entry by a factor of 10, holding all other parameters constant. See text for details.

Table 6: Aggregate Productivity Decomposition-Agency Model

<table>
<thead>
<tr>
<th></th>
<th>Low Competition</th>
<th>High Competition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregate Productivity</td>
<td>2.715</td>
<td>2.779</td>
</tr>
<tr>
<td>Mean Productivity</td>
<td>1.121</td>
<td>1.098</td>
</tr>
<tr>
<td>Covariance between market shares and productivity</td>
<td>1.594</td>
<td>1.680</td>
</tr>
</tbody>
</table>

Notes: Aggregate productivity is decomposed using Olley Pakes (1995) decomposition methodology.
Table 7: Aggregate Productivity Decomposition-"Family Owned" Model

<table>
<thead>
<tr>
<th></th>
<th>Low Competition</th>
<th>High Competition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregate Productivity</td>
<td>0.966</td>
<td>1.116</td>
</tr>
<tr>
<td>Mean Productivity</td>
<td>0.345</td>
<td>0.570</td>
</tr>
<tr>
<td>Covariance between market shares and productivity</td>
<td>0.621</td>
<td>0.546</td>
</tr>
</tbody>
</table>

Notes: Aggregate productivity is decomposed using Olley Pakes (1995) decomposition methodology.
Table 8: Effects of Higher Competition on Effort Choices

<table>
<thead>
<tr>
<th>Productivity ($\phi$)</th>
<th>Family Owned Model</th>
<th>Agency Model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%Δ in Effort</td>
<td>%Δ in Effort</td>
</tr>
<tr>
<td>−3.828</td>
<td>−</td>
<td>NA</td>
</tr>
<tr>
<td>−3.273</td>
<td>−</td>
<td>NA</td>
</tr>
<tr>
<td>−2.718</td>
<td>−</td>
<td>−37.08</td>
</tr>
<tr>
<td>−2.163</td>
<td>−</td>
<td>27.53</td>
</tr>
<tr>
<td>−1.608</td>
<td>−</td>
<td>−3.74</td>
</tr>
<tr>
<td>−1.053</td>
<td>−</td>
<td>−2.90</td>
</tr>
<tr>
<td>−0.497</td>
<td>−</td>
<td>−4.24</td>
</tr>
<tr>
<td>0.057</td>
<td>−13.50</td>
<td>−4.72</td>
</tr>
<tr>
<td>0.612</td>
<td>−13.35</td>
<td>−5.48</td>
</tr>
<tr>
<td>1.167</td>
<td>0</td>
<td>−5.72</td>
</tr>
<tr>
<td>1.722</td>
<td>0</td>
<td>−3.71</td>
</tr>
<tr>
<td>2.277</td>
<td>−13.36</td>
<td>−2.54</td>
</tr>
<tr>
<td>2.832</td>
<td>NA</td>
<td>−11.11</td>
</tr>
</tbody>
</table>

Notes 1: % Δ in Effort = Effort exerted when competition is HIGH
− Effort exerted when competition is LOW.

Notes 2: Productivity levels on the first panel are constructed using Tauchen and Hussey (1991) methodology to discretize the productivity distribution of firms in steady state. The parameter values reported in table (2) are used in equation (5). Effort levels are also discretized between 0 and $e$. 

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Figure 1: Wage per unit effort by productivity level

- Red line: High Competition
- Blue line: Low Competition