From Inside the Firm to the Growth Process[¤]

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ABSTRACT

This paper argues that the internal organization of the ¯rm and the growth process interact strongly to determine simultaneously the power of incentives within the ¯rm and the growth rate of the economy. We show how agents within the ¯rm can invest either by using their own human capital or by relying on some form of reputational capital to secure implicit relationships within the ¯rm and we discuss how these investments a®ect the growth rate of the economy.

Keywords: Bureaucratization, Schumpeterian Growth, Dynamic Collusion, Internal Organization of the Firm.
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1 Introduction

Growth theory recognizes that ¯rms play a key role in the growth process by allocating resources among sectors of the economy and by inducing innovation. Still ¯rms are very much considered as a black-box. Indeed, even though they may face various market constraints, ¯rms are simply modeled as transforming inputs into outputs and internal constraints are neglected. Implicitly, a major assumption in the literature is that relationships among the various members of the ¯rm are e±ciently designed to maximize and redistribute wealth among them. It follows then that the distribution of intra¯rm rents does not con°ict with pro¯t maximization and, as such, has no impact on the growth process. Indeed, almost no attention is given to the exact organizational arrangements that make productive activities feasible and to the incentive contracts which align the objectives of the ¯rm's members. Following the recent developments of incentive theory, microeconomists have instead built a whole theory of the ¯rm putting the organization of the production process and the structure of contractual transactions among its various partners at the core of the analysis. This \organization" theory discusses how agency problems a®ect the ¯rm's pro¯t and precisely focuses on the consequences of various informational problems inside the ¯rm on its overall performances.

A natural research program then is to embedd the insights of agency theory into the general equilibrium environment of growth theory. To further motivate this research program and see that there is more there than just a mere juxtaposition of insights from both literatures, note with Schumpeter (1942, p. 132) that, due to scale economies in the production of new economic knowledge, large corporations may have a comparative advantage in the innovation process. However, this is precisely to reap bene¯ts of those economies of scale that owners of the ¯rm tend to delegate control of productive assets to managers and workers and that this delegation creates signi¯cant information problems. Hence, the very same factors at the source of the growth process, at least from a Schumpeterian perspective, are also at the source of the agency problems that have so far been neglected by the theory. How the growth process and these agency problems interact becomes therefore a crucial aspect to investigate. Expanding on this, one would like to understand how incentives and organizational forms within the ¯rm respond and interact with the macroeconomic environment. [1]

A close look to the problem at hands shows that the interactions between intra¯rm incentives and growth may be two-ways. To see that intuitvely, consider an endogenous growth model with vertical di®erentiation ¶a la Aghion and Howitt (1992). In this kind of model, ¯rms in the research sectors of the economy are motivated by the perspective

[1] Besides our own work that we brie°y survey here, a small emerging literature has started to consider these issues. See Acemoglu, Aghion and Zilibotti (2002), and Fran¸cois and Roberts (2002) in this volume.

of enjoying monopoly pro¯ts when their R&D activity has been successful and allowed them to replace the incumbent monopolist. Clearly, agency problems in the monopolistic sectors tend to dampen incentives for innovation since they reduce pro¯ts in these sectors. This is the ¯rst channel by which growth and contracts interact. Hence quite naturally, agency problems in intermediate sectors reduce the rate of growth.[2]

On the other hand, a crucial determinants of agency relationships within any organization is the fact that they are not short-term but instead made of repeated interactions involving the same partners over time. The frequency of repetition a®ects then the structure of agency costs. This frequency however is itself a function of the e®ectiveness of the process of creative destruction which replaces old social relationships in incumbent monopolies by fresh ones in newly born ¯rms. This feature provides then the second channel by which growth and contracts interact. A higher growth rate of the economy reduces the expected life of monopolies and has a non-trivial impact on its agency costs. This impact may be negative if agency costs decrease as the ¯rm gets older in expected terms. This is for instance the case if informational problems becomes less acute over the ¯rm's life cycle, if incentive compatibility constraints can be smoothed over more periods or if repeated relationships enlarges the space of incentive feasible transactions[3]. This impact may be positive if agency costs increase when relationships are easier to sustain. This can be the case, in particular, when the ¯rm goes more bureaucratized and routinized as a response to agency problems.

In Martimort and Verdier (1998, 2000 and 2002), we precisely analyze this two-ways interaction between the growth process and the internal organization of the ¯rm. We start from the stylized observation made by sociologists[4] that long-lived organizations are also the most prone to cliques formation. Indeed, the separation between ownership and control within large scale organizations requires to use various sorts of monitors and supervisors to ¯ll the informational gap between owners of the ¯rm and privately informed managers. However, as times passes, supervisors and managers develop norms of reciprocity with the ultimate goal of implicitly colluding to protect the very information rents that the owners would like to capture. This collusion is an implicit contract which can be enforced either by various costly investments in non-directly productive activities (\in°uence costs") that collusive partners make to secure their transactions or by the simple repetition of their relationship. In the ¯rst case, the \in°uence costs" divert resources in the economy away from directly productive activities and the e±ciency of

[2]Here, we should underscore that this ¯rst e®ect is partial equilibrium in nature. Of course, if one sector contracts because of agency costs, more resources become available in other sectors and in particular in the R&D ones. This reallocation e®ect, that may seem at ¯rst glance of a dominated magnitude, goes in the opposite direction towards fostering growth.

[3]See François and Roberts (2000) for a model illustrating this idea.

[4]See Crozier (1962) among others.

the collusion depends on how much resources remain available for the innovation process. In the second case, colluding agents make a reputational investment in their relationship. The growth process affects the efficiency of collusion only through its impact on the colluding agent's expectations over the lifetime of their relationship.

The paper is organized in the following way. Section 2 presents a common framework to analyze those issues. Section 3 takes stock of the important results it provides.

2 A Simple model of Agency Costs and Schumpeterian Growth

Time is discrete and indexed by $t \in \{0; +\infty\}$. The economy is populated by a continuous mass L of individuals with linear intertemporal preferences:

$$u(y) = \sum_{t=0}^{\infty} \frac{y_t}{(1+r)^t} \quad (1)$$

where r is the interest rate and $y = \{y_t\}_{t \geq 0}$ is the vector of consumptions. Each of these individuals is endowed with one unit flow of labor which receives a wage w_t.

There is only one final consumption good (numeraire) which is produced from a continuum of intermediate goods by a perfectly competitive sector:

$$y_t = \int_0^1 y_{it} di \quad \text{where} \quad y_{it} = A_{it}\theta_{it}x_{it}^{\alpha} \quad (\alpha \in [0;1[) \quad (2)$$

is the flow of final good which can be produced using a quantity x_{it} of intermediate good i at date t. The parameter A_{it} is the basic productivity of the latest generation of intermediate good i. The overall productivity is also subject to a random shock θ_{it}. Shocks are i.i.d over time and sectors according to the same common knowledge distribution on $\{\underline{\theta}; \bar{\theta}\}$ (with $\Delta\theta = \bar{\theta} - \underline{\theta} > 0$) with respective probabilities $1 - \nu$ and ν.

Each intermediate good is produced by a monopolistic sector i with a Leontieff technology: one unit of intermediate good i requires one unit of labor. To depart from any distortions due to monopoly pricing, we assume that the monopoly can perfectly first-price discriminate the firms in the final sector. A monopolist born at date t in sector i commits to a production plan $\{\bar{x}_{i(t+\tau)}(\bar{\theta}); \underline{x}_{i(t+\tau)}(\underline{\theta})\}$ at all future dates $t+\tau$ where it may still be alive. Those outputs correspond respectively to the high and the low productivity shock that the monopolist may face.[5]

There are as many research sectors as intermediate goods. R&D firms in each sector compete to discover the next generation of good i. The arrival of innovations in a given

[5] It turns out that in equilibrium those outputs grow at a rate $(1+g)^{\frac{\alpha}{\alpha-1}}$ where g is the growth rate which is defined below.

sector follows a Poisson process. An innovation appears with probability $\lambda E_{it} \in [0,1]$ where E_{it} is the R&D investment of the firm which is measured in productivity-adjusted units of final good so that those firms have cost $C(E_{it}) = \bar{A}_t E_{it}$.

By innovating in sector i, a R&D firm acquires the leading-edge technology whose productivity parameter is given by $\bar{A}_t$ and becomes a monopolist from that date on. On a balanced growth path, a fraction λE of firms innovate in the research sector at each date and the leading-edge technology growth rate is $g = \lambda E(q - 1)$ where $q > 1$ can be viewed as a scale of how drastic innovations are. On such a balanced growth path, the wage w_t in the labor market grows also at the same rate. We denote by ω the productivity-adjusted wage, $w_t = \omega \bar{A}_t$.

2.1 Agency costs and Growth

Once established, a monopoly becomes a large firm with a separation between ownership and control creating an adverse selection problem between owners and the informed management using skilled labor. Let us first think about the simple case where the firms is only made of owners and informed management. On top for his reservation level (normalized to 0) informed management must receive an extra information rent to induce information revelation.[6] At any date $t + \tau$, the efficient management (facing a high shock $\bar{\theta}$) can lie on the internal productivity of the firm, pretending that the productivity is low and reducing thereby the returns left to shareholders by an amount

$$U_{t+\tau}(\bar{\theta}) = \bar{A}_t \cdot \Delta\theta x^{\alpha}_{t+\tau}(\underline{\theta}).$$

This quantity represents the information rent grasped by the informed management when a high productivity shock hits, i.e., with probability ν. This is an extra cost for shareholders when they decide how much to produce. Taking this into account, along a balanced symmetric growth path, the intertemporal profit of a firm in any intermediate sector profit may be written as:[7]

$$(3)\quad V_t = \operatorname{Max}_{\{x_{t+\tau}(\cdot)\}} \sum_{\tau=0}^{\infty} \left(\frac{1-\lambda E}{1+r}\right)^{\tau} \left(E_{\theta}[\bar{A}_t \theta x^{\alpha}_{(t+\tau)}(\theta) - w_{t+\tau} x_{(t+\tau)}(\theta)] - \nu \bar{A}_t \cdot \Delta\theta x^{\alpha}_{t+\tau}(\underline{\theta})\right)$$

where $E(\cdot)$ denotes the expectation operator w.r.t θ. Importantly, everything happens as if the true productivity bad shock $\underline{\theta}$ was deflated to take into account the dissipated information rent and becomes $\tilde{\underline{\theta}} = \underline{\theta} - \frac{\nu}{1-\nu} \cdot \Delta\theta$ that we assume positive from now on. Except for this modification, the optimization problem of the shareholders is the same as standard complete information problem and the optimal outputs can be easily found as $x_{t+\tau}(\tilde{\theta}) = (\alpha\tilde{\theta}/\omega)^{\frac{1}{1-\alpha}}(1+g)^{\frac{\tau}{\alpha-1}}$ with $\tilde{\theta} = \bar{\theta}, \tilde{\underline{\theta}}$.

[6] See Laffont and Martimort (2002, Chapter 2).

[7] In a symmetric equilibrium all sectors grow at the same rate and we can omit from now on indices i.

In a Schumpeterian growth model, The profit V_t is the engine of innovation. Firms in the R&D sector satisfy the following arbitrage equation:

$$\lambda V_t = \bar{\psi}_t$$

or to put it differently,

$$\lambda(1-\alpha)\alpha^{\frac{\alpha}{1-\alpha}}\left(\nu\bar{\theta}^{\frac{1}{1-\alpha}} + (1-\nu)\tilde{\underline{\theta}}^{\frac{1}{1-\alpha}}\right)\frac{1}{1-\delta(E)} = \omega^{\frac{\alpha}{1-\alpha}} \qquad (4)$$

where $\delta(E) = \frac{1-\lambda E}{1+r}(1+g)^{\frac{\alpha}{\alpha-1}} < 1$ is a strictly decreasing function of E and thus of the growth rate in the economy. Since periods are small enough to ensure that the interest rate and the probability of innovation are also small, the following approximation is valid: $1-\delta(E) \approx r + \lambda E\left(1 + \frac{\alpha}{1-\alpha}(q-1)\right)$. It is then straightforward to observe that equation (4) defines a strictly decreasing relationship between E and ω. Indeed a higher (anticipated) rate of creative destruction E reduces the profitability of current innovations. In order to have the R&D arbitrage condition satisfied, the productivity adjusted wage ω has to decrease to make sure investing in innovations is profitable.

The second equation needed to close our macroeconomic model is the equilibrium condition for the labor market. The L units of skilled labor must be distributed among intermediate sectors which may be at different ages:

$$L = \left(\sum_{\tau=0}^{\infty}\lambda E(1-\lambda E)^{\tau}\left(\nu\bar{\theta}^{\frac{1}{1-\alpha}} + (1-\nu)\tilde{\underline{\theta}}^{\frac{1}{1-\alpha}}\right)\alpha^{\frac{2}{1-\alpha}}\,\omega^{\frac{1}{\alpha-1}}(1+g)^{\frac{\tau}{\alpha-1}}\right) \qquad (5)$$

Under mild conditions, it can be shown that there exists a unique macro stationnary equilibrium pair $(\omega^*; E^*)$ satisfying (5) and (4). Quite intuitively as the virtual productivity $\tilde{\underline{\theta}}$ is strictly less than true productivity $\underline{\theta}$, asymmetric information, by reducing the discounted expected profitabilityof firms, reduces the growth rate and the productivity-adjusted wage of the economy.

2.2 Collusion, Exogenous Transaction Costs and Growth

At the individual level, firms may want to hire supervisors to fill the informational gap and increase their profit. Suppose that such a monitor is hired and can report hard evidences on the productivity shock only when it is bad ($\underline{\theta}$). The manipulability of information when it leaves information rent to the manager ($\bar{\theta}$) gives rise to some collusion between the supervisor and the informed management to protect this rent. Let us also assume that, because of the lack of enforceability of the implicit collusive agreement between the supervisor and the informed management, there exists a dead-weight loss of transferring bribes so that, if the manager gives a bribes b, the supervisor gets only a fraction k of it. To prevent collusion, the shareholders must now leave a wage $s_{t+\tau}(\bar{\theta})$ such that:

$$s_{t+\tau}(\bar{\theta}) = kU(\bar{\theta}):$$

A first obvious remark is that, supervision, even if it is corrupted, reduces the burden of agency cost for shareholders. Everything happens now as if the virtual productivity shock in the worst state becomes $\underline{\underline{\theta}}(k) = \underline{\theta} - k\frac{\gamma}{1-\gamma}\Delta\theta$. Modulo this slight modification, nothing changes in the above analysis. The equilibrium growth rate $E(k)$ decreases with larger values of k. Indeed, larger values of k are associated to easier collusion between the management and supervision functions. This, in turn makes incentive and informational problems more severe and reduce thereby the firm's profitability. In the limit of a perfect collusion without transaction cost (ie. $k = 1$), the growth rate is E^*. It corresponds to the case where supervision is totally useless to the firm. More generally, more collusion inside the firm dampens the growth rate of the economy.

3 Endogenous Transaction Costs

The parameter k above, when conveniently endogenized, provides the reverse link between the macroeconomy and the internal organization of the firm.

Suppose first that colluding agents may divert resources away from productive activities to improve side-contracting. This is the basic theme that is developed in Martimort and Verdier (2000). To see the consequence of these unproductive upfront investments, suppose that k is an increasing and concave function of l[8] the amount of labor diverted in those activities. The expected discounted benefit of colluding, namely $\gamma k(l_t) A_t \Delta\theta \sum_{\tau=0}^{\infty} \left(\frac{1-E}{1+r}\right)^{\tau} x^{\alpha}_{t+\tau}(\underline{\underline{\theta}}) - w_t l_t$ should be maximized to find the demand for unproductive labor. This yields the f.o.c:[9]

$$\omega^{\frac{1}{\alpha-1}} = k'(l)(\alpha\underline{\underline{\theta}}(k))^{\frac{1}{1-\alpha}}\Delta\theta \left(\frac{1}{1-\frac{\delta(1+r)}{1+g}}\right). \tag{6}$$

and implicitly a function $l = l^*(E, \omega)$. The equilibrium levels (l^0, E^0, ω^0) are thus obtained jointly by looking at (4), (6) and (5) where in the latter equation L is now replaced by the the amount of productive labor $L - l$.

We have seen above that, for a given quality of side-contracting, the equilibrium innovation effort E^* and the productivity adjusted wage ω^* are decreasing functions of k. At the same time, according to (6), the incentives to improve side-contracting $l = l^*(E, \omega)$ decrease also with the level of R&D effort E and the wage rate ω. These monotonicities

[8] Satisfying the Inada conditions $k'(0) = +\infty$ and $k'(+\infty) = 0$ to insure interior solutions.

[9] We assume that the investment in unproductive activities is simultaneous with the offer of contract made by the shareholders. This assumption avoids that the colluding agents choose l anticipating the impact that it has on the equilibrium outputs and rents. The goal of the investment is only to improve the technology of side-contracting. This assumption can be justified when those investments are not directly observable by the owners of the firm. In Martimort and Verdier (2000), we look at the case where l is chosen before the contract.

generate a strategic complementarity between the macro and the micro environments. Indeed, less innovation makes monopolies in the intermediate sectors enjoy a relatively quiet life. As their expected life time increases, investment into unproductive activities becomes more valuable. This, in turn, decreases the profitability of the intermediate sectors and the incentives to innovate in R&D sectors. Depressed incentives in the R&D sectors reduce further the rate of creative destruction in the economy, ensuring an even more quiet life to monopolies. Thanks to this strategic complementarity between the micro and the macro sides of the model, multiple stationary equilibria may therefore arise. Economies sharing the same fundamental characteristics may end up in very different long-run situations in terms of their internal organization and aggregate macroeconomic performances.

Instead of being true physical resources, the investments made to improve side-contracting between supervisors and agents may be untangible in the case of self-enforcing collusive behavior. Suppose that collusion within the firm born at date t is enforced with the following trigger strategies. As long as the supervisor reports $\bar{\theta}$ when $\underline{\theta}$ has realized, the agent gives a bribes $b_{t+\tau}$ and gives zero otherwise and, as long as the agent has given a positive bribe in the past, the supervisor reports $\bar{\theta}$ when $\underline{\theta}$ has realized and reports truthfully otherwise. It can then be shown (see Martimort and Verdier 2002) that there is no scope for such self-enforceable collusion when

$$(7) \qquad \sum_{\tau=0} \left(\frac{1-\lambda E}{1+r}\right)^{\tau} s_{t+\tau}(\bar{\theta}) \geq \sum_{\tau=1} \left(\frac{1-\lambda E}{1+r}\right)^{\tau} U_{t+\tau}(\bar{\theta}).$$

That is when the expected discounted sum of wages paid to the supervisor in the good state $\bar{\theta}$ is larger than the lagged expected discounted sum of informational rents that have to be left to management. On a stationary growth path, this collusion proof constraint can be reduced to[10]

$$s_t(\bar{\theta}) \geq \delta(E)U_t(\bar{\theta}).$$

The self-enforceability of collusion entails a dead-weight loss of side-contracting. More specifically, we have now $k = \delta(E) < 1$. As the future of the relationship within the firm has higher prospects, it becomes easier to transfer bribes and collusion is more efficient. Since $\delta(E)$ decreases with the rate of creative destruction E, growth plays a significant role in determining the kind of incentives schemes that prevail. The creative destruction phenomenon may act like a threat of termination for implicit relationships within the firm. As such, it helps owners to improve the period-per-period profit of the firm even though it obviously reduces the discounted sum of stream profits. A corollary of our analysis is that firms are more bureaucratic (with lower wages for supervisors and greater output distortions) when the growth rate of the economy is lower. The model predicts a negative correlation between inefficiency within firms and the growth rate of the economy.

[10] See Martimort and Verdier (2002) for more details.

Our model generates also a multiplier e®ect. Exogenous upward shifts in parameters such as ¸ and q exacerbates the growth rate in the economy as in stantard endogenous growth model. However, they also reduce the e±ciency of side-contracting which in turns improves pro¯ts in intermediate sectors and triggers even more growth. As an example, the arrival of a new general purpose technology which improves productivity in all sectors of the economy leads to a signi¯cant increases in the growth rate and changes organizational structures, bringing them towards less bureaucratic structures.

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