Chapter 3

Entrepreneurial Pressure, Innovation, and Rent Cannibalization

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3.1 Introduction

Would ideas that are incorporated as new ventures be incorporated in existing organizations, were the venture capital market less competitive? Does the venture capital market force or discourage incumbents to innovate?

In this paper, we propose a theory of innovation and entrepreneurship which determines:

1. How venture capital markets indirectly affect the innovation policy of established companies.

2. Under what circunstances new ideas are incorporated in existing or in new organizations.

New ideas occur to managers in a given sector. These ideas can be implemented in a new firm financed by venture capital or inside an existing firm. The willingness of an incumbent firm to adopt a new idea depends on the rents it has to give to the manager, on the incremental value of this idea, and on the threat that this idea constitutes for the firm if implemented outside.

Implementing an idea inside an existing organization allows the sharing of assets and might therefore be cheaper. But the advantage of implementing the new project on the existing organization also comes at a cost: in the presence of contractual imperfections, it is harder to reward the manager with the cash-flows generated by his project in the existing firm than in a new firm –where any positive cash-flow comes from the entrepreneur's project. If contingent contracting is valuable ex-ante –because of assymetric information, moral hazard or differences in beliefs, this gives to the venture capitalist an advantage over the existing firm at financing new projects.

Whether a project is done inside or outside depends therefore on the balance of two related comparative advantages: established firms, by relying on existing assets, might face a lower cost of implementing the idea, but venture-capitalists can write contracts that depend exclusively on cash-flows generated by the project. The more innovative a project is, the more attractive is venture capital financing. For the most innovative projects, the incumbent firm cannot compete with venture capital. Such projects are implemented outside. In general, we determine whether a project is done in the incumbent firm, in a new firm or nowhere, depending on its characteristics. We describe in this perspective the life-cycle of products and firms.

In our model, venture capital does not only affect innovation through the creation of new ventures, it also affects the willingness of incumbent firms to innovate. This effect is ambiguous. If entrepreneurs can easily finance projects outside, incumbent firms are forced to innovate (if they don't do it, it will get done in new firms). On the other hand, better venture capital markets imply higher rents to managers and reduce the value of innovation.

The value of a firm comes from the combination of the cash-flows generated by the current technology and the option to exploit new ones. Both are negatively affected by the efficiency of the venture capital market which changes the appropriability of new ideas and the life-cycle of technologies. Our model endogenizes the value of the firm and provides a framework for the valuation of innovative companies.

Our paper is related to three strands of literature. The first one is the literature on internal vs. external markets. Getner, Scharfstein and Stein (1994) develop a model of internal versus external capital markets, focussing on moral-hazard problems and asset redeployability. More recently, Gromb and Scharfstein (2001) study the organizational choice between internal or external venturing for new projects. The interaction between the incentives and redeployability trade-off on the one hand and the equilibrium of the labor market on the other hand determines the optimal form of organization.

Second, our paper is related to the standard endogenous growth literature and the literature on innovation and incomplete contracts which endogenizes the organizational form of R&D. The main difference of our model with this two literatures is that we focus on the implementation rule for new ideas (e.g. where are new ideas implemented?) rather than on the production of new ideas.

Third, our paper is also related to recent contributions on the appropriability of firms' assets by their employees. Rajan and Zingales (2001) study how firms organize in reaction to the threats by employees of appropriating its rents. They relate the intensity of this threat to the efficiency of financial markets and mention that internal competition (the firm versus its employees) might be more effective at forcing firms to innovate than external competition. Hellmann (2002) studies when employees choose to become entrepreneurs, depending on the property right environment and the nature of projects. Cassiman and Ueda (2002) study what projects are done inside an established firm and which ones outside. They find that this depends on the project's complementarity with the existing firm's assets and on the capacity constraint of the firm. The mechanism they explore is the option value that an incumbent has to wait for a better use of it's innovative capacity. The optimal management of this real option leads to a decision rule that favors projects that have high value or high complementarity. By contrast, we focus on contractual frictions, and we find that high value projects tend to be done outside the incumbent firm.

The paper delivers a set of empirical predictions. In particular, the model predicts that big ideas (or high valued projects) will be implemented outside the existing firms. Sectors with more contractual frictions, like for example human capital intensive sectors, are sectors were more innovations will be implemented in outside ventures (Section 3.5). The model also shows that more efficient venture capital markets shorterns the life-cycle of firms in a sector. However, more efficient venture capital markets has ambigous effects in the life cycle of products (the innovation rate can be either increased or reduced).

Next section introduces a static version of the model, where the main intuitions and the contractual environment are explained. Section 3.3 presents the full dynamic model and endogenizes the value of the firm. Section 3.4 characterizes the efficiency properties of the equilibrium and the effect of venture capital in the innovation level. Section 3.5

generalizes the contractual friction. Section 3.6 concludes.

3.2 The Static Set Up

There are three risk-neutral actors in an economy: an incumbent firm, a manager and a competitive venture capitalist.

The objective of the firm is to maximize shareholders' value. Let q be an index of the current technology's productivity. The incumbent firm holds the technology and let $V > 0$ be the value to shareholders at the begining of the period. The manager has an idea (or project) that if succesful will replace the incumbent's technology with a new one of value τV (with $\tau > 1$). For now, we take τ as given. This idea can be implemented at a cost C inside the incumbent firm and at a cost C' within a new organization. Once implemented, the idea succeeds with probability p, in which case the old technology becomes obsolete. If the project is not implemented by the firm, we assume that it is not possible to prevent the manager from trying it outside. So, if the firm buys a project it will implement it.

The manager decides the organizational form (new or old) for his project; and this decision changes the implementation cost, but it also affects the contractual environment. Even if both types of organizations have access to the same contractual instruments, new organizations have a contractual edge. As will be shown, subject to the same constraints, the contracts offered by a new organization are more contingent on the project's payoffs. This advantage increases the managerial rents of creating a new firm in the presence of moral hazard, assymetric information or managerial optimism.

The game takes place as follows. A manger in the firm receives the idea. After this, the firm makes a take-it or leave-it offer to the manager. The manager thus chooses the most rewarding of the two following options:

- he can implement the project outside, if the venture capital market is willing to finance it.
- he can accept the offer of the firm, if there is one.

We now specify the contractual environment for these offers.

Assumption 3.1 *In any organizational form, wealth can only be transfered to the manager with cash and stock of the company.*

Let $V^{out}(\tau)$ be the value the manger gets by implementing a project of size τq through the venture-capitalist. If the firm wants to do the project inside, it has to offer contractual package that the manager values slightly more than his outside option as an entrepreneur. Let $T(\tau)$ denote the cost of this package to the current shareholdes. When no venture capitalist is willing to finance the project, $V^{out}(\tau) = 0$ and therefore $T(\tau) = 0$. Let $\mathcal{O}$ be the set of projects that a venture capitalist is willing to finance.

The firm maximizes shareholder value,

$$\max_{\mathcal{I}} \left\{ 1_{\{\tau \in \mathcal{I}\}} \left[(1-p) V + p\tau V - T(\tau) \right] + 1_{\{\tau \notin \mathcal{I},\, \tau \in \mathcal{O}\}} \left[(1-p) V \right] + 1_{\{\tau \notin \mathcal{O} \cup \mathcal{I}\}} \left[V \right] \right\} \quad (3.1)$$

where $\mathcal{I}$ is the set of projects that are implemented inside the firm. The objective function (3.1) is interpreted as follows. If the project is implemented inside ($\tau \in \mathcal{I}$), then the firm has to pay a transfer $T(\tau)$ to the manager and with probability p the project is succesful, generating a value of τV to the current shareholders. If the firm does not implement the project and the project is implemented outside ($\tau \notin \mathcal{I}$, $\tau \in \mathcal{O}$) then with probability p the shareholders loose their firm, so the share holders receive an expected value of $(1-p)V$. If the firm does not implemente the project, and the project cannot be implemented outside ($\tau \notin \mathcal{O} \cup \mathcal{I}$), then the shareholders retain the value of the firm V.

We now explicit how the ex-ante surplus of the project is affected by the way the manager is rewarded. We assume the following,

Assumption 3.2 *The manager is optimistic relative to the incumbent and the venture capitalist with respect to his own idea. Let $\tilde{p}$ denote the optimistic prior belief of the manager, and p the rational prior belief. Then*

$$1 \geq \tilde{p} > p \geq 0$$

An investor's ability to offer contingent contracts to the manager now matters. The reason is that contingent contracts allow to pay the manager with "dreams", which is not possible with non-contingent claims. The cheapest way for a rational investor to pay the manager is to give him the money in the state of nature that he overvalues (i.e. in case that his project succeeds).

The competitive venture capitalist offers to finance the project as long as $p\tau V > C'$, i.e. for any $\tau > \tau^{out}$ where

$$\tau^{out} = \frac{C'}{pV}$$

The most attractive offer that he can make to the manager is an equity claim on the project of objective value $p\tau V - C'$ so that he just breaks even. Given the structure of the project, an equity claim is contingent on the success of the project, which the manager overvalues. The venture capitalist then, will offer the manager the highest claim possible in the state of the world where the firm is a success such that he just breaks even. The venture capitalist gets $\frac{C'}{p}$ from the cash flows of a succesful project and the subjective value of the remaining equity for the manager is $\tilde{p}\left[\tau V - \frac{C'}{p}\right]$.

Proposition 3.1 *The subjective return of the external market offer for the manager with idea τ is $V^{out}(\tau)$ where*

$$V^{out}(\tau) = \begin{cases} \frac{\tilde{p}}{p}\left[p\tau V - C'\right] & ;\ \textit{when } p\tau V > C' \\ 0 & ;\ \textit{otherwise} \end{cases}$$

Due to their optimistic beliefs, managers overestimate the value of their outside option as entrepreneurs by a factor $\frac{\tilde{p}}{p}$.

If she wants the project to be done inside, the incumbent has to make an offer to the manager of subjective value V^{out}.

We first establish that the firm's offer, if any, consists exclusively of stock.

Proposition 3.2 *The offer of the firm consists exclusively of stock. To transfer of a subjective value $V^{out}(\tau)$ to the manager the firms has pay the manager an objective cost of $T(\tau)$ where*

$$T(\tau) = \begin{cases} \frac{p\tau + (1-p)}{\widetilde{p}\tau + (1-\widetilde{p})} V^{out}(\tau) > 0 & ;\ \textit{when } \tau > \tau^{out} \\ 0 & ;\ \textit{otherwise} \end{cases}$$

Notice that the transfer the firm is making to the manager is smaller than the V^{out}, $\left(\frac{p\tau+(1-p)}{\widetilde{p}\tau+(1-\widetilde{p})} < 1\right)$. This is so because the firm is paying the manager with "dreams". The intuition for this proposition is as follows. If the firm had to pay with cash the cost to do so would be $V^{out} = \frac{\tilde{p}}{p}\left[p\tau V - C'\right]$. Stocks are a cheaper way to pay since the manager overestimates the potential impact of his innovation on the value of the firm. The shareholders' cost of giving away a fraction x of the firm is $[p\tau + (1-p)]xV$; but the manager's subjective valuation is higher, $[\widetilde{p}\tau + (1-\widetilde{p})]xV$. Therefore, the cheapest way to pay the manager is to pay him exclusively with stock at a shareholders' cost of $\frac{p\tau+(1-p)}{\widetilde{p}\tau+(1-\widetilde{p})}V^{out}$. The firm can bridge part of the gap in beliefs with the manager, but not as well as the venture capitalist. To see this, notice that to transfer a unit of subjective value to the manager, the venture-capitalist only has to give a claim of value $\frac{p}{\widetilde{p}} < 1$ but the firm has to give a claim of value $\frac{p\tau+(1-p)}{\widetilde{p}\tau+(1-\widetilde{p})} > \frac{p}{\widetilde{p}}$.

When does the incumbent firm implement the project? Two cases have to be distinguished depending on whether the manager has the opportunity to implement the project outside or not.

For a given τ, if $V^{out}(\tau) = 0$ $(\tau \notin \mathcal{O})$,then $T(\tau) = 0$ and from (3.1) the firm implements the project when $p(\tau - 1)V - C > 0$. In this case, the firm cares about the incremental gains of the project and compares these to the implementation cost C. Let τ^{in} be

$$\tau^{in} = 1 + \frac{C}{pV}$$

The interpretation of this threshold is the following: for any $\tau > \tau^{in}$ the firm is willing to finance the project in the absence of venture capital pressure.

When V^{out} is positive $(\tau \in \mathcal{O})$, the firm faces the threat of the project being done outside. If the project is implemented outside the shareholders lose V with probability p. That implies that the firm does not only consider the incremental gains of the project: it also has to take into account the loss incurred if the project succeeds outside and the transfer required to keep the manager inside. The value of doing the project is $p(\tau - 1)V - C - T(\tau)$. The project will be done inside then, when $p(\tau - 1)V - C - T(\tau) > -pV$,

$$p\tau V - C - \frac{\tau + (1-p)/p}{\tau + (1-\widetilde{p})/\widetilde{p}}\left[p\tau V - C'\right] > 0$$

Let $\widetilde{\alpha} = (1-\widetilde{p})/\widetilde{p}$ and $\alpha = (1-p)/p$ (where $\widetilde{\alpha} < \alpha$). The previous equation can be expressed as

$$\frac{\alpha - \widetilde{\alpha}}{\tau + \widetilde{\alpha}}\left[p\tau V - C'\right] < C' - C \tag{3.2}$$

where $\frac{\alpha-\widetilde{\alpha}}{\tau+\widetilde{\alpha}}\left[p\tau V - C'\right]$ is the mispricing of the outside option of the manager due to the optimism bias. It increases with τ and converges to $(\alpha - \widetilde{\alpha})pV$ when τ goes to $+\infty$. This is the result of two competing effects: on the one hand, the valuation gap is increasing with τ; on the other hand, for high τ's, the potential contribution of the manager is less diluted in the existing technology and therefore the firm can bridge the gap in beliefs more easily.

If $1-(C'-C)/pV(\alpha-\widetilde{\alpha})<0$, then (3.2) always holds for any τ; and if $1-(C'-C)/pV(\alpha-\widetilde{\alpha})>0$, we can rewrite it as

$$\tau<\frac{\tau^{out}+\widetilde{\alpha}(C'-C)/pV(\alpha-\widetilde{\alpha})}{1-(C'-C)/pV(\alpha-\widetilde{\alpha})}$$

Let τ^{dis} be defined as

$$\tau^{dis}=\begin{cases}\frac{\tau^{out}+\widetilde{\alpha}(C'-C)/pV(\alpha-\widetilde{\alpha})}{1-(C'-C)/pV(\alpha-\widetilde{\alpha})} & ;\text{ when } C'-C<pV(\alpha-\widetilde{\alpha})\\ +\infty & ;\text{ otherwise}\end{cases}$$

For $\tau<\tau^{dis}$ the inequality (3.2) holds and the firm is willing to do the project inside if $V^{out}>0$.

Proposition 3.3 (The Venture Capital Advantage) *For any $\tau>\tau^{dis}$, if $V^{out}>0$, the project will be done outside.*

Venture capital is financing projects, even when they have a higher cost of implementation. Why is this happening? At the threshold τ^{dis}, the gap in beliefs becomes too costly for the firm to afford doing the project inside. This happens for high quality projects (high τ). The reason is that the mispricing of the entrepreneurial outside option V^{out} is increasing with τ: this mispricing is $(\alpha-\widetilde{\alpha})\,pV$ when τ is very large. For high levels of τ, the price that is required to convince a manager to do the project inside becomes too high for the firm to afford it. This mispricing is not an issue for the venture-capitalist who can effectively offer a totally contingent contract.

In this section we have characterized the equilibrium behavior of innovation for a given value of the firm V. We have seen that the venture capitalists have an advantage because they can offer "de-facto" more contingent contracts. This allows them to attract managers with ideas, even when they have implementation costs that are higher than the firm's. We show that the advantage of the venture capitalist appears even when both the firm and the venture capitalist have access to the *same* type of contracts. The difference in the payoff structure that they face, generates the venture capital advantage, because they can give the manager payoff that are more contingent on the success of their projects than the firms. The manager values this, because as in our case, he overvalues the proability of success. In the next section we proceed to endogenize the value of the firm in a dynamic set up.

3.3 Dynamic Set-up: Endogenizing the Value of the Firm

The value of an idea for a manager, $V^{out}(\tau)$, depends on the value of becoming the incumbent τV. The net present value of cash-flows received by the incumbent's shareholder,V , depends on the life-cycle of technologies and the share of the revenues from new technologies that the incumbent is able to appropriate. Both terms are endogenous. In this section, we obtain V, T and V^{out} as the solutions to a dynamic problem faced by the incumbent.

Time is continuous. Technologies are indexed by their quality, q, as in a vertical quality ladder model. We consider a linear specification of the model where the incumbent receives an instantaneous profit flow of[1]:

$$\pi(q) = \pi q$$

and where the implementation costs. are $C_q = Cq$ and $C'_q = C'q$.

With poisson arrival rate λ, a manager gets an idea about a way to switch to a higher technology, one of quality τq $(\tau > 1)$. Where τ is drawn from a time invariant and quality independent distribution $F(\cdot)$.

The value of the current incumbent firm is denoted by $V(q)$. The transfer offered by the firm to the manager with an idea τ is denoted by $T(\tau q; q)$ and the outside subjective valuation for the manager is denoted by $V^{out}(\tau q; q)$.

In this context the transfer and the outside subjective valuation are homogenous of degree one. So we can write $T(\tau q; q) = qT(\tau)$ and $V^{out}(\tau q; q) = qV^{out}(\tau)$.The threshold τ^{in}, τ^{out} and τ^{dis} are independent of q.

Let $\mathcal{O} = [\tau^{out}, \infty)$ be the set of projects that can be implemented outside.

The value of the firm is linear, $V(q) = qV$, and is the outcome of the following

[1] We provide in appendix 1 the microfundations for this specification.

maximization:

$$rV = \max_{\mathcal{I}} \left\{ \pi + \lambda \int_{\mathcal{I}} \{p[\tau - 1]V - C - T(\tau)\} \, dF(\tau) - \lambda \int_{\mathcal{O}-\mathcal{I}} pV dF(\tau) \right\} \tag{3.3}$$

where $\mathcal{I}$ represents the set of projects that are implemented inside and Let $\mathcal{I}^*$ denote the optimal policy rule.

Note that q is irrelevant for the characterization (it plays just a multiplicative role) so we can omit it from the analysis.

The value equation (3.3) says that the incumbent firm enjoys a flow of profits equal to π every instant it remains the monopolist. With Poisson probability λ, an idea arrives to a manager. If the idea is implemented inside ($\tau \in \mathcal{I}^*$), then the total cost of implementing the idea for the firm is the direct cost of implementation C, plus the transfer that is made to the manager $T(\tau)$. With probability p, the idea is a success, and the firm enjoys an increase in value equal to $\tau V - V$ (the difference between being the τ-incumbent versus being the current incumbent). If the idea is implemented outside ($\tau \in (\mathcal{O} - \mathcal{I})$), the current incumbent only loses if the idea is succesful (an event of probability p). In that case, the current incumbent is replaced by a new one and the current shareholders loose the total value of the firm V. Equation (3.3) is the dynamic version of (3.1).

To characterize the optimal decisions depending on C' we analyze three distinct regions given the values of τ^{dis}, τ^{out}, and τ^{in} defined in the previous section.

Proposition 3.4 *For any $C' > 0$, the values of τ^{in}, τ^{out} and τ^{dis} fall in one of the following three regions:*
Region I:

$$\tau^{dis} < \tau^{out} < \tau^{in}$$

Region II:

$$\tau^{out} < \min\left\{\tau^{dis}, \tau^{in}\right\}$$

Region III:

$$\tau^{in} < \tau^{out} < \tau^{dis}$$

For any $C' < C$, the equilibrium lies in region I. There exists $\bar{C} > C$, such that for $C' > \bar{C}$, the equilibrium lies in region I; for $C' \in \left(\bar{C}, C\right)$ the equilibrium lies in region III.

In Region I, all projects are done outside.

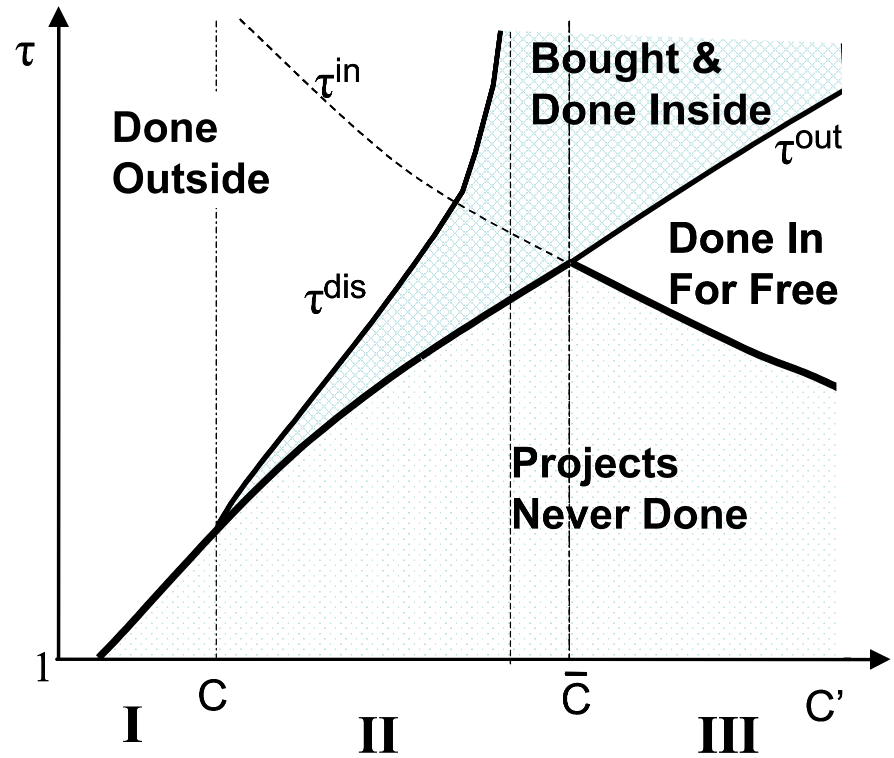


Figure 3-1: The route of innovation

In Region II, the projects with a $\tau < \tau^{out}$ will never be done. Projects with $\tau \in \left(\tau^{out}, \tau^{dis}\right)$ will be done inside, with a positive transfer to the manager. And projects with $\tau > \tau^{dis}$ will be incorporated outside the firm.

In Region III, all the projects with $\tau \leq \tau^{in}$ will never be done. Projects with $\tau \in (\tau^{in}, \tau^{out})$ will be done inside the firm with no payment to the manager because her outside option is zero. For values of τ between τ^{out} and τ^{dis}, the firm will do the project inside, but makes a positive transfer to the manager. When τ is larger than τ^{dis}, the firm cannot compensate the manager, and the project is incorporated outside the firm.

We can obtain a comparative statics of $V, \tau^{dis}, \tau^{out}$ and τ^{in} with respect to the efficiency of the venture capital market (C'). The difficulty is that V is endogenous and depends itself of C'. It is therefore required to use the value equation to find these results. The proof is given in appendix 2.

Proposition 3.5 *The equilibrium values of τ^{dis}, τ^{out} and τ^{in} are monotonic in C' and* *have the following derivatives*

$$\frac{\partial \tau^{dis}}{\partial C'} > 0$$
$$\frac{\partial \tau^{out}}{\partial C'} > 0$$
$$\frac{\partial \tau^{in}}{\partial C'} < 0$$

and $\frac{\partial V}{\partial C'} > 0$ *if* $C' > C$ *and* $\frac{\partial V}{\partial C'} = 0$ *if* $C' < C$.

Figure 1 shows the functions τ^{dis}, τ^{out} and τ^{in} in a (C', τ) space. Notice that we solve the equilibrium for a given value of C', and then compute the different implementation rules as functions of τ, given this C'.

We can also consider the limiting case where C' is very big, so that the incumbent behaves as a monopoly. This asymptotic behavior is described by:

$$\begin{cases} \lim_{C' \to +\infty} \tau^{in} = \tau^{\infty} < \infty \\ \lim_{C' \to +\infty} \tau^{out} = \infty \\ \lim_{C' \to +\infty} \left(\tau^{dis} - \tau^{out}\right) = \infty \\ \lim_{C' \to +\infty} V = V^{\infty} < \infty \end{cases}$$

where $\tau^{\infty}, V^{\infty}$ are the solutions of

$$\begin{cases} \tau^{\infty} = 1 + \frac{C}{pV^{\infty}} \\ rV^{\infty} = \pi_0 + \lambda \int_{\tau^{\infty}}^{\infty} (p(\tau - 1)V - C)dF(\tau) \end{cases}$$

3.4 Innovation and Efficiency

3.4.1 Innovation Rate

In our model all the projects above a certain threshold $\widetilde{\tau}$ are implemented. When this threshold goes down, the rate of innovation $\lambda(1 - F(\widetilde{\tau}))$ increases. This means that the life-cycle of products becomes shorter but also that the average "size" of innovation (the average implemented τ) becomes smaller.

We first want to describe how the innovation rate changes with the cost of external venturing C'.

Proposition 3.6 *The innovation threshold* $\widetilde{\tau}$

- *decreases with C' if $C' > \bar{C}$*

- *increases with C' if $C' < \bar{C}$*

The interpretation is the following: as long as $C' > \bar{C}$, the margin of innovation $\widetilde{\tau}$ corresponds to the zone where $V^{out} = 0$, so that C' does not affect the decision of the monopolist through the transfer to the manager but only through its impact on the value of being an incumbent: the role of C' in this region has purely a rent sharing effect between the shareholders and the managers. A lower C' means a loss of monopoly rents and therefore decreases the willingness of the incumbent to innovate. On the contrary, when $C' > \bar{C}$, the margin of innovation $\widetilde{\tau}$ corresponds to zone where $V^{out} > 0$. Decreasing C' increases the range of projects that are feasible externally and therefore increases innovation. We proceed now to determine how the welfare of shareholders and managers is affected by changes in C'.

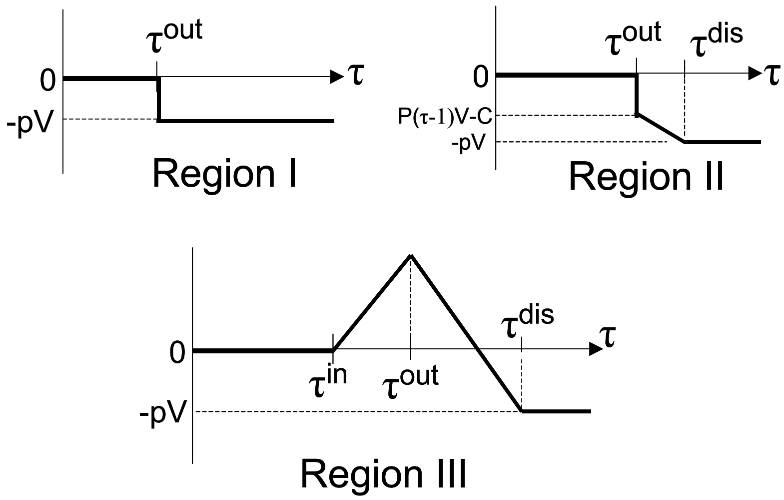
3.4.2 Monopoly Rents

We ask now the following question : How does the value of an incumbent firm react to the occurrence of an idea τ?

The impact on value of an innovation differs according to the three regions previously described as it is shown in figure 2. We proceed now to describe in detail how this graph was obtained.

Consider region I. On this region, all the projects are done outside. Once a manager gets an idea that can be implemented, the incumbent firm is destroyed with probability p. So, the incumbent's return to an idea in this region is 0 when $\tau < \tau^{out}$ and $-pV$ when $\tau \geq \tau^{out}$.

Consider region II. Projects with a τ between τ^{out} to τ^{dis}, are bought by the monopolist and done inside. And for $\tau > \tau^{dis}$, the manager implements the project outside. The monopolist return to an idea is then 0 for $\tau < \tau^{out}$. For τ between τ^{out} and τ^{dis}, the return is $(p - \tilde{p})\,\tau V - pV + \frac{\tilde{p}}{p} C' - C$ which is negative for $\tau = \tau^{out}$ and decreases with τ, up to τ^{dis} where it becomes equal to $-pV$. For any $\tau > \tau^{out}$, the project is done outside and the return to the firm is $-pV$.



Incumbent's Return to Innovation

Consider now region III, projects with $\tau < \tau^{in}$ are never done. For $\tau \in (\tau^{in}, \tau^{out})$ the projects are done inside for free ($T(\tau) = 0$) and the private return to innovation is $p(\tau - 1)V - C$ wich is increasing in τ. For $\tau \in \left(\tau^{out}, \tau^{dis}\right)$ the project has to be bought and the return is now $p(\tau - 1)V - C - T(\tau) = (p - \tilde{p})\tau V - pV + \frac{\tilde{p}}{p}C' - C$ which is decreasing in τ and becomes $-pV$ for $\tau = \tau^{dis}$. Notice that the return is continuos at τ^{out}. Last, for $\tau > \tau^{dis}$, the project is done outside with an ex-ante loss to the firm of $-pV$.

3.4.3 Aggregate Efficiency

In this section we analyze the efficiency of the equilibrium.

The social planner values every unit of production at $\frac{\pi_0}{\beta}$, where β is the profit share of output accrue to the monopolist. We can define the social value function of an existing firm as

$$rU = \frac{\pi_0}{\beta} + \lambda \int_{\tau \in In} (p(1-\tau)U - C)\, d\tau + \lambda \int_{\tau \in Out} (p(1-\tau)U - C')\, d\tau$$

Where In is the set of innovations done inside the firm and Out is the set of the ones done outside.

If $C < C'$, then it is always efficient to do the project inside the incumbent (if it is to be done). A project is socially profitable inside whenever the value generated by it is bigger than the cost of implementation :

$$p(1-\tau)U > 0$$

Define

$$\tau^{fb} = 1 + \frac{C}{pU}$$

The social value U is given by the following set of equations (for $C < C'$):

$$\begin{aligned} rU &= \frac{\pi_0}{\beta} + \lambda \int_{\tau^{fb}}^{\infty} \left(p(1-\tau)U - C\right) d\tau \\ \tau^{fb} &= 1 + \frac{C}{pU} \end{aligned}$$

From which we can infer that:

Proposition 3.7 *The incumbent, when not exposed to entrepreneurial pressure ($C' = +\infty$), tends to underinnovate:*

$$\tau^{fb} < \tau^{\infty}$$

The reason why this is so is very simple. If there is no entrepreneurial pressure, then the monopolist will innovate whenever $p(\tau - 1)V > C$. Given that $V < U$, the monopolist does not value an innovation as much as the social planner does (it only values a share β of the production), so the monopolist underinnovates.

Corollary 3.1 *The following holds*

- *If $C' > \bar{C}$, there is underinnovation and therefore a motive for public start-up subsidies.*
- *Depending on the parameters, $C' = C$ might lead to under or over-innovation.*

The central planner can implement the first best level of innovation by using various public policy tools. If C' needs to be decreased, start-up subsidies can be used. If C' needs to be increased, taxes on firm-creation can be used. It is also possible to reinforce laws on non-compete or non-disclosure agreements or to make bankruptcy more costly.

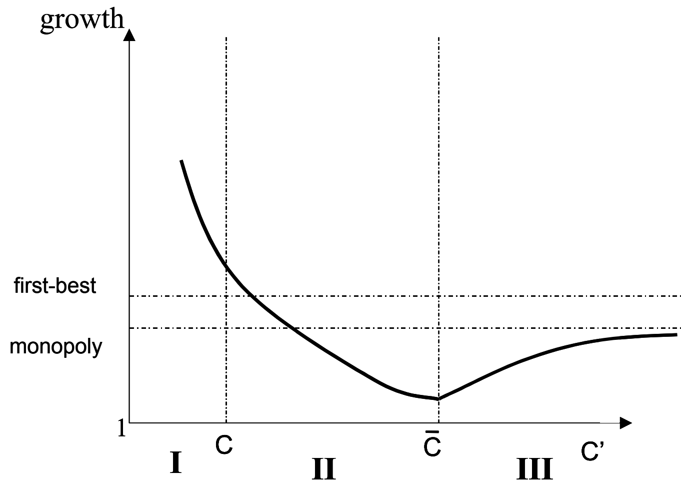


Figure 3-2: Efficient Innovation

3.5 The Value of Contracting Outside

A crucial feature of our model is that financing a project as a new venture allows for more contingent contracts. We have shown that this result holds when both the incumbent and the new firms are subject to the same constraint: paying with stock or cash. Restricting the analysis to these two instruments has the advantage of keeping the dynamic part of our model simple. To illustrate the generality of this point we show in the static framework that the comparative advantage of the venture-capitalist subsists for large class of contracts. The space of possible contracts for both parties (the incumbent and the venture-capitalist) can be arbitrarily close to perfect contracting.

The structure of the game is as in section 1. The only change is that we relax assumption 2 in the following way. It is also possible to write contracts contingent on the new project's payoff, but such contracts are enforceable only with probability θ and void with probability $1-\theta$. Stock and cash are still available.

Assumption 3.3 *In any organizational form, wealth can only be transfered to the manager with the three following instruments:*

1. *Cash,*
2. *Stock,*

3. *Contracts contingent on the new project's payoff. Such contracts are enforceable only with probability* θ *and void with probability* $1-\theta$.

This change in the contractual environment has no impact from the point of view of a venture capitalist, for whom stock is purely contingent on the project's payoff –the third instrument is therefore redundand with the second. But it enhances the contractual flexibility of the firm. In particular, for $\theta = 1$, the firm has the same contractual edge as the venture-capitalist.

The assumption captures the fact that large organizations might try to commit to reward "internal entrepreneurs" through contingent contracts (the most sophisticated rely on the use of tracking stocks), but in many cases such contracts are mere promises. They are hard to enforce, because they are contingent on accounting variables that the incumbent's management can manipulate.

In that context, the cheapest way for the incumbent to transfer an amount of subjectuve value V^{out} to the manager is the following:

If $\theta\tau V > \frac{V^{out}}{\widetilde{p}}$, the incumbent promises to the manager a transfer $\frac{1}{\widetilde{p}}\frac{V^{out}}{\theta}$ if the project generates positive cash-flows. Both parties know ex-ante that this contract will be enforceable with probability θ and void otherwise.

If $\theta\tau V < \frac{V^{out}}{\widetilde{p}}$ the incumbent offers to the entrepreneur a package that includes the integrality of the cash-flows generated by his project plus a fraction α of the firm. From the point of view of the entrepreneur, the value of this offer is $\theta\widetilde{p}\tau V + \alpha[\widetilde{p}(1-\theta)\tau V + (1-\widetilde{p})V]$. Therefore,

$$\alpha = \frac{V^{out}/V - \theta\widetilde{p}\tau}{\widetilde{p}(1-\theta)\tau + (1-\widetilde{p})}$$

Considering the value of the transfer to the entrepreneur from the point of view of the incumbent's shareholder, there are again two cases to consider:

- If $\theta > \theta^\star(\tau) = \frac{V^{out}}{\widetilde{p}\tau V}$, the value to the shareholder of the transfer is $\frac{p}{\widetilde{p}}V^{out}$, which is the same as the objective value transfered by the VC to the manager. In this case, the incumbent has the same transformation rate than the venture-capitalist. \$1 of subjective value is transfered to the entrepreneur at cost $\$\frac{p}{\widetilde{p}}$.

- If $\theta < \theta^\star(\tau)$, the value the incumbent's shareholder has to transfer to the manager for matching the outside offer is:

  $T(\tau) = \theta p\tau V + \frac{p(1-\theta)\tau+(1-p)}{\widetilde{p}(1-\theta)\tau+(1-\widetilde{p})}(V^{out} - \theta\widetilde{p}\tau V) > \frac{p}{\widetilde{p}}V^{out}$.

This means that as θ becomes small, the "transformation rate" of the venture-capitalist deteriorates, implying a larger cost of financing new projects. In particular, when $\theta = 0$, we are back to the framework of the first section with a transformation rate of $\frac{p\tau+(1-p)}{\widetilde{p}\tau+(1-\widetilde{p})}$.

The class of contracts we consider is large enough to allow situations where the incumbent firm is not at a contracting disadvantage compared to the venture capitalist. This happens when $\theta > \theta^{\star}(\tau)$. However, for projects that are sufficiently innovative, the venture-capitalist always has an advantage. Since $V^{out}(\tau) = \frac{\widetilde{p}}{p}(p\tau V - C')$, $\theta^{\star}(\tau) = (1 - C'/p\tau V)$ which is arbitrarily close to 1 for τ large enough. Therefore, for τ large enough, $T(\theta, \tau) > \frac{p}{\widetilde{p}}V^{out}$.

Proposition 3.8 *For any θ, there exist $\tau^{\star}$ such that for any $\tau > \tau^{\star}$, the incumbent has a contracting disadvantage relative to the venture-capitalist, i.e.*

$$T(\theta, \tau) > \frac{p}{\widetilde{p}}V^{out}(\tau)$$

The analysis in this part has been done in the static framework, i.e. taking V as exogenous. It is possible to carry it to the dynamic framework without affecting the results

What is θ related to? The parameter θ captures the inability of a firm to make promises contingent in a project payoff. This inability to contract is going to be more severe the more intangible the project is (when the ability to value the project through accounting procedures becomes harder). Also, a higher θ might be associated with the strength of the legal system. Weak legal system will be unable to commit to enforce contracts, and hence θ will be low.

3.6 Conclusion

By increasing the number of projects that can be financed externally, better venture capital markets exert pressure on incumbent companies to innovate more than they would otherwise. There is an opposite effect however: Because they force shareholders to give-up more rents to managers, better capital markets decrease the value of being the incumbent firm and therefore the incentive to innovate. This leads to a non-monotonic relationship between capital market efficiency and growth.

Which projects are done inside vs. outside depends on the balance between two comparative advantages: the incumbent firm can use existing assets while the venture capitalist can write contracts contingent on the project's outcome. In the presence of contractual frictions, the most innovative projects are implemented in new ventures. The established firm cannot match the attractiveness of the entrepreneurial outside option for such projects.

If the marginal innovation is done under pressure from outside, a better VC market increases the innovation rate. If the marginal innovation would have been implemented without outside pressure, a better VC market, by decreasing the rents of being the incumbent firm, decreases the rate of innovation. Therefore, in equilibrium, the relation between innovation and the efficiency of external capital markets has an inverse-U shape.

3.7 Appendix I. The Static Aggregate

Consumers are linear,

$$U_0 = E_0 \int_0^{\infty} c_t e^{-rt} dt$$

There is a competitive final good that uses a continuoum of intermediates, indexed from 0 to 1, and labor (L) to produce units of consumption according to the following production function :

$$Y = \left[\int_0^1 q(i) \, k(i)^{1-\alpha} \, di \right] L^{\alpha}$$

$q(i)$ represents the quality of the leading machine in sector i. $k(i)$ is the numbers of machines from sector i that are used in the production of the final good. The final good will be our numeraire.

Call $\psi(i)$ the price of one machine in sector i. The demand for machines for a given sector i is :

$$k(i) = [(1-\alpha) \, q(i) / \psi(i)]^{\frac{1}{\alpha}} L$$

There is a monopolist in every sector that holds the patent for the leading quality machine. The monopolist can create machines at a constant marginal cost of $\phi q(i)$. We assume that innovations are drastic (the old technology becomes obsolete). Given the isoelastic demand functions, the monopolists solve the following profit maximizing problem.

$$\max \pi_i(q) = k(i) \left[\psi(i) - \phi q(i) \right]$$

The FOC conditions deliver :

$$\psi(i) = \frac{\phi q(i)}{1-\alpha}$$

$$k(i) = \left[\frac{(1-\alpha)^2}{\phi} \right]^{\frac{1}{\alpha}} L$$

so profits for any particular sector with machine q are

$$\pi_i(q) = \pi_0 q(i)$$

where $\pi_0 = \left[\frac{(1-\alpha)^2}{\phi} \right]^{\frac{1}{\alpha}} \frac{\alpha \phi}{1-\alpha} L$. This is the profit function used in section 2, once we introduced the dynamic version of the model.

3.8 Appendix II. Comparative Statics

Assumption 3.4 *The rate of growth of the economy can never be higher than the discount rate.*

$$r > \lambda p \int_1^\infty \tau dF(\tau)$$

This assumption guarantees that all value functions are bounded. We then move on to prove the following proposition,

Proposition 3.9

- *The value function is given by:*
  - *If* $C' > C$:

$$rV = \pi_0 + \lambda \int_{\min(\tau_{in},\tau_{out})}^\infty \left\{ [p\tau V - C - T(\tau)]^+ - pV \right\} dF(\tau)$$

  - *where* $T(\tau) = \frac{\tau+(1-p)/p}{\tau+(1-\tilde{p})/\tilde{p}} [p\tau V - C']^+$
  - *If* $C' < C$:

$$rV = \pi_0 - \lambda p(1 - F(\tau_{out}))V$$

- *A smaller cost of doing the project outside* C'
  - *reduces the value of being an incumbent:*

$$\frac{\partial V}{\partial C'} > 0$$

  - *reduces the threshold at which external projects become viable:*

$$\frac{\partial \tau_{out}}{\partial C'} > 0$$

  - *reduces the threshold* τ_{in} *at which the incumbent becomes willing to do a project if there is no transfer to the manager:*

$$\frac{\partial \tau_{in}}{\partial C'} < 0$$

First, consider the case where $C' < C$ so that all innovation occurs outside:

$$rV = \pi_0 - \lambda pV(1 - F(\tau_{out}))$$

Differentiating this equation, we obtained

$$[r + \lambda p(1 - F(\tau_{out}))]dV = \lambda pVf(\tau_{out})d\tau_{out}$$

Using the fact that $pV\tau_{out} = C' \Rightarrow pVd\tau_{out} = dC' - p\tau_{out}dV$. Substituting back we get

$$\frac{d\tau_{out}}{dC'} = \frac{r + \lambda p(1 - F(\tau_{out}))}{\lambda pVf(\tau_{out}) + [r + \lambda p(1 - F(\tau_{out}))]pV} > 0$$

So, $\frac{\partial\tau_{out}}{\partial C'} > 0$ and

$$\frac{dV}{dC'} = \frac{\lambda f}{r + \lambda p(1 - F(\tau_{out})) + \lambda pf}$$

So, in this region:

$$\frac{dV}{dC'} > 0$$

Which implies :

$$\frac{d\tau_{in}}{dC'} < 0$$

We now need to consider the case where $\tau_{in} > \tau_{out}$ (i.e. $C' - C < pV$) . The incumbent does not innovate when the threat is not credible because an innovation always have a negative incremental value compared to the statu-quo. In this case,

$$rV = \pi_0 + \lambda \int_{\tau_{out}}^{\infty} \left[[p\tau V - C - T(\tau)]^{+} - pV\right] dF(\tau)$$

For $\tau \in [\tau_{out}, \tau_{dis}]$ we have that

$$p\tau V - C - T(\tau) = p\tau V - C - \frac{\tau + (1-p)/p}{\tau + (1-\widetilde{p})/\tilde{p}}\,[p\tau V - C'] > 0$$

Plugging back into the value function

$$rV = \pi_0 + \lambda \int_{\tau_{out}}^{\tau_{dis}} \left[-pV - C - \frac{\alpha - \widetilde{\alpha}}{\tau + \widetilde{\alpha}}p\tau V + \frac{\tau + \alpha}{\tau + \widetilde{\alpha}}C'\right] dF(\tau) - \lambda pV(1 - F(\tau_{out}))$$

Computing the comparative statics:

$$\left[(r + \lambda p(1 - F(\tau_{out})) + \lambda p \int_{\tau_{out}}^{\tau_{dis}} \frac{\alpha - \widetilde{\alpha}}{\tau + \widetilde{\alpha}} \tau dF\right] \frac{dV}{\lambda} = (pV - (C' - C)) f d\tau_{out} + \left(\int_{\tau_{out}}^{\tau_{dis}} \frac{\tau + \alpha}{\tau + \widetilde{\alpha}} d\tau\right) dC'$$

Using the fact $pV\tau_{out} = C' \Rightarrow pVd\tau_{out} = dC' - p\tau_{out}dV$ and replacing $d\tau_{out}$ by $(dC' - p\tau_{out}dV)/pV$, we see that in this region:

$$\frac{dV}{dC'} > 0$$

This implies:

$$\frac{d\tau_{in}}{dC'} < 0$$

Using the fact that $r > \lambda \int_{\tau_{out}}^{\tau_{dis}} \tau dF$, replacing this time dV by $(dC' - pVd\tau_{out})/(p\tau_{out})$, we have that:

$$\frac{d\tau_{out}}{dC'} > 0$$

Third, consider the case where $\tau_{in} < \tau_{out}$ (i.e. $C' - C > pV$) so that the incumbent does innovate at the margin where the outside value of the project is zero. Then, the value is given by

$$rV = \pi_0 + \lambda \int_{\tau_{in}}^{\infty} \left\{ [p\tau V - C - T(\tau)]^+ - pV \right\} dF(\tau)$$

At τ_{in}, the function we are integrating equals zero (the firm is indifferent between doing or not). Using the fact that $r > \lambda p \int_{\tau_{out}}^{\tau_{dis}} \tau dF$, we conclude as before.

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