Essays in Corporate Finance

by

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Submitted to the Department of Economics
in partial fulfillment of the requirements for the degree of

Doctor of Philosophy

at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

September 2001

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Abstract

This dissertation presents three essays in Corporate Finance. In the first essay, I study managerial incentives in internal capital markets. In particular, I develop a two-tiered agency model to study division managers' incentives within internal capital markets. Division managers try to influence the external capital market's assessment of the firm and the internal capital market's assessment of their divisions in order to increase their level of funding. I show that, as the number of divisions increases, the external capital market's assessment of the firm becomes a public good for division managers, and the internal capital market replaces the external capital market in the provision of managerial incentives. I also show that, while diversified firms have an advantage in allocating resources, this may come at the expense of managerial incentives. Based on the analysis, the paper relates the value of diversification to characteristics of the firm, the industry, the external capital market, and the internal capital market.

In the second essay, I propose a model of entrepreneurship in which investors decide whether to become venture capitalists or to form firms and entrepreneurs decide whether to join a firm or seek financing in the venture capital market. The venture capital market allows better matching between investors and entrepreneurs, but this comes at the cost of adverse selection. The model suggests that as a sector matures, innovation takes place first within firms, then in ventures backed by venture capitalists backed ventures, and finally within firms again. In addition, I analyze the relationships between the venture capital market and investors' diversity, investors' scope of expertise and entrepreneurial incentives.

The third essay, which is co-authored with Andres Almazan, examines how the trading activities of institutional investors can help to mitigate agency conflicts in corporations. The access of institutional investors to privileged information produces an adverse selection effect that reduces the trading activity of institutional investors and generates a free-rider problem that affects the intensity with which institutional investors wish to "vote with their feet". We also study ownership implications, incentives to acquire information and the interaction of the Wall Street Rule with other mechanisms of governance (i.e. capital structure).

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Acknowledgments

I would like to thank my advisors Denis Gromb and Bengt Holmstrom for their guidance and infinite patience. I have been very lucky to have them as advisors. They are excellent economists, but more importantly great persons. For many things I owe them a debt that I can never repay.

I also want to thank Sendhil Mullainathan for his encouragement as well as the generosity with his time.

I also need to thank Amparo Urbano at the University of Valencia. She was my first mentor and the one who opened my eyes to research.

This thesis owes a great deal to my friends and fellow students Alberto Abadie and Andres Almazan. They have shared my MIT experience from the beginning to the end.

The interaction with classmates and friends has also been very valuable. Among them are Maricarmen Almazan, Fernando Aportela, Fernando Broner, Daniel Dulitzky, Tomomi Kumagai, Osmel Manzano, Jaime Ortega and many others that I am not forgetting.

Finally, I would like to thank Gary King, he has been making the life of many generations of graduate students at MIT much easier.

Financial support from the Bank of Spain during the first four years is gratefully acknowledged.

Chapter 1

Managerial Incentives and Internal Capital Markets

1.1 Introduction

Corporate diversification seems to be out of style. However, this does not change the fact that corporations remain remarkably diversified. For example, 87 percent of the 500 largest U.S. public companies operated in more than one SIC code in 1992 (Montgomery 1994). This suggests that internal capital markets within corporations make an important part of the investment decisions in the economy. In fact, one of the main functions of corporate headquarters is the allocation of funds across the divisions of the corporation. This paper studies the incentives for division managers within internal capital markets. External capital markets base investment decisions, among other things, on current performance. To the extent that division managers are concerned about future investment decisions, external capital markets become a source of managerial incentives.[1] However, external capital markets do not usually finance corporate divisions directly; instead, divisions compete with each other for funds. The amount of funds that a division receives depends on both the external capital markets' assessment of the firm and the internal capital markets' assessment of the division. Division managers may try to influence the internal and the external capital market's learning processes. In particular,

[1]There are many reasons why managers might be concerned with future investment decisions. For example, managers may derive private benefits in proportion to the size of their organizations.

division managers have incentive to perform well today because superior performance translates into more future funds for the firm as well as into a larger share of these funds being allocated to their divisions.

I view headquarters as an empire-builder which seeks to maximize the size of its organization. Further, it is plausible that corporate headquarters has an informational advantage over external capital markets. This advantage may be justified in several ways. For example, Gertner, Scharfstein, and Stein (1994) argue that corporate headquarters has a stronger incentive to monitor division managers since, unlike external capital markets, it has control rights and is able to make liquidation decisions.[2] This characterization captures what I believe is the essence of headquarters: it might create value by improving the capital markets' allocation of resources, but it is also subject to agency problems, which in this paper take the form of empire-building.

I study the effect of internal capital markets on managerial incentives. It is assumed that each manager runs a division. Managers, like headquarters, are viewed as empire-builders whose primary concern is the size of their divisions. In addition, managers can take actions that are costly to them but nevertheless increase current profits.[3] These actions may be interpreted in a natural way as giving up pet projects or minimizing costs. The important element is that these actions can influence the external and the internal capital markets' assessments of the division by increasing current profits. The incentive to increase current profits depends on the marginal influence of a manager's action on those assessments and therefore on the future funding of the division.

The assignment of funds within stand-alone firms is trivial since corporate headquarters can only channel funds to one division.[4] The only division manager in a stand-alone firm has incentives to improve the external capital markets' assessment of the firm in order to attract more funds to the firm and hence to the manager's division. In multidivisional firms, the problem is more complicated. This paper shows that the double layer of capital markets has important implications for managerial incentives. When a division manager takes an action that increases

[2]Alternatively, corporate headquarters may acquire this informational advantage from its interaction within the corporation.

[3]In this paper, increasing current profits is value improving. Stein (1988) and (1989) has argued that there may be a trade off between short- and long-term profits. In particular, too much emphasis on current profits may induce myopic behavior.

[4]Stand-alone firms are firms with one line of business or one division.

the future funding of the corporation, these funds are shared among all the divisions within the corporation. An incentive problem arises as the direct link between resources generated and availability of funds is broken at the divisional level, and the external capital markets' assessment of the firm becomes a public good for division managers.

In multidivisional firms, internal capital markets constitute a second source of managerial incentives. Division managers have incentives to be perceived as efficient, not only by the external capital market, but by headquarters, because this increases their division's share of funds. As the number of divisions increases, the marginal funding that a division receives by increasing current profits depends more on the internal than on the external capital markets' assessment of the division, and therefore internal capital markets become more important than external capital markets in the provision of managerial incentives. In general, multidivisional firms provide more (*less*) incentives than stand-alone firms if the internal capital market's assessment of the division is more (*less*) marginally influenceable than the external capital markets' assessment of the division.

This paper studies this relative influenceability by explicitly modelling capital markets' learning processes. If corporate headquarters has an informational advantage over the external capital market, the effect of diversification on managerial incentives is ambiguous. To the extent that corporate headquarters has inside information, it is able to make inferences about a division's efficiency beyond profit-related measures. This diminishes the possibility of division managers influencing headquarters by boosting up current profits, and therefore reduces the incentives to do so. However, corporate headquarters is also at an advantage over external capital markets when inferring a division's efficiency from its profits. For example, headquarters may be able to sort out whether current profits are the consequence of some transitory shock, making current profits a more informative signal of a division's efficiency. This increases the weight given to current profits on headquarters' assessment of the division, thereby improving managerial incentives.

Based on the previous considerations, the analysis yields several testable implications. First, the value of diversification (multidivisional firms) is greater for less developed external capital markets.[5] By development of external capital markets, I refer to their ability to process

[5]Stein (1997) proposes a different argument for the negative relation between market development and diver-

information. Moreover, when external capital markets are sufficiently developed, firm diversification becomes value-reducing. This is consistent with available empirical evidence. Recent empirical work shows that U.S. capital markets discount diversified corporations during the 1980s by as much us 13 to 15 percent (Berger and Ofek 1995). However, in countries where external capital markets are less developed, markets see diversifying strategies as value-enhancing (Fauer, Houston and Naranjo 1998). Along the same line, Matsusaka (1993) shows that acquiring shareholders benefited from diversifying acquisitions in the late 60s in the U.S. when the capital markets were less developed.

Second, stand-alone firms provide stronger incentives than multidivisional firms in new and high growth industries. These industries are characterized by higher ex-ante uncertainty about efficiency, which increases the weight given to new information and makes external capital markets a stronger source of incentives than internal capital markets. The reason is that internal and external capital markets use different types of signals to evaluate divisions. Internal capital market's evaluations rely relatively more on non-profit related signals, which do not provide managers with incentives to increase current profits.

Third, after controlling for market and industry effects, younger firms should remain stand-alone. Younger firms are characterized by higher ex-ante uncertainty that, as in the previous result, increases the value of specialization (non-diversification).

This paper also studies the effect of related versus unrelated diversification on managerial incentives. Related diversification refers to divisions in different businesses but with some operational synergies. Under related diversification, division managers may affect with their actions not only the assessment of their divisions, but also the assessment of related divisions in the corporation. To the extent that the investment in a division depends on the assessment of the other divisions in the corporation, related diversification has implications for managerial incentives. However, I show that the effect of related diversification on managerial incentives is ambiguous.

Other papers have studied internal capital markets. As in this paper, Stein (1997) models corporate headquarters as an intermediary between external capital markets and division

sification be value based on the superior allocation of resources by informed headquarters.

managers. Internal capital markets create value because corporate headquarters has an informational advantage over external capital markets, and given a certain amount of resources, headquarters has incentives to allocate funds efficiently. Division managers, however, are passive agents that have no effect on divisional profits.

Rajan, Servaes and Zingales (2000) and Scharfstein and Stein (2000) introduce active division managers. Their papers focus on bargaining power and influence activities and study their effect on the allocation of resources by internal capital markets. They both conclude that multidivisional firms might be value-decreasing because corporate headquarters are likely to incur in cross-subsidization. This paper steps back from allocation problems and studies the effect that a "well functioning" internal capital market has on managerial incentives.

Gertner, Scharfstein and Stein (1994) analyze the effect of internal capital markets on managerial incentives. Their paper concludes that internal capital markets have the negative effect of reducing managerial incentives because, unlike with external finance, (division) managers do not have control rights and might be subject to ex-post opportunistic behavior. Gertner, Scharfstein and Stein (1994) identify headquarters with owner-investors, and in doing so, they leave aside agency problems at the headquarters level. Furthermore, by considering only one division, their article is not able to address competition for corporate resources which is one of the main characteristics of internal capital markets.

The rest of the paper is structured as follows. In section 2, we present the main model. Section 3 solves the model and gives the main results. Section 4 studies the effects of related diversification. Section 5 analyzes possible extensions. Finally, section 6 offers concluding remarks.

1.2 Model

I consider a two-period model ($t = 1, 2$) with no discounting and four stages in each period. In stage 1, external capital markets provide funds to the firm. In stage 2, corporate headquarters invests these funds across the divisions in the corporation. In stage 3, division managers choose non-observable actions that increase divisional profits. Finally, in stage 4, profits are realized.

AGENTS

There are three risk-neutral agents: External capital markets, corporate headquarters, and division managers.

External capital markets / Outside Investors own the corporation and provide the necessary funds for investment. External capital markets maximize a firm's expected profits. Specifically, external capital markets provide F_t funds to the firm in period t.

Corporate headquarters acts as an intermediary between external capital markets and division managers. It allocates the funds provided by external capital markets across the divisions of the corporation. Corporate headquarters has monitoring skills that allow it to acquire better information about the divisions and to potentially improve the allocation of resources inside the firm. However, corporate headquarters is an empire-builder: it derives benefits in proportion to the funds invested in its corporation.[6] Its allocation of funds maximizes a firm's future expected investment. If headquarters is indifferent in how to allocate the funds, it maximizes expected profits.

Division managers invest the funds assigned by corporate headquarters. It is assumed that division managers produce the same agency problem as headquarters: they obtain private benefits in proportion to their divisions' sizes. Division managers may take actions that are costly to them but increase divisional profits. They only take these actions if an increase in divisional profits both influences external capital markets' as well as headquarters' assessments of their divisions and raises future funding. In particular, division manager i has the following utility function:

$$u_i = I_{i1} - g(a_{i1}) + I_{i2} - g(a_{i2})$$

where I_{it} is investment in division i in period t and a_{it} is the action taken by division manager i in period t. The cost function $g(.)$ is increasing and convex, and $g^{'}(0) = 0$.[7]

ORGANIZATION AND TECHNOLOGY

[6]This may be interpreted in several ways. First, it captures managerial career concerns. Empirical evidence on managerial compensation shows that there is a high correlation between the level of compensation and firm size (Hall and Liebman 1998). To the extent that managers perceive this relation, they may try to augment the size of their corporation by increasing the level of investment. Alternatively, it represents private benefits, such as social status and power, that managers derive from running a large organization.

[7]Implicit in this set up is an important assumption: division managers participation constraints are not binding. In the model, division managers take costly actions and they are not rewarded for them in equilibrium. External capital markets and headquarters anticipate their actions which therefore do not influence their assessments.

While stand-alone firms have only one division, multidivisional firms consist of N ($N > 1$) divisions. Every division i is characterized by a parameter η_i which represents its efficiency level. This parameter η_i is constant over time and sums up all technological and organizational factors that influence division $i's$ performance. Division i is also subject to a transitory shock ε_{it} that affects divisional profits in period t. Shocks are uncorrelated across divisions and across time and have zero expectation. Finally, division manager i may increase profits in period t by taking non-observable action a_{it}.

Division i's profits in period t are given by the following expression:

$$\pi_{it} = (\eta_i + a_{it} + \varepsilon_{it})I_{it} - \frac{1}{2}I_{it}^2$$

INFORMATION

This paper makes the following assumptions regarding information:

(A1) At the beginning of the first period, all agents have the same prior, denoted by Ω_1, about a division's efficiency level η_i. This assumption allows me to abstract from strategic revelation of information in the investment decisions.[8]

(A2) At the beginning of the second period, headquarters and division managers have an informational advantage over external capital markets about their divisions' efficiencies, an advantage acquired throughout the first period. We denote by $\Omega_2^{Mkt}, \Omega_2^{HQ}$ and Ω_2^{Mng} the information at the beginning of the second period of external capital markets, headquarters, and division managers respectively.

There is the implicit assumption that external capital markets and corporate headquarters cannot commit to financing decisions that are ex-post inefficient. In practice, an important part of the information that determines the optimal level of investment (e.g. industry prospects, firm's characteristics etc.) cannot be fully contracted on, since ignoring this information and contracting ex-ante is likely to be prohibitively expensive. Besides, committing to an investment

[8]If headquarters has an informational advantage at the beginning of the first period, its investment decision might reveal information to external capital markets. To the extent that headquarters is concerned with external capital markets' assessment of the corporation, headquarters would have incentives to influence this assessment with its investment decision. This is not the case in the second period. When headquarters make its investment decision in the second period, external capital markets have already made all funding decisions and thus there are no longer incentives to influence external capital markets' assessment.

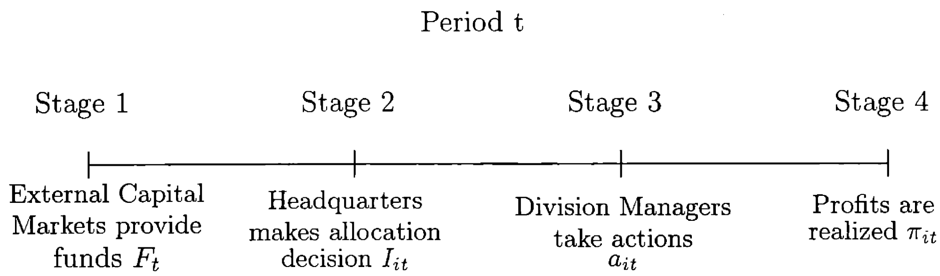

Figure 1

plan that sometimes results in ex-post underinvestment is also going to be non-credible, since ex-post all interested parties, external capital markets, headquarters, and division managers, have incentives to increase the level of investment.

1.3 Analysis

In this section, I solve the model for stand-alone and multidivisional firms and derive the main results of the paper. I then explore a richer set of assumptions about the learning process that allows me to derive additional implications. Proofs are provided in the appendix.

1.3.1 Stand-alone firms

To reduce notation, I drop the subindex i for the division in stand-alone firms. The model is solved backwards.

Second Period

In stage 3, the division manager has no incentive to increase profits since all investment decisions are already made, therefore $a_2^{SF} = 0$. This result is just a consequence of the two-period structure of the model.[9] In stage 2, since headquarters obtains benefits in proportion to the firm's investment, it channels all available funds to the only division in the firm ($I_2^{SF} =$

[9]The two period structure and assumptions (A1) and (A2) allow me to separate the allocation and the incentive effects. In the first period, all agents have the same information so multidivisional firms do not better allocate their resources. In the second period, managers have no further incentives to take costly actions since all investment decisions are already taken. This is of course a particularity of the model; in reality we should observe both effects acting at the same time.

F_2^{SF}). Finally, in stage 1, external capital markets provide the amount of funds that maximize expected profits:

$$Max_{I_2}\ E\left[(\eta + a_2^{SF} + \varepsilon_2)\ \mid \Omega_2^{Mkt}\right] I_2 - \frac{1}{2} I_2^2$$

The level of funding F_2^{SF} is given by the expected efficiency of the firm's division conditional on external capital markets' information:

$$F_2^{SF} = I_2^{SF} = E\left[\eta \ \mid \ \Omega_2^{Mkt}\right]$$

First Period

In stage 3, the division manager realizes that the investment in the second period depends on external capital markets' assessment of the firm. The division manager tries to influence this assessment by taking unobservable action a_1^{SF} which increases first-period profits. Since there is no private information at the time of taking the action, markets are able to infer a_1^{SF} in equilibrium. Solving, the following f.o.c. is obtained for the managerial action:

$$g'(a_1^{SF}) = \frac{\partial E\left[E\left[\eta \mid \Omega_2^{Mkt}\right] \mid \Omega_1, a_1^{SF}\right]}{\partial a_1}$$

The condition says that the division manager has greater incentives (greater a_1^{SF}) the larger the marginal effect of his action on external capital markets' assessment.

In stage 2, headquarters channels all available funds to the division ($I_1^{SF} = F_1^{SF}$). Finally, in stage 1, external capital markets make their funding decision. The optimal level of funding F_1^{SF} takes into account the impact on a_1^{SF} and on the learning process Ω_2^{Mkt}.

Assuming that investment decisions do not affect the learning process,[10] the optimal level of investment is given, as in period 2, by the expected efficiency of the firm's division plus the (inferred) equilibrium managerial action:

$$F_1^{SF} = I_1^{SF} = E(\eta \mid \Omega_1) + a_1^{SF}$$

[10]This means that I_1 does not affect Ω_2^{Mkt} or Ω_2^{HQ}.

1.3.2 Multidivisional Firms

Second Period

In stage 3, division managers have no incentive to increase profits since all investment decisions are already made ($a_{i2}^{MF} = 0$). In stage 2, headquarters maximizes firm's profits subject to investing all available funds F_2:

$$Max_{\{I_{i2}\ st \sum_{i=1}^{N} I_{i2}=F_2\}} E\left[\sum_{i=1}^{N}\left[(\eta_i + a_{i2}^{MF} + \varepsilon_{i2})I_{i2} - \frac{1}{2}I_{i2}^2\right] \mid \Omega_2^{HQ}\right]$$

Assuming an interior solution, the following level of investment is obtained for division i:

$$I_{i2}^{MF} = \frac{F_2}{N} + \frac{N-1}{N}\left\{E(\eta_i \mid \Omega_2^{HQ}) - \frac{1}{N-1}\sum_{j\neq i} E(\eta_j \mid \Omega_2^{HQ})\right\}$$

In the solution, a marginal increase in the level of funding F_2 is divided equally among the divisions in the corporation. This is a special characteristic of the model[11], more generally, as division managers do not receive the full marginal returns of their actions in the form of more funding for their divisions. External capital markets' assessment of the corporation is a public good for division managers because an increase in the total level of funding is shared among all the divisions in the corporation. As a public good, its provision is subject to a free-rider problem that reduces the role of external capital markets as a provider of managerial incentives.[12]

In stage 1, the external capital markets' funding decision takes into account how headquarters allocates funds across divisions. The level of funding provided to the multidivisional firm is the sum of the expected efficiency of the divisions in the firm:

$$F_2^{MF} = \sum_{i=1}^{N} E(\eta_i \mid \Omega_2^{Mkt})$$

A multidivisional firm receives the sum of the funds obtained by an equivalent portfolio of single firms.[13] This is despite the informational advantage of headquarters in allocating

[11] This is due to the fact that all divisions have a profit function with the same degree of concavity.

[12] The situation in stand-alone firms is different, as the manager receives all the funds that the firm attracts since there is no other division ($I_t^{SF} = F_t^{SF}$).

[13] It is implicitly assumed that there is no difference in the learning process of external capital markets between

resources across divisions.[14]

First Period

Stage 3. The two previous equations identify division i's investment in the second period given external capital markets' and headquarters' assessments of the division at the beginning of that period. Division managers try to influence these assessments by boosting first-period profits. Division managers' incentives to increase first-period profits are given by the following equation:

$$
\begin{aligned}
g'(a_{i1}^{MF}) \quad = \quad & \frac{1}{N} \frac{\partial E\left[(N-1)E(\eta_i \mid \Omega_2^{HQ}) - \sum_{j \neq i} E(\eta_j \mid \Omega_2^{HQ}) \mid \Omega_1, a_{i1}^{MF}\right]}{\partial a_{i1}} + \\
& + \frac{1}{N} \sum_{j=1}^{N} \frac{\partial \left\{E\left[E(\eta_j \mid \Omega_2^{Mkt}) \mid \Omega_1, a_{i1}^{MF}\right]\right\}}{\partial a_{i1}}
\end{aligned}
$$

This equation identifies the different sources of managerial incentives. The first term captures the incentives provided by the internal capital market: a division manager tries to influence the allocation of resources inside the corporation by manipulating headquarters' evaluation process. The second term captures the incentives provided by external capital markets: a division manager also tries to influence external capital markets' evaluation process in order to increase the total funds available to the corporation.

In addition, the equation identifies the possible interactions in the learning process among divisions. Managers may try to influence the perceived efficiency of the other divisions in the corporation. I will return to this point when I consider related versus unrelated diversification. For now, it is assumed that division managers do not affect the evaluation of the other divisions in the firm:

stand-alone and multidivisional firms.

[14]In general, the amount of funds that a multidivisional firm is able to raise might be larger or smaller than the funds raised by a portfolio of comparable individual firms. Assume for example that each of the N divisions attracts F funds as stand alone firms. If we now consider a multidivisional firm with these N divisions, the marginal return of the NF^{th} unit could be larger or smaller than the opportunity cost of capital and therefore the amount of funds raised by the multidivisional firm may be larger or smaller than NF. However, what is important for incentives is not the total level of funding but the marginal effect of the manager's action on the level of funding.

$$\frac{\partial E\left[E(\eta_j \mid \Omega_2^h) \mid \Omega_1, a_{i1}\right]}{\partial a_{i1}} = 0 \quad h = \{Mkt, HQ\} \text{ and } i \neq j \tag{A3}$$

Under (A3), managerial incentives boil down to the following equation, where both sources of managerial incentives (internal and external) are still present:

$$g'(a_{i1}^{MF}) = \frac{1}{N}\frac{\partial E\left[E(\eta_i \mid \Omega_2^{Mkt}) \mid \Omega_1, a_{i1}^{MF}\right]}{\partial a_{i1}} + \frac{N-1}{N}\frac{\partial E\left[E(\eta_i \mid \Omega_2^{HQ}) \mid \Omega_1, a_{i1}^{MF}\right]}{\partial a_{i1}}$$

Proposition 1 *As the number of divisions increases internal capital markets substitute for external capital markets in the provision of managerial incentives.*

The level of managerial incentives is a weighed average of the incentives provided by internal and external capital markets. As the number of divisions increases, the weight is shifted towards the internal capital market. While an increase in the number of divisions aggravates the free rider problem, it increases the importance of headquarters' assessment on the marginal funding received by the division.

Lemma 1 *If headquarters has no informational advantage with respect to external capital markets ($\Omega_2^{Mkt} \equiv \Omega_2^{HQ}$), the level of investment and managerial incentives in each division are independent of the organizational structure.*

The lemma stresses the importance of headquarters' informational advantage. If headquarters has no informational advantage, the total level of incentives does not depend on the number of divisions. The literature on internal capital markets has pointed out headquarters' informational advantage as one of the main sources of value-creation in multidivisional corporations.[15] In our model, this is captured by higher expected profits in the second period for multidivisional corporations. However, headquarters' superior information affects managerial incentives in the first period, which may contribute to value-creation or explain value-destruction in multidivisional corporations.

Proposition 2 *Multidivisional firms provide stronger (weaker) incentives than stand-alone*

[15] See Stein (1997).

firms if managerial actions have a greater (smaller) marginal effect on headquarters' evaluation process than on external capital markets' evaluation process:

$$a_{i1}^{MF} > a_{i1}^{SF} \quad \textit{if} \quad \frac{\partial E\left[E(\eta_i \mid \Omega_2^{HQ}) \mid \Omega_1, a_{i1}\right]}{\partial a_{i1}} > \frac{\partial E\left[E(\eta_i \mid \Omega_2^{Mkt}) \mid \Omega_1, a_{i1}\right]}{\partial a_{i1}}$$

Headquarters' informational advantage might have positive or negative consequences for managerial incentives. Internal capital markets provide stronger managerial incentives when headquarters' informational advantage reinforces the link between managerial actions in period 1 and investment in period 2. This link is reinforced when managerial actions have a high marginal effect on headquarters' assessment of the divisions, which in turn depends on the weight given to period 1 profits in the assessment process. A richer set of assumptions about the learning process is necessary to determine whether headquarters' informational advantage increases or decreases managerial incentives.

Stage 2. Headquarters makes its investment decision by maximizing the expected level of future funding. Under the assumption that the investment levels do not affect the learning process, that is, $\{I_{i1}\}$ do not affect Ω_2^{HQ} or Ω_2^{Mkt}, then the level of investment is the following:

$$I_{i1}^{MF} = \frac{F_1}{N} + \frac{1}{N}\left\{(N-1)\left[E(\eta_i \mid \Omega_1) + a_{i1}^{MF}\right] - \sum_{j \neq i}\left[E(\eta_j \mid \Omega_1) + a_{j1}^{MF}\right]\right\}$$

Stage 1. The level of funding in the first period is the sum of the expected efficiency of the divisions plus the inferred level of managerial actions:

$$F_1^{MF} = \sum_{i=1}^{N}\left[E(\eta_i \mid \Omega_1) + a_{i1}^{MF}\right]$$

1.3.3 More structure

In order to make finer predictions, I explicitly model the learning process by making the following assumptions:

(A4) $\varepsilon_{it} = \varepsilon_{1it} + \varepsilon_{2it}$

(A5) ε_{1it} are ε_{2it} distributed $N(0, \sigma_{\varepsilon_1}^2)$ and $N(0, \sigma_{\varepsilon_2}^2)$ respectively.

(A6) The prior of the efficiency parameter η_i is distributed $N(m_i, \sigma_\eta^2)$.

(A7) All distributions are common knowledge and independent.

(A8) External capital markets observe $\{\pi_{it}, I_{it}\ \forall i, t\}$

(A9) Corporate headquarters observe $\{\pi_{it}, I_{it}, \varepsilon_{2it}, S_{it}\ \forall i, t\}$ where $S_{it} \equiv \eta_i + u_{it}$ and u_{it} is distributed $N(0, \sigma_u^2)$.[16]

Assumptions (A4)-(A7) are made for convenience, since the updating process of the normal distribution is well understood. Assumptions (A8) and (A9) sum up headquarters' informational advantage over external capital markets. On the one hand, headquarters is able to make judgements on efficiency beyond profit-related measures. In particular, headquarters observes signal S_{it} which allows a direct assessment of a division's efficiency. This signal decreases managerial incentives because it reduces the weight given to first period profits in the assessment process. On the other hand, headquarters is also in a better position to interpret first period profits and determine to what extent they are the result of some transitory shock. This is captured by the assumption that headquarters, unlike external capital markets, is able to observe ε_{2it}. This type of informational advantage tends to make headquarters a stronger source of incentives because it increases the weight given to first-period profits in headquarters' assessment of the division.

Lemma A1 in the appendix identifies the updating under assumptions (A4)-(A9). Proposition 2 boils down to the following proposition under the richer set of assumptions.

Proposition 3 *(i) When external capital markets are highly inefficient relative to internal capital markets (when $\frac{\sigma_{\varepsilon_2}^2}{\sigma_{\varepsilon_1}^2}$ is very large), multidivisional firms provide stronger incentives than stand-alone firms. (ii) When the prior about efficiency is very diffuse (when is σ_η^2 large), stand-alone firms provide stronger incentives than multidivisional firms. (iii) When corporate headquarters observe very precisely divisions' efficiency levels (when σ_u^2 is very small), stand-alone firms provide stronger incentives than multidivisional firms:*

$$For\ \ \sigma_\eta^2 > 0,\ a_{i1}^{MF} > a_{i1}^{SF} \quad iff \quad \sigma_u^2 \frac{\sigma_{\varepsilon_2}^2}{\sigma_{\varepsilon_1}^2} > \sigma_\eta^2$$

This result deserves some comments:

[16] Division managers' information at the beginning of the second period does not affect our analysis. When division managers take their actions in the second period, all investment decisions are already made.

*(i)*When external capital markets are relatively inefficient at processing the information contained in divisional profits (when $\frac{\sigma^2_{\varepsilon_2}}{\sigma^2_{\varepsilon_1}}$ is very large), they give little weight to first-period profits in their division's assessment.[17] This diminishes the division managers' ability to influence external capital markets' assessment, and, therefore, reduces managerial incentives to increase current profits. The problem particularly affects stand-alone firms because external capital markets are their only source of incentives, whereas multidivisional firms also rely on their internal capital markets.

The following quote about India from Ghemawat and Khanna (1998) describes the kind of problems associated with less developed capital markets that I have in mind:

> "Domestic institutional investors are only gradually acquiring the skills necessary for monitoring investments while foreign institutional investors are typically unfamiliar enough with the Indian business scene to provide adequate monitoring services."

Proposition 3 suggests a negative relation between the value of diversification and the degree of development of external capital markets. This is consistent with available empirical evidence. While the U.S. market discounts diversified firms by as much as 13 percent, Fauer, Houston and Naranjo (1998) show that in countries with difficult access to external finance, markets see diversifying strategies as value-enhancing.[18]

Further, the result suggests that the relative profitability of divisions in multidivisional and stand-alone firms is negatively correlated with the degree of development of external capital markets. Consistently, Berger and Ofek (1995) find that in the U.S., stand-alone firms have higher margins and profitability than similar divisions in multidivisional firms. The allocation effect does not have clear implications for profitability at the division level. If, for example, we assume decreasing returns in investment, underinvesting in one division may actually increase

[17]The total variance of the noise that external capital markets face is $\sigma^2_{\varepsilon_1} + \sigma^2_{\varepsilon_2}$. The ratio $1 + \frac{\sigma^2_{\varepsilon_2}}{\sigma^2_{\varepsilon_1}}$ measures the relative variance of the noise faced by external and internal capital markets. When $\frac{\sigma^2_{\varepsilon_2}}{\sigma^2_{\varepsilon_1}} = 0$, external capital markets can sort out as much noise as internal capital markets. When $\frac{\sigma^2_{\varepsilon_2}}{\sigma^2_{\varepsilon_1}}$ is very large, it means that external capital markets cannot sort out a relatively large part of the noise.

[18]The allocation effect reinforces the negative relation between external capital market development and the value of diversification. However, given that internal capital markets are always superior in allocating resources, the allocation effect cannot explain the observed diversification discount.

profit per unit of investment.[19]

So far, we have made comparisons between multidivisional firms and *all else equal* portfolios of stand-alone firms. However, the organizational structure is also endogenous. As external capital markets develop and can sort out a greater part of the noise (lower $\sigma^2_{\varepsilon_2}$), they become a more powerful source of incentives and diversification becomes a less valuable strategy. The allocation effect reinforces the incentives effect. As external capital markets develop and can sort out some of the noise, their allocation of resources improves and internal capital markets do not add as much value by allocating resources.[20] This suggests that as external capital markets develop (lower $\sigma^2_{\varepsilon_2}$) firms should go through a focusing process.[21]

The following corollary summarizes the implications derived from part *(i)* in the previous proposition.

Corollary 1 *(1) There is a negative relation between the value of diversification and the degree of development of external capital markets. Further, when the external capital market is sufficiently developed diversification is value-reducing. (2) The relative profitability of divisions in multidivisional and stand-alone firms is negatively correlated with the degree of development of external capital markets. (3) As external capital markets develop (lower $\sigma^2_{\varepsilon_2}$), diversification is less valuable and firms go through a focusing process.*

(ii) A diffuse prior about efficiency (high σ^2_η) makes managerial incentives decrease in multidivisional firms relative to stand-alone firms. A higher σ^2_η increases the weight of new information in the learning process. While in stand-alone firms all new information comes from profits, which division managers may increase with their actions, in multidivisional firms part of the new information comes from direct signals on efficiency (S_{it}), which the managers cannot

[19]Similarly, cross-subsidization may explain why multidivisional firms are less profitable than a portfolio of comparable single firms. However, cross-subsidization does not have clear implications for profitability at the division level.

[20]As external capital markets develop, they might also use some direct measures of efficiency which tend to decrease managerial incentives. However, it is important to recognize that we are comparing external versus internal capital markets. The important issue is not whether the external capital market observes more or less but how much it observes in relation to the internal capital market. I am implicitly assuming that the gap in information between internal and external capital markets is closed in profit related measures. The direct signal s_{it} which might be derived from working within the organization is less sensitive to market development.

[21]Habib, Johnsen, and Naik (1997) show that spin offs announcements in the U.S. have been generally accompanied by an increase in the firm's value.

influence. Firms in new and high growth industries and younger firms are likely to have high ex-ante uncertainty (high σ_η^2) about their efficiency, which suggests the following corollary:

Corollary 2 *(1) Stand-alone corporations provide stronger incentives in new and high growth industries. (2) Stand-alone corporations provide stronger incentives in younger firms.*

The allocation and incentive effects might go in opposite directions. As σ_η^2 increases, the information of the internal capital market becomes more valuable in determining the optimal allocation of resources. The empirical implications depend on which of these two effects dominate. If the incentive effect is stronger, then: (1) the diversification discount should be higher for firms in new and high growth industries; (2) new and high growth industries, unlike more mature industries, should be characterized by stand-alone firms[22]; (3) the diversification discount should be higher for younger firms; (4) the age of a division should be negatively correlated with the probability of being as a stand-alone firm.

(iii) Finally, proposition 4 also says that as σ_u^2 decreases, managerial incentives decrease in multidivisional firms. This result captures the dark side of information. When headquarters gets very precise signals, it does not rely as much on current profits to determine future investment allocation. This has a negative effect on managerial incentives because it breaks the relation between current performance and future financing decisions. Optimal organizational design should take into account this effect: it might be optimal for corporate headquarters not to get too involved in operational issues and just act a provider of capital which would allow for a certain arm's length relation. The allocation effect goes in opposite direction, as σ_u^2 increases multidivisional firms' allocation of funds is worsened. The optimal organizational structure should balance these two effects. Baker (1992) illustrates the story of Beatrice. This conglomerate created value while top management maintained an arm's length relation with their divisions. However, when the company changed management, and the new management tried to get more involve in their divisions, Beatrice started to loose value.

[22]In new, high growth industries profits are also likely to be a more noisy signal of efficiency (higher $\sigma_{\varepsilon 1}^2$ and $\sigma_{\varepsilon 2}^2$) but for us what matters is not the noisiness of the signal but the relative efficiency of the internal and external capital markets' processing of information $\frac{\sigma_{\varepsilon 2}^2}{\sigma_{\varepsilon 1}^2}$.

1.4 Related diversification

So far, this paper has considered divisions with no non-financial synergies. This may be interpreted as pure diversification. This section studies the effects of "related" diversification, which refers to divisions with some operational synergies. These synergies create spillovers in the learning process: the information from one division conveys information about other divisions in the corporation, and influences external capital markets' and headquarters' learning processes. These spillovers, as they influence investment decisions, are internalized by division managers and affect managerial incentives. The analysis proceeds in two stages. First, I analyze the effect of related diversification on the incentives provided by external capital markets. Second, I study the implications of related diversification for the incentives provided by internal capital markets.

1.4.1 External Capital Market

In order to isolate the effect of related diversification on the incentives provided by external capital markets, the following simplifying assumption is made:

$$\sigma_u^2 = 0 \text{ and } \sigma_{\varepsilon_1}^2 = 0 \tag{A10}$$

Under 1.1, headquarters perfectly observes a division's efficiency, and external capital markets are the only source of incentives.

There are alternative ways to capture relatedness between divisions. Related divisions may be exposed to positively correlated shocks. In addition, related divisions may have efficiency spillovers.[23] The following two alternative assumptions are meant to capture and separate these two sources of relatedness.

(A7$^{\text{i}}$) ε_{2it} and ε_{2jt} are joint normal with $\sigma_{\varepsilon_{2i}\varepsilon_{2j}} \equiv Cov(\varepsilon_{2it}, \varepsilon_{2jt}) > 0$ for $t = 1, 2 \;\; \forall i, j$. All other variables are uncorrelated.

(A7$^{\text{ii}}$) η_i and η_j are joint normal with $\sigma_{\eta_i\eta_j} \equiv Cov(\eta_i, \eta_j) > 0$ for $\forall i, j$. All other variables

[23] These two "types" of relatedness basically capture that as much as divisions have common operational grounds, there are permanent and transitory shocks that are likely to affect all divisions simultaneously. Imagine, for example, two divisions which depend on the outcome of a certain R&D project. A temporary delay or complete failure of the project would negatively affect both divisions.

are uncorrelated.

We consider the case with $N = 2$.

Lemmas A2 and A3 in the appendix identify the interactions in the learning process. In particular, under positively correlated shocks (*efficiency spillovers*), an increase in the managerial action reduces (*increases*) external capital markets' efficiency assessment of related divisions. The following two propositions identify the effect of related diversification on the incentives provided by external capital markets:

Proposition 4 *Under positively correlated shocks (A7i), managerial incentives are stronger than under pure diversification* ($a_{i1}^{RSMF} > a_{i1}^{MF}$) *iff* $\sigma_{\varepsilon_{2i}\varepsilon_{2j}} > \sigma_{\eta_j}^2(1 + \frac{\sigma_{\varepsilon_{2i}}^2}{\sigma_{\eta_i}^2})$

Proposition 5 *Under efficiency spillovers (A7ii), managerial incentives are stronger than under pure diversification* ($a_{i1}^{ESMF} > a_{i1}^{MF}$) *iff* $\sigma_{\eta_i\eta_j} < \sigma_{\varepsilon_{2j}}^2(1 + \frac{\sigma_{\eta_i}^2}{\sigma_{\varepsilon_{2i}}^2})$

Diversification into related industries (industries which are influenced by positively correlated shocks and/or efficiency spillovers) has an ambiguous effect on the incentives provided by external capital markets. There are two opposing effects. First, there is a *direct effect* on the process of learning about a manager's own division. Positively correlated shocks (*efficiency spillovers*) increase (*reduce*) the marginal effect of a division manager's action on external capital markets' efficiency assessment of the division. The intuition goes as follows: Under positively correlated shocks, external capital markets can better infer, using information from related divisions, whether a transitory shock has occurred. Current profits become more informative about the division's efficiency. Therefore, external capital markets put more weight on profits in their assessment of divisions, which increases managerial incentives. Under efficiency spillovers, external capital markets can learn about a division's efficiency from related divisions. This reduces the weight of current profits in external capital markets' assessment of the division, thereby decreasing managerial incentives.

Second, there is an *indirect effect* on the learning process about related divisions. Under positively correlated shocks (*efficiency spillovers*), a division manager's action has a negative (*positive*) effect on external capital markets' efficiency assessment of related divisions, which reduces (*increases*) the funds provided to the corporation. Division managers internalize this effect, and, therefore, positively correlated shocks (*efficiency spillovers*) reduce (*increase*) managerial incentives.

So far, I have analyzed the effect of related diversification on incentives and thus on first-period expected profits. However, related diversification also affects expected profits in the second period. Relation across divisions may improve or worsen external capital markets' funding decision and second-period expected profits. On the one hand, having related divisions improves the learning process for each individual division. On the other hand, having unrelated divisions allows for the averaging out of errors in the learning process.

1.4.2 Internal Capital Market

This section studies the implications of related diversification for the incentives provided by internal capital markets. Relatedness across divisions might be manifested through three different channels. As in the previous section, related divisions are likely to have positively correlated shocks and efficiency spillovers. In addition, judging efficiency errors (u_{it}) may also be positively correlated across related divisions.[24] The following three assumptions capture these three sources:

(A7$^{\text{iii}}$) ε_{1it} and ε_{1jt} are joint normal with $\sigma_{\varepsilon_{1i}\varepsilon_{1j}} \equiv Cov(\varepsilon_{1it}, \varepsilon_{1jt}) > 0$ for $t = 1, 2\ \forall i, j$; $\sigma^2_{u_{it}} = \infty$. All other variables are uncorrelated.

(A7$^{\text{iv}}$) η_i and $\eta_j$are joint normal with $\sigma_{\varepsilon_{1i}\varepsilon_{1j}}\sigma_{\eta_i\eta_j} \equiv Cov(\eta_i, \eta_j) > 0\ \ \forall i, j$; $\sigma^2_{u_{it}} = \infty$. All other variables are uncorrelated.

(A7$^{\text{v}}$) u_{1it} and u_{1jt} are joint normal with $\sigma_{u_{it}u_{jt}} \equiv Cov(u_{it}, u_{jt}) > 0$ for $t = 1, 2\ \forall i, j$. All other variables are uncorrelated.

I also make the following assumption in order to leave internal capital markets as the only source of incentives.

(A10$^{\text{i}}$) $\sigma_2^2 = \infty$

Lemmas A4-A6 in the appendix show the updating process under the above assumptions. The effect of related diversification on the incentives provided by the internal capital market is summarized in the following proposition:

[24]For example, a division manager's evaluation of related industries might be biased in the same direction.

Proposition 6 *(i) If divisions are subject to positively correlated shocks ($A7^{iii}$), related diversification improves the provision of managerial incentives in internal capital markets with respect to unrelated diversification. (ii) If divisions are subject to efficiency spillovers ($A7^{iv}$), related diversification reduces the provision of managerial incentives in internal capital markets with respect to unrelated diversification. (iii) Under positively correlated learning errors ($A7^{v}$), related diversification reduces the provision of managerial incentives in internal capital markets with respect to unrelated diversification.*

As in the previous section, there is a *direct effect* and an *indirect effect*, but now these two effects go in the same direction. The *indirect effect* has opposite implications for the incentives provided by the internal and the external capital markets: an increase in headquarters' efficiency assessment of a related division decreases investment in the division, while an increase in external capital markets' efficiency assessment of a related division increases investment in the division. Therefore, positively correlated shocks (*efficiency spillovers*) increase (*reduce*) managerial incentives. A manager's action has a higher (*lower)* marginal effect on the efficiency assessment of her or his division (direct effect) and reduces (*increases*) the efficiency assessment of related divisions (indirect effect).

Finally, correlated judging errors make the direct signal (S_{it}) more informative, as headquarters can better sort out its noise from the signal of related divisions. This decreases the weight of current profits on headquarters' assessment of the division and reduces managerial incentives.

The following table summarizes the section:

Relation	External Capital Market	Internal Capital Market
Correlated Shocks	Ambiguous	Increase
Efficiency Spillovers	Ambiguous	Decrease
Correlated learning errors	———	Decrease

1.5 Extensions

1.5.1 Influence Activities

In internal capital markets, there is a close long-term relation between corporate headquarters and division managers, which may allow for the possibility of influence activities. Division managers may spend too much time trying to make a good impression on their superiors. This possibility can be easily incorporated into the model. Consider the following two changes in the main set up ((A4)-(A9)): (1) There is a total amount of time T that the division manager costlessly spends in every period between productive activity a_{it} and influence activity i_{it}; (2) Influence activity i_{it} is not observable and has the effect of improving headquarters' direct signal as follows[25]:

$$S_{it} = \eta_i + G(i_{it}) + u_{it} \text{ where } G' > 0 \text{ , } G'' < 0, G'(0) = \infty \text{ and } G'(T) = 0$$

Proposition 7 *(i) In stand-alone firms there are no influence activities ($i_t^{SF} = 0$). (ii) In multidivisional firms there are influence activities ($i_{it}^{MF} > 0$). (iii) The level of influence activities in multidivisional firms increases with the number of divisions.*

Parts *(i)* and *(ii)* of the proposition just capture that division managers undertake influence activities only to the extent that corporate headquarters has some real power (the possibility to allocate resources across several divisions). As the number of divisions increases, and the internal capital market replaces the external capital markets in the provision of managerial incentives, the level of influence activities increases (Part *(iii)*).[26] This result suggests that there should be a positive relation between diversification discount and the size of the internal capital market as measured by the number of divisions.

[25]The non-observability assumption is meant to capture that corporate headquarters cannot completely sort out whether the division is good or the division manager is putting a lot of time into "selling" his division to headquarters.

[26]What is important for this result is that influence activities have a larger effect on headquarters' than on external capital markets' assessment of the division.

1.5.2 Cross-subsidization.

So far, this paper has focused on the effect of a "well functioning" internal capital market on managerial incentives. The agency problem at the headquarters level, namely, its empire building behavior, has not prevented the optimal allocation of resources *given* the level of funding. However, recent papers (Rajan , Servaes and Zingales 2000, and Scharfstein and Stein 2000) have suggested that headquarters may incur in cross-subsidization. Headquarters' cross-subsidization may have negative consequences on the incentives provided by internal capital markets, as it may weaken the link between current performance and future investment. Let's, for example, take an alternative utility function for corporate headquarters which captures headquarters' incentive to cross-subsidize in a naive way:

$$(F_1 + F_2) - \sum_{i=1}^{N} \left(I_{i1} - \frac{I_{i1}}{F_1} \right)^2 - \sum_{i=1}^{N} \left(I_{i2} - \frac{I_{i2}}{F_2} \right)^2$$

With this objective, it is easy to verify that no incentives are provided by internal capital markets while the incentives provided by external capital markets remain the same.[27] Since in multidivisional firms the effectiveness of external capital markets in the provision of managerial incentives is reduced by a public good problem, in the example, stand-alone firms always provide more managerial incentives than multidivisional firms. In general, under cross-subsidization, the allocation problem may be amplified by an incentive problem.

1.6 Conclusion

This paper has studied the implications of internal capital markets for managerial incentives. I have shown that as the number of divisions increases the internal capital market substitutes for the external capital market in the provision of managerial incentives. I have also shown that headquarters' informational advantage, while improving the allocation of resources, might have adverse consequences for managerial incentives. The analysis has produced several testable

[27] Under this objective function, the level of investment in the second period is $\frac{F_2}{N}$, which does not depend on headquarters' assessment of the division and therefore the internal capital market does not provide managerial incentives.

implications. First, there is a negative relation between the development of external capital markets and the value of diversification. Second, as external capital markets develop we should observe a decrease in diversification. Finally, external capital markets provide stronger incentives in new and high growth industries, as well as in newer firms within an industry. In several extensions, we have also analyzed the effect of "related" diversification, cross-subsidization, and influence activities on the incentives provided by internal capital markets.

Let me conclude by suggesting a few avenues for future research. Throughout this paper, headquarters has used its informational advantage to improve the external capital markets' allocation of resources. In this sense, I have been focusing on "well functioning" internal capital markets. However, it is important to realize that headquarters' investment decisions might convey information to external capital markets and to division managers. Headquarters could behave strategically in its conveyance of information by distorting its investment decisions. It would be interesting to study these possible distortions and their implications for managerial incentives and firm value.

This framework is also well suited to study some of the issues related to organizational design. For example, in some organizations resources are allocated using multiple layers. The specific organizational structure would determine to what extent any two divisions within the organization are in direct competition for corporate resources. Inducing cooperation between certain divisions may imply reducing their degree of competition for corporate resources.

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Chapter 2

The Venture Capital Market: Matching and Adverse Selection

2.1 Introduction

The importance of venture capital markets has increased considerably in the last twenty years. For instance, venture capital disbursements have gone from $255 million in the 1965-69 period to $12,125 million in 1990-96 in the U.S.[1] However, the importance of venture capital financing varies considerably across sectors and countries. The venture capital market has become especially important in specific areas such as Silicon Valley and the Northeast. Furthermore, venture capital is heavily concentrated in certain sectors: office and computing machinery, other non-electrical machinery, communications and electronics, professional and scientific instruments and pharmaceuticals.

This raises some intriguing questions: What makes a venture capital market more or less efficient than other forms of financing? Why does the venture capital market concentrate in certain sectors and regions? Why has the venture capital market become so important in the U.S. and not in other countries?

This paper provides some insights into these questions by modeling investors' decisions about whether to become venture capitalists (VCs) or to form firms and entrepreneurs' decisions about

[1] Millions are in 1997 USD. Information source: Gompers and Lerner (1999).

whether to join firms or seek financing in the venture capital market.

The paper focuses on the following difference between venture capital and within firm financing: When an entrepreneur joins a firm, she develops her project within the firm. If the project belongs to the firm's area of expertise, the firm observes a noisy signal about the quality of the project and decides whether to undertake or turn down the project.[2] If the firm rejects the project, the entrepreneur cannot take the project and seek financing somewhere else. The rationale behind this assumption is that the entrepreneur's project is specific to the firm.

The situation in the venture capital market is different. If the entrepreneur decides not to join a firm, she generates a project on her own and then seeks financing from a venture capitalist (VC). The VC screens the project, and if the project belongs to her area of expertise, she observes a noisy signal about its quality. If the VC rejects the project, the entrepreneur can approach other VCs, who might observe a different signal about the quality of her project. In the model, a key feature of the market is its *anonymity* (as in Sah and Stiglitz [1986]): A VC approached by an entrepreneur does not know whether the project has previously been rejected by other VCs.

Financing within a firm and in the venture capital market has different properties. Anonymity makes it easier for the entrepreneur to approach other VCs after being rejected, which increases the probability for both good and bad projects to be implemented in the venture capital market. Therefore, the expected value of a project can increase or decrease with the number of VCs that an entrepreneur can visit. The entrepreneur's ability to approach several VCs sequentially has opposing effects: On the one hand, a venture capital market allows for better matching between investors and entrepreneurs because it increases the probability of an entrepreneur finding a investor who has the expertise to evaluate and carry out her project. We will refer to this as the *matching effect.* On the other hand, an *adverse selection effect* arises because VCs cannot determine whether entrepreneurs have been previously rejected.

The expected value of a project in the venture capital market evolves in the following way: As the number of VCs increases, the number of matching opportunities increases, but so does adverse selection. However, the larger the number of VCs, the lower the probability that there has not been a good match between an entrepreneur and a VC (i.e. the weaker the matching

[2] Xerox

effect) and the higher the probability that an entrepreneur has been rejected previously by other VCs (i.e. the stronger the adverse selection effect). Therefore, the expected value of a project in the venture capital market is first increasing (i.e. when the matching effect is stronger than the adverse selection effect) and then decreasing (i.e. when the matching effect is weaker than the adverse selection effect) with the number of VCs.

The analysis has several implications. First, a minimum number of investors is necessary to attract entrepreneurs to the venture capital market. Whether a entrepreneur chooses to join a firm or seeks financing in the venture capital market depends on where she obtains a higher expected value. Therefore, the venture capital market must provide the entrepreneur with enough matching opportunities. This suggests that coordination failures can prevent the emergence of a venture capital market.

Second, in equilibrium, as the number of investors increases so does the size of the venture capital market (i.e. the number of investors opting to be VCs). Furthermore, when the number of investors is large enough, there is excessive entry in the venture capital market. When an investor decides whether to form a firm or to become a VC she does not take into account the increased adverse selection imposed on other VCs.

Third, beyond a certain number of investors, the fraction of investors that become VCs decreases and, in equilibrium, the expected value of a project within a firm and in the venture capital market is the same.[3]

The analysis has several implications for the dynamics of the venture capital market. Suppose that as a sector matures, the number of investors with expertise to screen ventures in the sector increases.[4] The model suggests that in the early stage most innovations are undertaken within firms. Then, as the sector matures, the relative importance of the venture capital market increases. Finally, when the sector reaches sufficient maturity, the relative importance of the venture capital market decreases and innovation "returns" to the firm.

Fourth, when the average quality of projects increases so does the relative size of the venture capital market. While an increase in the average quality of projects improves the performance of both firms and VCs (i.e. the expected value of an entrepreneur within firms and in the venture

[3]In the venture capital market, the matching effect and the adverse selection effect offset each other.

[4]Investors must have expertise to screen and carry out projects. Having access to financing is a necessary, but not a sufficient, condition to become an investor; the investor must also be an expert.

capital market), the effect is stronger in the venture capital market because of the market's higher probability of undertaking both good and bad projects.

This implies the following dynamics for innovation: If due to a positive shock, the average quality of a sector's projects increases, so does the relative size of the venture capital market (i.e. innovation goes out of the firm and into the venture capital market). When the shock dies out (i.e. the average quality of projects decreases) the relative size of the venture capital market decreases (i.e. innovation returns to the firm).

The analysis of the basic model identifies a positive (*negative*) relation between the relative importance of the venture capital market and the size of the matching (*adverse selection*) effect. However, this raises some further questions: Which are the factors that determine the relative importance of these two effects? How do VCs respond to the adverse selection that they face? How do adverse selection and matching affect entrepreneurial incentives?

In this paper, we provide some answers to these questions. First, investors' diversity is behind both the matching and adverse selection effects. We show that a wide variety of areas of expertise among potential investors reinforces the matching effect and improves the performance of the venture capital market. on the other hand, investors having different screening technologies reinforces the adverse selection effect and the venture capital market deteriorates.

Second, the negative effect of adverse selection can be alleviated by a more precise screening technology. We endogenize the investors' choice whether to become highly specialized in a few areas of expertise or to have a larger range of expertise at the cost of profound expertise within a single area. Whether or not firms or VCs follow a narrow-but-deep expertise strategy depends on the relative strength of two opposing forces: the adverse selection effect pushes VCs towards a narrow strategy, but if firms can shape entrepreneurs' projects to their area of expertise, firms can focus on fewer areas.

Third, capacity constraints faced by investors (i.e. investors being able to undertake only a limited number of projects) affects the relative importance of adverse selection and matching. The analysis suggests that the venture capital market becomes relatively important when the number of investors is small and the ratio of the number of investors to the number of entrepreneurs is neither too large nor too small. On the one hand, if the number of investors is relatively large, the investors' capacity constraint is not binding and entrepreneurs can seek financing from other VCs after being rejected. As a consequence, the adverse selection effect is important, and it limits the number of VCs. On the other hand, if the number of entrepreneurs is relatively large, the investors' capacity constraint binds and it is difficult to find VCs willing to finance projects. Therefore, the matching effect is weaker and it limits the size the venture capital market.

Finally, the choice of the entrepreneur whether to join a firm or to seek financing in the venture capital market affects her incentives. The analysis draws the conclusion that venture capital markets have a negative effect on entrepreneurial incentives: Entrepreneurs seeking financing in the venture capital market generate more projects but they are of lower average quality than entrepreneurs in firms.

The paper is related to several lines of research. Methodologically, the closest link is Sah and Stiglitz (1986). Their paper compares the performance of two organizational forms: hierarchies and polyarchies. In their model, polyarchies have similar characteristics to our venture capital market; independent testing and anonymity are the key ingredients of both. Otherwise, their question and their approach is quite different.

Like our paper, Landier (2001a) and Gromb and Scharfstein (2001) also consider an equilibrium labor-market model of entrepreneurship. In Landier (2001a) entrepreneurs receive private information about their current project and decide whether to continue their current project or abandon it and raise funds to undertake a new project. Several equilibria arise. If the market interprets a departure from an established firm as a sign of low managerial activity, entrepreneurs will not depart from an established firm unless they receive bad news about their current project. But if the market interprets a departure from an established firm as a sign that the manager has an attractive new project, entrepreneurs will depart from an established firm unless they receive good news about their current project.

Gromb and Scharfstein (2001) compare the financing of new ventures in start-ups and in established firms. In their model, established firms, unlike start-ups, have several projects available. This implies that while established firms can use information on failed entrepreneurs to redeploy them into other projects, failed entrepreneurs in start-ups must seek other jobs in an imperfectly informed labor market. While this is ex-post inefficient, it provides entrepreneurs with high-powered incentives ex-ante.

Unlike Landier (2001a) and Gromb and Scharfstein (2001), who focus on the redeployability of failed entrepreneurs, our paper studies information processing and project implementation in venture capital markets and within firms. Furthermore, we endogenize both the number of venture capitalists and the number of entrepreneurs in the venture capital market.

There is also a large body of literature on venture capital financing (Berglof [1994], Gompers [1995]; etc.) Unlike our paper, this literature focuses on the specific details of the contractual arrangements between VCs and entrepreneurs.

The remainder of the paper is structured as follows: Section II presents the model. Section III analyzes the equilibrium. Section IV studies the effect of investors' diversity on the venture capital market. Section V endogenizes investors' decisions whether to become highly specialized in a few areas of expertise or to have a larger scope of areas of expertise at the cost of a more profound expertise within a single area. Section VI analyzes capacity constrained investors. Section VII studies entrepreneurial incentives. Section VIII concludes. An appendix with proofs is also provided.

2.2 The Model

We consider a model with five dates ($t = 1,\dots,5$) and no discounting. There are N risk-neutral investors who have the expertise to evaluate new projects as well as the resources to finance them. There is a continuum $[0, 1]$ of risk-neutral entrepreneurs with the ability to generate new projects. Being wealthless, entrepreneurs need to look for financing from the investors. The sequence of events is as follows:

At $t = 1$, each investor decides whether to be a VC or to form a firm. An investor's decision maximizes her expected profit. Let N_{vc} and N_f be the number of investors that become VCs and that form firms respectively, with $N = N_{vc} + N_f$. We will explain the difference between both types of organization shortly.

At $t = 2$, each entrepreneur decides whether to join a firm or to seek financing from a VC. An entrepreneur's decision maximizes her expected value. Let α $(1 - \alpha)$ be the fraction of entrepreneurs that seek financing from VCs (that join firms). Entrepreneurs deciding to join a firm are evenly distributed across firms.

At $t = 3$, each entrepreneur discovers a project requiring an initial investment I; with probability p the project is good (G) and worth X at $t = 5$, and with probability $(1 - p)$ the project is bad (B) and worth zero.

At $t = 4$, if the entrepreneur has joined a firm, the investor screens the project and decides whether the project should be implemented or not. But if the entrepreneur is in the venture capital market, the entrepreneur seeks financing from any of the N_{vc} VCs in the market with equal probability $1/N_{vc}$. The VC screens the project and decides whether to finance it or not. If the VC rejects the project, the entrepreneur approaches one of the other VCs in the market. The process continues until either the entrepreneur has approached all the VCs or a VC decides to finance the project.

When an investor (firm or VC) screens a project, one of the following happens: (i) With probability $(1-r)$ the investor has no expertise to carry out the project[5]; (ii) With probability r the investor has the expertise to carry out the project and observes a noisy signal g or b about its quality (i.e. with $\Pr(g|G) = rq_1$ and $\Pr(g|B) = r(1 - q_2)$ and $(q_1, q_2) \in (\frac{1}{2}, 1)^2$). The probabilities q_1 and q_2 measure the informativeness of the signal. Specifically, $(1 - q_1)$ and $(1 - q_2)$ respectively are the sizes of the type I and type II errors.

If an entrepreneur joins a firm, the probability that an investor has the expertise to carry out a project, i.e. r, depends on whether the investor has formed a firm, i.e. $r = r_f$, or has become a VC, i.e. $r = r_{vc}$.

At period $t = 5$, the project's value is shared between the investor and the entrepreneur. For simplicity, we assume that the entrepreneur receives an exogenous fraction δ of the expected value of the project that is implemented.[6] This implies the following sharing of value:

$$\text{Value to Entrepreneur} = \delta \left(X - \frac{I}{\Pr(G|\text{Project is Implemented})} \right)$$

[5]This can be interpreted as receiving no signal about the quality of the project.

[6]A more general analysis would involve bargaining under asymmetric information between entrepreneurs and venture capitalists. Typically this is a difficult problem to solve and while interesting in itself it is not necessary to capture the trade-offs in the model.

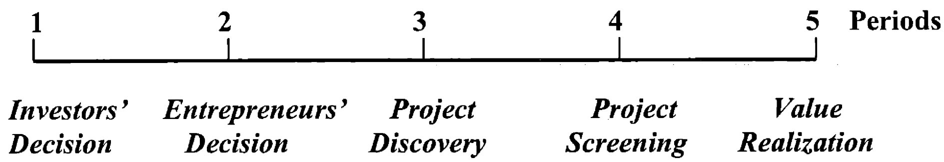

Figure 2-1:

$$\text{Value to Investor} = (1-\delta)\left(X - \frac{I}{\Pr(G|\text{Project is Implemented})}\right) + \frac{I}{\Pr(G|\text{Project is Implemented})}$$

where $\Pr(G|\text{Project is Implemented})$ is the fraction of the projects implemented that are good. In general, the fraction of implemented projects that are good will be different in the venture capital market and within firms.

The following assumptions guarantee that a project is not implemented unless the investor observes a positive signal about its quality.

$$pX - I < 0$$

$$pq_1(X-I) - (1-p)(1-q_2)I > 0$$

2.3 Analysis of the Equilibrium

2.3.1 Firms

The expected value of a project within a firm (i.e. V_f) is the value of a good project multiplied by the probability that the project is good and implemented (i.e. $r_f(pq_1(X-I))$ plus the value of a bad project multiplied by the probability that the project is bad and implemented (i.e.

$(1-p)(1-q_2)(-I))$.

$$V_f = r_f(pq_1(X-I) - (1-p)(1-q_2)I)$$

Note that V_f increases with the project's average quality (i.e. increases with p and X, and decreases with I). More interestingly, V_f also increases as the screening technology improves (i.e. as q_1 and q_2 increase). A better screening technology leads to more good projects and less bad projects being undertaken, which increases the average quality of the projects implemented. Finally, V_f increases with the level of expertise within the firm (r_f). A higher level of expertise increases the probability of a good match between the firm and the entrepreneur and, hence, the probability of implementation.

Entrepreneurs receive a fraction δ of the expected value of their projects. Therefore, the expected value for an entrepreneur within a firm, i.e. W_f, is:

$$W_f = \delta V_f$$

2.3.2 Venture Capitalists

The expected value of a project in the venture capital market (i.e. V_{vc}) is the value of a good project multiplied by the probability that the project is good and implemented (i.e. $\left(1-[(1-q_1)r_{vc}+(1-r_v)]^{N_{vc}}\right)p(X-I)$) plus the value of a bad project multiplied by the probability that the project is bad and implemented (i.e. $\left(1-[q_2 r_{vc}+(1-r_v)]^{N_{vc}}\right)(1-p)(-I)$).

$$\begin{aligned} V_{vc}(N_{vc}) &= \left(1-[(1-q_1)r_{vc}+(1-r_v)]^{N_{vc}}\right)p(X-I) \\ &\quad - \left(1-[q_2 r_{vc}+(1-r_v)]^{N_{vc}}\right)(1-p)I \end{aligned}$$

V_{vc} increases with the project's average quality (i.e. higher p and X, and lower I) and with the precision of the screening technology (i.e. higher q_1 and q_2).

It is worth noticing that V_{vc} depends on the number of VCs in the market. Furthermore, the effect is non-monotonic. Increasing the number of VCs in the market increases the probability that there is a good match between entrepreneurs and an investor's expertise. However, the extra rounds of matching allows second chances for projects that have already been rejected. This is more important for bad projects than for good projects since bad projects are more likely to be rejected in the first place. As a consequence, as the number of VCs increases the ratio of good to bad projects implemented decreases. The importance of this effect is related to the relative size of type I and type II errors. The larger the probability of accepting a bad project (i.e. $(1-q_2)$) and the smaller the probability of rejecting a good project (i.e. $(1-q_1)$) the higher is the ratio of bad to good projects implemented in the extra rounds of matching. The following lemma summarizes this discussion:

Lemma 2 *The expected value of a project in the venture capital market, V_{vc}, first increases and then decreases with the number of VCs.*

Finally, although within the firm a higher level of expertise (r_f) always increases a project's expected value (V_f), this does not necessarily occur in the venture capital market. A higher level of expertise increases the probability that both good and bad projects are implemented due to the *matching effect*. However, the relative number of good to bad projects implemented *decreases* with the level of expertise due to the *adverse selection effect*[7]: As the number of VCs capable of implementing a project increases (i.e. when r_{vc} increases), it is more likely that a project that is presented to a VC has already been screened and rejected.

Entrepreneurs receive a fraction δ of the expected value of their projects. Therefore, the expected value for an entrepreneur in the venture capital market, i.e. W_{vc}, is:

$$W_{vc}(N_{vc}) = \delta V_{vc}(N_{vc})$$

2.3.3 Market Equilibrium

In this section, we characterize the relative importance of the venture capital market and firms in equilibrium.

Let α be the fraction of entrepreneurs that seek financing in the venture capital market, and Π_f and Π_{vc} be the expected profits for an investor within a firm and a VC respectively.

[7]The probability that a good project is not implemented is given by $(1-r_{vc}q_1)^{N_{vc}}$ and the probability that a bad project is not implemented is given by $(1-r_{vc}(1-q_2))^{N_{vc}}$.

These are given by the following expressions:

$$\Pi_f = \frac{(1-\alpha)}{N - N_{vc}}(1-\delta)V_f$$

Π_f is equal to the number of entrepreneurs working in each firm (i.e. $\frac{1-\alpha}{N-V_{vc}}$) multiplied by the expected profit per entrepreneur obtained by a firm (i.e. $(1-\delta)V_f$).

$$\Pi_{vc} = \frac{\alpha}{N_{vc}}(1-\delta)V_{vc}$$

Π_{vc} is the total expected profit obtained in the venture capital market (i.e. $\alpha(1-\delta)V_{vc}$) divided by the number of VCs (i.e. N_{vc}).

Result 1 *If $r_f \geq r_{vc}$, a subgame perfect equilibrium always exists in which all the investors form firms (i.e. $N_{vc} = 0$; $\alpha = 0$).*

This equilibrium is sustained by a coordination failure. When deciding whether to join a firm or to go to the venture capital market entrepreneurs face the following trade-off. On the one hand, when an entrepreneur joins a firm she has a higher probability of a match between the firm and the entrepreneur's project ($r_f \geq r_{vc}$). On the other hand, the venture capital market offers the entrepreneur the possibility of going from one VC to another until she finds a VC who is willing to finance her project. The venture capital market has to offer enough matching opportunities to be attractive for entrepreneurs. Therefore, if all investors decide to form firms, there will be no incentive for an investor to deviate and become a VC. A single VC will not be able to attract entrepreneurs because she cannot create enough matching opportunities.

There are two implications of this result. First, public intervention that solves the coordination problem might be desirable in order to create a venture capital market. Once a critical mass of VCs exists, other VCs will decide to join in and entrepreneurs will be attracted to the venture capital market. Second, we should observe geographical and sectorial concentration in the venture capital market. This is consistent with empirical evidence: the venture capital market tends to be concentrated in specific geographical areas and industries. For example, in the U.S. the venture capital activity is concentrated in the Silicon Valley and the Northeast.

We now study the properties of the most efficient equilibrium. This amounts to looking for a subgame perfect equilibrium with the additional requirement that no group of investors can simultaneously deviate while all being strictly better off. We will refer to this as *"the no coordination failure requirement."*[8]

Result 2 *There is a unique subgame perfect equilibrium satisfying the no coordination failure requirement. There are three possible equilibrium regions:*

(i) if $V_{vc}(x) < V_f$ for all $x \in [1, N]$, there is no venture capital market;

(ii) if $V_{vc}(N) > V_f$ all investors become VCs;

(iii) if $V_{vc}(N) < V_f$ and $V_{vc}(x) > V_f$ for some x in $[1, N]$, there are both VCs and firms; and the size of the venture capital market (N_{vc}, α) is given by the following equilibrium conditions: $V_{vc}(N_{vc}) = V_f$ and $\alpha = N_{vc}/N$.

There are two scenarios. If the adverse selection in the venture capital market is very strong or the expertise within the firm is relatively high (i.e. $r_f >> r_{vc}$), firms perform better than the venture capital market (i.e. the expected value of a project within the firm is higher than in the venture capital market) regardless of the size of the venture capital industry, i.e. $V_{vc}(x) < V_f$ for all $x \geq 1$. In this case, there is a unique equilibrium and all investors opt to form firms.

In the alternative scenario, the venture capital market performs better than firms as long as the number of VCs is not too large. In this case, there is a minimum and a maximum number of VCs, $N_{\min}$ and $N_{\max}$, such that the venture capital market performs better as long as there are $N_{vc} \in [N_{\min}, N_{\max}]$ VCs in the venture capital market. The intuition is as follows: while a minimum number of VCs is necessary to form a venture capital market, when there are "too many" VCs in the market the adverse selection effect is too strong.

This result suggests the following dynamics for a given sector: Assume that the number of investors increases as the sector matures. In the early stage of a sector N is small,[9] i.e. $N < N_{\min}$, and most of the innovation takes place within firms. As the sector matures and the number of potential investors increases, i.e. $N > N_{\min}$, a venture capital market emerges and

[8]For convenience we will be ignoring integer constraints when necessary.

[9]In order to become an investor, it is necessary to have some expertise in the sector, i.e. some probability $r > 0$ of being able to screen and implement the project.

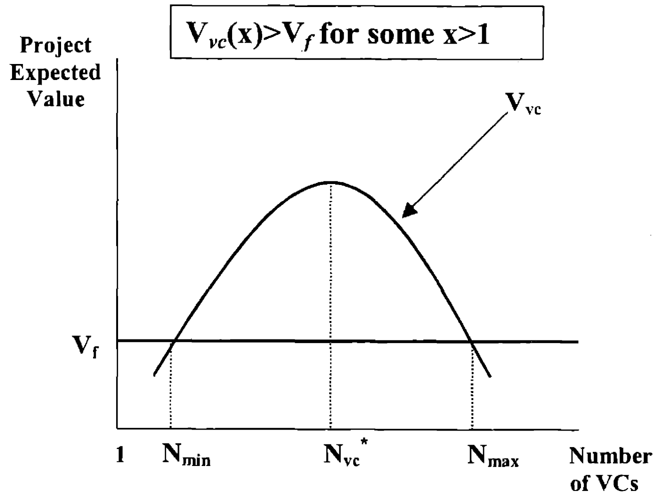

Figure 2-2:

entrepreneurs seek financing in it. The venture capital market grows with the age of the sector. The sector reaches a point $N > N_{\max}$ where the relative importance of the venture capital market decreases and an increasing proportion of the innovation takes place within firms. The following corollary summarizes this discussion:

Corollary 3 *If the expected value from an entrepreneur in the venture capital market is higher than within the firm for a given number of VCs, i.e. $V_{vc}(x) > V_f$ for some $x \geq 1$, but smaller for one VC, i.e. $V_{vc}(1) < V_f$, then there is a unique equilibrium satisfying the no-coordination failure requirement that depends on the number of investors N. In particular , define $N_{\min}$ and $N_{\max}$ such that $V_{vc}(N_{\min}) = V_{vc}(N_{\max}) = V_f$ and $N_{\min} \leq N_{\max}$ then the unique equilibrium is:*

- $N_{vc} = \alpha = 0$ *if* $1 < N < N_{\min}$
- $N_{vc} = N$ *and* $\alpha = 1$ *if* $N_{\min} < N < N_{\max}$
- $N_{vc} = N_{\max}$ *and* $\alpha = N_{\max}/N$ *if* $N > N_{\max}$

The limits defining the regions of the equilibrium, i.e. $N_{\min}$ and $N_{\max}$, depend on the underlying parameters of the model. The following corollary summarizes the comparative statics on these parameters:

Corollary 4 *(i) $N_{\min}$ decreases with p and X, and increases with I and r_f. (ii) $N_{\max}$ increases with p and X, and decreases with I and r_f.*

The effect of the probability of a match between the firm and the entrepreneur, i.e. r_f, is straightforward since V_f increases with r_f. More interesting is the effect of p, X and I. While these parameters have the same qualitative effect on V_f and V_{vc}, the relative importance of the effect is different. In particular, a venture capital market allows better matching between projects and expertise and therefore more projects are implemented. Because a project is more likely to be implemented in the venture capital market, an increase in the average quality of the projects has a higher impact on the expected value of a project in the venture capital market (V_{vc}) than on the expected value of an entrepreneur within a firm (V_f).[10]

The result reinforces the previous empirical implications: to the extent that younger sectors have, on average, better investment opportunities (i.e. projects), these sectors should be characterized by relatively larger venture capital markets. Furthermore, the result suggests a positive relation between the size of the venture capital market and the arrival of new ideas to a sector. To the extent that new ideas increase the average quality of the projects generated, they will have the effect of increasing the relative importance of the venture capital market.

Two final comments about the properties of the equilibrium are in order. First, when the venture capital market and firms coexist, i.e. $N > N_{\max}$, the average quality of the projects implemented in the market is lower, but projects have a higher probability of being implemented.

Second, the venture capital market is subject to a problem of excessive entry. When an investor has to decide whether to be a VC or to form a firm, she does not take into consideration that entering the venture capital market imposes a negative externality on the incumbent VCs. In other words, there is *business stealing* and an *adverse selection effect.*

Result 3 *Let $N_{vc}^* \equiv \arg\max_{N_{vc}} V_{vc}(N_{vc})$ and assume that $V_{vc}(N_{vc}^*) > V_f$, then the expected output in the economy is the maximum for $N_{vc} = N_{vc}^*$ and $\alpha = 1$. If the number of investors N is greater than N_{vc}^*, then there is excessive entry in the venture capital market.*

[10] The effect of the signals' precisions, i.e. q_1 and q_2, and of the degree of expertise, i.e. r_{vc}, is generally ambiguous. However, it can be easily seen that as $r_{vc} \to 0$ then $N_{\min} \to \infty$ and as $q_2 \to 0$ then $N_{\max} \to \infty$.

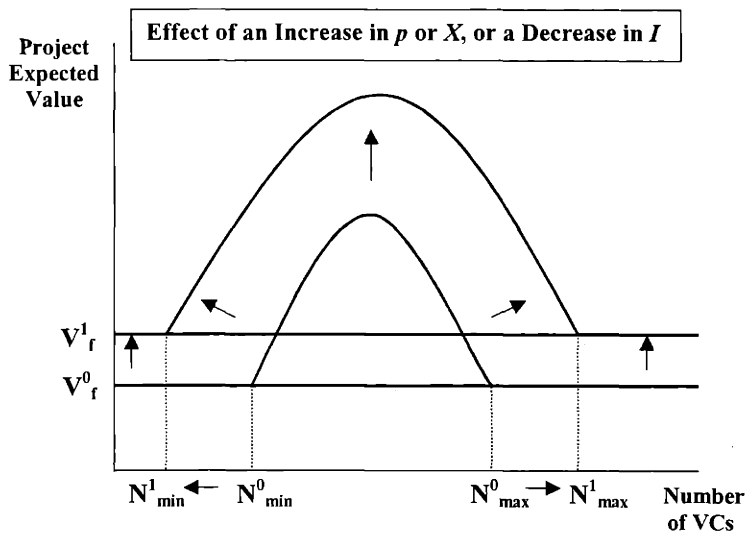

Figure 2-3:

2.4 The Effects of Diversity

So far, we have seen that the relative size of the venture capital market depends on the relative importance of the matching and the adverse selection effects. Behind these two effects is investors' diversity, i.e. investors who have different types of expertise and different screening technologies. This section studies what happens to the size of the venture capital market as investors' diversity increases.

2.4.1 Diversity and Expertise

We introduce the following change to our basic set up. As in the basic model, when an investor screens a project one of the following can happen: (i) With probability $(1-r)$ the investor has no expertise to carry out the project; (ii) With probability r the investor has the expertise to carry out the project and observes a noisy signal about its quality. However, now we assume that with probability d_I (for diversity), an investor's expertise on a given project is independent across investors, and with $(1-d_I)$, if an investor has expertise on a given project all other investors also have expertise on the project. Furthermore, to simplify the analysis, we set $q_1 = q_2 = q$.[11]

In this set up, the expected values of a project within a firm and in the venture capital market are given by the following expressions respectively:

$$V_f = r_f(pq(X-I) - (1-p)(1-q)I)$$

$$\begin{aligned} V_{vc}(N_{vc}, d_I) &= d_I \left\{ \begin{array}{c} \left(1 - [(1-q)r_{vc} + (1-r_{vc})]^{N_{vc}}\right) p(X-I) \\ -\left(1 - [qr_{vc} + (1-r_{vc})]^{N_{vc}}\right)(1-p)I \end{array} \right\} + \\ &\quad +(1-d_I)\cdot r_{vc} \left\{ \begin{array}{c} \left(1-(1-q)^{N_{vc}}\right) p(X-I) \\ -\left(1-q^{N_{vc}}\right)(1-p)I \end{array} \right\} \end{aligned}$$

Result 4 *If $r_f > r_{vc}$, the relative size of the venture capital market increases with diversity, i.e. $V_{vc}(N_{vc}, d_I)$ is increasing in d_I.*

The relative importance of the venture capital market increases with diversity as captured by d_I. The intuition is as follows: If there is a venture capital market it means that the expected value of a project is as least as high there as it is within a firm. Since $r_f > r_{vc}$, for those projects where the expertise is correlated across investors (this happens with probability $(1-d_I)$), firms perform strictly better than the venture capital market (i.e. those projects have a higher expected value within a firm). Therefore, if there is a venture capital market, it must be the case that the venture capital market performs better for those projects that require an expertise that is independent across investors (this happens with probability d_I). An increase in diversity, i.e. in the probability that a project requires an expertise that is independent across investors, increases the relative value of the venture capital market as well as its relative size.

2.4.2 Diversity and Screening

In this section, we analyze the other side of investors' diversity. Here, diversity is captured by the disagreement among investors when screening a project. Once again, when an investor

[11] This assumption fixes the size of the type I and II errors. It implies that the expected value of a project taken after it has previously been screened and rejected by another investor is negative.

screens a project one of the following can happen: (i) With probability $(1-r)$ the investor has no expertise to carry out the project; (ii) With probability r the investor has the expertise to carry out the project and observes a noisy signal about its quality. However, now we assume that with probability d_{II} (for diversity) the signal observed by the investors with expertise is independent across investors, and with probability $(1-d_{II})$ all the investors that have expertise on a project (i.e. that receive a signal) observe the same signal. Under this assumption:

$$V_f = r_f(pq(X-I) - (1-p)(1-q)I)$$

$$\begin{aligned} V_{vc}(N_{vc}, d_{II}) &= d_{II} \left\{ \begin{array}{c} \left(1 - [(1-q)r_{vc} + (1-r_{vc})]^{N_{vc}}\right) p(X-I) \\ -\left(1 - [qr_{vc} + (1-r_{vc})]^{N_{vc}}\right)(1-p)I \end{array} \right\} + \\ & +(1-d_{II}) \cdot (1-(1-r_{vc})^{N_{vc}}) \left\{ \begin{array}{c} pq(X-I) \\ -(1-p)(1-q)I \end{array} \right\} \end{aligned}$$

Result 5 *The relative size of the venture capital market decreases with diversity, i.e.* $V_{vc}(N_{vc}, d_{II})$ *is decreasing in* d_{II}.

The intuition for this result is as follows: The venture capital market has the advantage of allowing better matching between projects and investors but this comes at the cost of adverse selection. The adverse selection is aggravated when the signal observed by the investors with expertise is uncorrelated.

The result implies that the adverse selection effect becomes especially important in sectors where there is not a standard framework to screen new projects. This will typically be the case in younger sectors whose foundations are not solidly established. This is consistent with the following empirical observation: It is a common practice in the venture capital market to have joint ventures between VCs (Gompers and Lerner 1999). The fact that several VCs are typically involved in the financing of venture capital projects might be a way of mitigating the adverse selection problem that they face.

While this effect suggests a drawback of venture capital markets in the financing of younger sectors, it is important to remember that this is not the whole story. First, we have just seen that there is another side of diversity that makes venture capital markets more desirable, and, second, the adverse selection effect is a lesser problem when the fraction of good projects is larger, which is usually the case in younger sectors.

2.5 Depth and Scope

The importance of matching and adverse selection is related to the level of expertise (r) and the precision of the screening technology (q). Until now, we have been taking the probability of having expertise (r) and the precision of the signal (q) as exogenous. However, these are generally choice variables for the investors. There is a natural trade-off between the scope and level of expertise. Investors may choose to have expertise in many areas (large r) but will have to give up a higher level of expertise within one area (low q). In order to analyze this trade-off, we introduce the following change to the model: We assume that $q_1 = q_2 = q(r)$ where $q(1) = 1/2$, $q(0) = 1$, $q'(r) < 0$, $q''(r) < 0$, $r_{vc} = r$, and $r_f = r + \Delta$.[12]

Result 6 *VCs' and firms' scope of expertise increases with the fraction and the relative value of good projects, i.e. p and $\frac{X-I}{I}$ respectively.*

If the fraction of good projects or the relative value of good to bad projects is small, then it is very costly for the investor to make mistakes in their screening process. In that case, investors will follow a narrow-but-deep strategy.

This has the following empirical implication. If younger sectors have projects of higher average quality, these sectors should be characterized by investors with broad expertise, and as sectors mature, investors will shift towards a narrow-but-deep strategy.

Result 7 *Ceteris paribus, an increase in the scope of expertise of the other VCs in the market, i.e. r_{-i}, or in their level of expertise, i.e. q_{-i}, decreases the scope of expertise of the VC, i.e. r_i.*

This results highlights the negative externalities that VCs impose on each other. On the one hand, if a VC increases her scope of expertise, she has a negative effect on the other VCs

[12] Δ, which will typically be positive, captures the idea that to the extent that entrepreneurs who join a firm develop their project within it, the firm can shape the project to its area of expertise.

because they will have less projects to implement (*business stealing effect).* On the other hand, if a VCs increases her level of expertise, she also imposes a negative externality on the other VCs because it worsens the pool of projects that they face (*adverse selection effect*). When the VC is deciding her scope, and hence her level of expertise, she will not internalize these two effects. As a result, VCs can be too wide or too narrow in their strategy from the social point of view.

Result 8 *The scope of expertise within a firm decreases with the firms' ability to shape the projects of the entrepreneurs to her area of expertise, i.e.* Δ.

The last two results identify the trade-offs faced by VCs and firms when determining their areas of expertise. It would seem that VCs should have a narrower strategy than firms because VCs face adverse selection. However, this is not all the story; firms, to the extent that they can shape the projects of their entrepreneurs to their areas of expertise, i.e. $\Delta > 0$, may be able to afford to focus more on fewer areas of expertise (i.e. adopt a narrow but deep strategy).

2.6 Limited Capacity to Implement Projects

Investors typically have a limited amount of resources to finance new projects. Investors' limited capacity affects the relative importance of matching and adverse selection, and, hence, of the venture capital market. This section explores the implications of this limited capacity in the performance and relative importance of the venture capital market.

In order to analyze the implications of investors' limited capacity, we introduce the following change to the basic set up: Each investor can implement a continuous of $[0, n]$ projects and there is a continuous $[o, e]$ of entrepreneurs.

First, we analyze the equilibrium in a venture capital market with a continuous $[0, \alpha e]$ of entrepreneurs and N_{vc} VCs.

A VC screens each project that seeks financing from her with probability $\varepsilon_{vc} = Min\left\{1, \varepsilon^*\right\}$

where ε^* is given by the following equation[13]:

$$n = \frac{\alpha e}{N_{vc}} \left[\left(1 - (1 - \varepsilon^* r_{vc} q_1)^{N_{vc}}\right) p + \left(1 - (1 - \varepsilon^* r_{vc}(1 - q_2))^{N_{vc}}\right)(1 - p) \right]$$

The bracket in the equation is the probability that a project is implemented in a venture capital market with N_{vc} VCs, each of them screening the project with probability $\varepsilon^*$and undertaking it if a good signal g is observed. Therefore, the right-hand side of the equation is the expected number of projects undertaken by each VC. If $\varepsilon^* > 1$, there is not enough projects in the venture capital market and VCs have "excess" capacity; in this case, they will screen all available projects , i.e. $\varepsilon_{vc} = 1$.

The expected value of a project (V_{vc}), the expected value for an entrepreneur (W_{vc}) and the expected profit per VC (Π_{vc}) are:

$$V_{vc}(N_{vc}, \alpha e) = \left\{ \begin{array}{c} \left(1 - (1 - q_1 \varepsilon_{vc} r_{vc})^{N_{vc}}\right) p(G - I) \\ - \left(1 - [1 - (1 - q_2)\varepsilon_{vc} r_{vc}]^{N_{vc}}\right)(1 - p)I \end{array} \right\}$$

$$W_{vc}(N_{vc}) = \delta V_{vc}(N_{vc})$$

$$\Pi_{vc} = \frac{\alpha e}{N_{vc}}(1 - \delta)V_{vc}$$

Next, we examine the equilibrium within firms with a continuous $[0, (1-\alpha)e]$ of entrepreneurs and $(N - N_{vc})$ firms.

A firm screens each project with probability $\varepsilon_f = Min\{1, \varepsilon^{**}\}$ where ε^{**} is given by the

[13]This is a simplifying assumption. If there is extra financing capacity in the venture capital market (i.e. venture capitalists cannot undertake all the projects that they judge to be of good quality), then venture capitalists have to use a rationing rule. We have assumed that this rule implies that venture capitalists screen the projects presented to them with a probability ε which is constant across projects. A more detailed analysis of the rationing rule would imply introducing a time dimensionality on the arrival of the projects and this would significantly complicate the analysis.

following equation[14]:

$$n = \frac{(1-\alpha)\,e}{N - N_{vc}} \varepsilon^{**} r_f \left[q_1 p + (1-q_2)(1-p)\right]$$

The expected value of a project (V_f), the expected value of an entrepreneur (W_f) and the expected profit per firm (Π_f) are:

$$V_f = \varepsilon_f r_f \left[q_1 p(X - I) - (1-q_2)(1-p)\right] I$$

$$W_f(V) = \delta V_f(V)$$

$$\Pi_f = \frac{(1-\alpha)\,e}{N - N_{vc}} (1-\delta) V_f$$

Result 9 *If there is a venture capital market, firms' capacity constraint binds, i.e. there is no equilibrium where $\varepsilon_f < 1$ and $N_{vc} > 0$.*

The intuition behind this result is as follows: If firms are operating at full capacity, i.e. $\varepsilon_f < 1$, the expected profit per firm (Π_f) is higher than the expected profit per VC (Π_{vc}). The venture capital market has the disadvantage of the adverse selection effect, but here it has no advantage in terms of better matching because firms are already operating at full capacity, i.e. $[0, n]$. But $\Pi_f > \Pi_{vc}$, integer constraints aside, cannot be an equilibrium because more investors would opt to form firms rather than to be VCs. This will continue until $N_{vc} = 0$ or $\Pi_f = \Pi_{vc}$.[15]

Result 10 *If the ratio of projects to capacity (e/nN) is high enough then there is an equilibrium without VCs and this equilibrium is socially optimal.*

Increasing the number of entrepreneurs alleviates the adverse selection in the venture capital market. However, if the ratio of entrepreneurs to investors is very high then the additional matching provided by the venture capital market has less social value since firms might be

[14] The interpretation is similar to the case of the venture capital market.
[15] If $\Pi_f = \Pi_{vc}$ then $\varepsilon_f = 1$.

operating at close to full capacity. Once again, this suggests that in the early stage of a sector, when the number of investors is small, innovation takes place within firms. Only when a critical mass of investors is reached and the sector becomes "tighter" will a venture capital market emerge.

On the other extreme, if the sector becomes very tight, so that the ratio of projects to capacity (e/nE) is low enough, then the capacity constraint binds in both firms and VCs. This is precisely the case analyzed in the previous sections where we did not impose capacity constraints. We saw that when the number of investors is large enough, the relative size of the venture capital market diminishes and a proportionally larger part of the innovation takes place within firms.

Result 11 *For a given number of entrepreneurs, i.e. e, and level of capacity, i.e. n, there is a number of investors such that beyond that number the relative importance of the venture capital market decreases.*

In summary, the venture capital market is relatively more important when there is a "balance" between the number of investors and entrepreneurs. On the one hand, if the ratio of investors to entrepreneurs is very large, the adverse selection effect becomes very strong and most financing takes place within firms. On the other hand, if the number of investors is very small, the extra matching provided by the venture capital market has little value for investors since they can operate at full capacity within firms and thus avoid the adverse selection.

2.7 Entrepreneurial Incentives

What effect does entrepreneurial incentives have on an entrepreneur's decision either join a firm or seek financing in the venture capital market? We have seen that firms and VCs are very different in the number and the average quality of the projects undertaken. This affects entrepreneurs' ex-ante incentives to generate projects and, more specifically, to generate projects of a 'certain quality. However, entrepreneurial incentives have so far not played a role in the analysis. This section endogenizes entrepreneurial incentives. The analysis will proceed in two stages. First, we will endogenize the probability of generating a good project, i.e. p. Second,

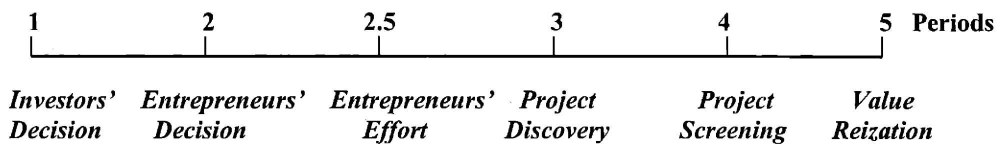

Figure 2-4:

we will endogenize the probability of generating a project. These two aspects are meant to capture the qualitative and quantitative sides of innovation.

For reasons that will become clear in the analysis, this section also introduces a change in the value of the projects. If the project is good the value remains the same; however, if the project is bad there is a probability l (for luck) that a bad project will be worth X. The following assumptions guarantee that an investor only finances a project when she receives a positive signal about its quality:

$$(p + l(1-p))X - I < 0$$

$$p + l(1-p)q_1(X-I) - (1-p)(1-l)(1-q_2)I > 0$$

2.7.1 Driving for Excellence

This section endogenizes the probability that a project is good, i.e. p, in the following way: We assume that p depends on the amount of non-observable effort (i.e. e) that the entrepreneur exercises between period two and period three. In particular, $p(e)$ where $p'(e) > 0$, $p''(e) < 0$ and $\lim_{e \to \infty} p(e) = 1$.

As before, entrepreneurs receive a fraction δ of their project's expected value. This implies the following sharing of the value ex-post:

$$\text{Value to Investor} = (1-\delta)\left\{\begin{array}{l} X - \frac{I}{\Pr(X|\text{Project is Implemented})} \\ -\frac{e^*}{\Pr(X\cap\text{Project is Implemented})} \end{array}\right\} + \frac{I}{\Pr(X|\text{Project is Implemented})}$$

$$\text{Value to Entrepreneur} = \delta\left\{\begin{array}{l} X - \frac{I}{\Pr(X/\text{Project is Implemented})} \\ -\frac{e^*}{\Pr(X\cap\text{Project is Implemented})} \end{array}\right\} + \frac{e^*}{\Pr(X\cap\text{Project is Implemented})}$$

where $\Pr(X|\text{Project is Implemented})$ is the fraction of the implemented projects that are worth X, $\Pr(X\cap\text{Project is Implemented})$ is the probability that a project is implemented and worth X, and e^* is the equilibrium effort.[16]

In general, these probabilities and, therefore, the ex-post sharing of the value within firms will differ from the probabilities and the ex-post sharing value in the venture capital market.

An entrepreneur that decides to seek financing in the venture capital market solves the following program:

$$\arg\max_e \text{Value to Entrepreneur}_{VC} \times \left\{\begin{array}{c} p(e)[1-(1-r_{vc}q_1)^{N_{vc}}] \\ +l(1-p(e))[1-(1-r_{vc}(1-q_2))^{N_{vc}}] \end{array}\right\} - e$$

Result 12 *The amount of effort of an entrepreneur in the venture capital market, i.e.* e^i_{vc}, *is increasing in* δ, *in the equilibrium effort exercised by entrepreneurs in the venture capital market, i.e.* e^*_{vc}, *in* $X-I$ *and in the quality of the screening technology, i.e.* q_1 *and* q_2. *The amount of effort is non-monotonic in the number of VCs in the venture capital market; there is a number of VCs such that an increase in the number of VCs beyond that number reduces entrepreneurial incentives.*

[16]Notice that the sharing of the value depends on the equilibrium effort: Because the effort is not observable the firm and the venture capital market will be compensated according to the entrepreneur's expected effort, which in equilibrium will be equal to the actual effort.

The result shows that there is a complementarity in the effort exercised by the VCs in the market. An increase in effort, *ceteris paribus*, increases the average quality of the projects in the venture capital market, which in turn increases the ex-post value of the entrepreneur and, therefore, has a positive effect on entrepreneurial incentives. This suggests that there is scope for public intervention. For example, if the government promotes research activity through grants and this increases the probability of coming up with a good project, i.e. p, this will in turn increase the ex-post value received by entrepreneurs. The increase in the ex-post value obtained by entrepreneurs will further boost up entrepreneurial incentives.

The result also shows that managerial incentives increase with the precision of the screening technology. The effect works through two different channels: first, by increasing the average quality of the projects implemented and therefore the value obtained by the entrepreneur, and second by increasing the probability that a project is implemented if it is good and rejected if it is bad. We can relate this to the section on Depth and Scope. While increasing the precision of the screening technology has a negative externality on the other VCs in the market because of adverse selection, it also has a positive externality through the entrepreneurial incentives effect just described.

Finally, an increase in the number of VCs has a non-monotonic effect on entrepreneurial incentives. On the one hand, the matching effect increases entrepreneurial incentives because a good project has a higher probability of being undertaken. On the other hand, as the number of VCs increases so does adverse selection, and, therefore, it reduces entrepreneurs' ex-post value and incentives.[17]

An entrepreneur that joins a firm solves the following program:

$$\arg\max_{e} \text{Value to Entrepreneur}_f \times r_f\{p(e)q_1 + l(1-p(e))(1-q_2)\} - e$$

Result 13 *The amount of effort of an entrepreneur in the firm, i.e. e_f^i, is increasing in δ, in the equilibrium effort exercised by the entrepreneurs within the firm, i.e. e_f^*, in $X - I$ and in the quality of the screening technology, i.e. q_1 and q_2.*

The intuition for this result is very similar to the case of the venture capital market, so we

[17] For this result is important the implication that the bargaining power, i.e. δ, remains constant.

refer the reader to the previous explanation.

Result 14 *If the economy has both firms and VCs, i.e.* $N > N_{vc} > 1$*, entrepreneurial effort is higher within firms than in the venture capital market, i.e.* $e_f^* \geq e_{vc}^*$*. Furthermore, if the probability of obtaining a value* X *when the project is bad is zero, i.e.* $l = 0$*, then entrepreneurial effort is the same within firms and in the venture capital market, i.e.* $e_f^* = e_{vc}^*$*, otherwise,* $e_f^* > e_{vc}^*$*.*

This result implies that the venture capital market has adverse consequences on entrepreneurial incentives. Entrepreneurs within firms generate projects of better average quality than in the venture capital market. The second part of the result highlights the mechanism at work. Entrepreneurs in the market have a higher probability of having their project implemented but a lower ex-post value due to the adverse selection faced by the VC. If the probability of having a good outcome (X) with a bad project is zero (i.e. $l = 0$), the higher probability and the lower ex-post value offset each other and entrepreneurial incentives are the same within the firm and in the venture capital market. However, if the probability of having a good outcome (X) with a bad project is greater than zero (i.e. $l > 0$), there is an extra effect that reduces entrepreneurial incentives. If $l > 0$, it is possible that the entrepreneur will experience a good outcome with a bad project in both the venture capital market and within a firm. However, the negative effect on entrepreneurial incentives is stronger in the venture capital market since there is a higher probability that a bad project will be undertaken.

This result reinforces the previous result that the venture capital market takes more projects but of a lower average quality. In a sense, the fact that the venture capital market is more willing to "take chances" actually induces entrepreneurs to gamble at the expense of VCs; or put it another way, because the venture capital market takes projects of lower average quality, it induces its entrepreneurs to generate projects of a lesser quality.

2.7.2 Promoting Innovation

This section explores the interaction between an entrepreneur's decision and her incentives to do research. Unlike in the previous section, which focused on the quality of the projects generated (i.e. the quality of the research), this section explores the incentives to generate projects (i.e.

the quantity of the research), and assumes that once the entrepreneur generates a project, there is a constant probability p that the project is good.

We assume that an entrepreneur generates a project with probability ρ, which depends on the amount of non-observable effort (i.e. $\overline{e}$) that the entrepreneur exercises between periods two and three. In particular, $\rho(\overline{e})$ where $\rho'(\overline{e}) > 0$, $\rho''(\overline{e}) < 0$.

As before, entrepreneurs and investors shared the generated value in such a way that entrepreneurs receive a fraction δ of their projects' expected value.

Result 15 *If the economy has both firms and VCs, i.e. $N > N_{vc} > 1$, in equilibrium, entrepreneurial effort within firms and in the venture capital market is the same, i.e. $\overline{e}^*_f = \overline{e}^*_{vc}$.*

The intuition for this result is similar to the one in the previous section: Entrepreneurs in the market have a higher probability of having their project implemented but a lower ex-post value due to adverse selection. These two effects offset each other and entrepreneurial incentives remain the same within the firm and in the venture capital market.

The result has an additional implication: If there is substitutability between quality and quantity of projects (e.g. if an increase in e increases the marginal cost of $\overline{e}$), the two previous results imply that while the entrepreneurs within firms generate less projects than entrepreneurs in the venture capital market, the average quality of the projects generated within them is higher.

2.8 Conclusion

Venture capital has grown a huge amount in the last twenty years. Nevertheless, its growth has been focused in certain sectors and regions. This suggests that the venture capital market has special characteristics that make it optimal only under specific condicions and in certain circumstances. This paper has proposed a model of venture capital that endogenizes investors' decisions about whether to become a VC or to form a firm, and entrepreneurs' decisions about whether to join a firm or seek financing in the venture capital market. The key distinction between firms and the venture capital market is that the latter allows better matching between the entrepreneurs and the investors' expertise. However, this comes at the cost of adverse selection. The relative importance of these two effects determines the relative size of the venture capital market.

The model has derived a firm, venture capital market, firm dynamics of innovation within a sector. When the sector is young, most of the innovation takes place within firms. As the sector matures, the venture capital market increases its relative importance favored by the matching effect (i.e. innovation "goes out" of the firm and into the venture capital market). Finally, when the sector is mature enough, the adverse selection effect becomes too strong and the relative importance of the venture capital market decreases (i.e. innovation "returns" to the firm).

We have also studied the effect of diversity, investors's scope of expertise, limited capacity by investors and entrepreneurial incentives on the relative importance of within firm and venture capital financing

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Chapter 3

Trading by Institutional Investors and Changes on Corporate Governance: How Effective is the Wall Street Rule?

3.1 Introduction

Equity ownership by institutional investors has increased substantially in the last twenty years. This concentration of ownership in the hands of institutional investors is a concern to managers and boards, and has become an important element in understanding the governance of the modern corporation. Institutional investors' activism may take several forms: they can intervene directly (perhaps through the board) in the affairs of the corporation; they can voice their concerns; or, more subtly, they can trade their ownership away if the corporation does not conform to their expectations. The last form of activism is prominent among institutional investors. Indeed, when institutional investors have not been satisfied with the performance of a corporation, their most common action has been to just sell the stock, what it is known as *Voting with their Feet* or *the Wall Street Rule* (e.g. Lowestein, 1988).

Empirically, studies have shown that there are price pressures due to institutional investors selling stock (Brown and Brooke, 1993). A recent paper, Parrino, et al., (2000), documents the link between the market activity of institutional investors and certain drastic changes in corporations. They show that there is an abnormal decrease in institutional investor ownership two years prior to a forced CEO turnover, with the greatest reduction occurring in the four quarters immediately preceding the turnover. Furthermore, the reduction in institutional investor ownership increases the probability that an outsider is appointed. Borokhovich et al., (1996) and Huson et al. (1999) have shown that the market reacts positively and that firm performance improves after an outsider is appointed. Parrino, et al., (2000) takes this as evidence that institutional investors do not only convey information to the market, but that they also induce changes in corporations.[1] These findings suggest that institutional investors have an important role both as conveyors of information to the market and as catalysts of changes in corporations. However, this double role also generates a fundamental conflict that we explain below.

If sales by institutional investors occur in the presence of asymmetries of information, institutional investors may be forced to sell shares at a discount. When multiple institutional investors are involved, a free-rider problem arises among them. Each institutional investor would prefer the others to sell their shares at a discount and avoid taking losses in the stock.

The existence of the previous conflict raises some questions: How does the *Wall Street Rule* operate in the marketplace? When would it be more effective? Does concentrated ownership by institutional investors (i.e. large blocks in hands of institutional investors) facilitate or impede the workings of the *Wall Street Rule*? How does the *Wall Street Rule* interact with other corporate governance mechanisms?

To address these issues we develop a simple model of a traded firm with potential governance problems. Some of its owners, who we identify as institutional investors, enjoy privileged information about the firm (that could be potentially useful to change the way the firm is run) but cannot participate directly in corporate governance. Their only means to induce changes in the firm is by trading their shares in the open market. As they do so, they blow the whistle about the problems faced by the firm and induce interventions to remedy governance deficiencies.

[1] *"To the extent that institutional investors are better informed, we would expect that selling by institutions would be associated with a greater likelihood that an insider is appointed to replace a fired CEO."*

After examining the basic model in which investors are exogenously endowed with information, we endogenize the acquisition of information by investors. We show that greater incentives to acquire information may or may not translate into value creation. While some pieces of information, *productive information,* are useful to correct governance conflicts, other pieces, *speculative information*, do not provide any real benefit to the firm, and simply produce large asymmetries of information among market participants. We focus on a situation in which the process of acquisition of information results in the simultaneous acquisition of both productive and speculative information and use the insights to arrive at implications for the optimal structure of ownership in corporations. A very simple theory of ownership emerges. Keeping the percentage of ownership constant, fewer and larger institutional investors will be associated with circumstances in which corporate governance changes are unlikely to be required.

Finally, we relate the *Wall Street Rule* to another mechanism of corporate governance. In particular, we examine how leverage interacts with institutional investors' trading. We find that an increase in leverage may enhance the *Wall Street Rule* as a governance mechanism.

The paper is organized as follows. Section 2 describes the basic model. Section 3 solves the model. Section 4 endogenizes the acquisition of information and studies the optimal number of investors. Section 5 extends the basic model to examine the interaction between the *Wall Street Rule* and the capital structure. Section 6 concludes.

3.2 The Model

We consider a model with four dates ($t = 1, ..., 4$) and no discounting. There is a firm with a unitary mass of shares that operates in a risk neutral economy. Among the shareholders of the firm, a class of them, which we will refer to as institutional investors, owns sizable blocks of shares. In particular, there are N institutional investors each with a block of shares $\bar{\alpha}_i > 0$ ($i = 1, ..., N$), where $\sum_i^N \bar{\alpha}_i \leq 1$.

At $t = 1$, the firm reaches one of the following states. With probability $1-x$ the firm reaches state $\tilde{G}$ (i.e. good), and with probability x it reaches state $\widetilde{B}$ (i.e. bad). Furthermore, state $\widetilde{B}$ can be separated into two substates, $\tilde{B}_M$ and $\tilde{B}_0$, that, conditional on reaching $\tilde{B}$, occur with probability y and $1 - y$ respectively.

At $t = 2$, institutional investors receive inside information about the state, $\widetilde{G}$ or $\widetilde{B}$, reached at $t = 1$.[2] Furthermore, in state $\widetilde{B}$ institutional investors observe a signal $S \in \{S_M, S_0\}$ about the true substate of the firm. We assume that $\text{Prob}(S_M|\widetilde{B}_M) = 1$ and $\text{Prob}(S_0|\widetilde{B}_0) = q \in [0,1]$. Probability q is a measure of the informativeness of the signal. For instance, if $q = 1$ the signal perfectly reveals the true substate (i.e. S_M is received if and only if $\widetilde{B}_M$ is reached), while if $q = 0$ the signal is uninformative (i.e. S_M is always received in state $\widetilde{B}$).[3] In the rest of the paper we will assume that $q(1-y) > 1/2$.[4]

At $t = 3$, institutional investors can trade upon the information received at $t = 2$. Institutional investors incur a fixed (and relatively small) cost of trading.[5] For simplicity, we assume that institutional investors decide simultaneously if and how much they trade. Once trade orders are submitted by institutional investors, the price is fixed competitively by a market maker and non-informed traders take the other side of the trades. Furthermore, institutional investors can only participate with the original submission of orders and they can be identified when trading. In other words, we consider a non-anonymous trading environment with only one round of trading.

A central element of the analysis is the connection between the trading activity of institutional investors and changes in the governance of the firm. We abstract from the actual mechanism that will produce the intervention in the firm and simply assume that the likelihood of governance changes is related to the total number of shares sold by institutional investors.[6] This intends to capture the widespread view that managers and boards worry about their shareholder base and is consistent with empirical studies (i.e., Parrino et al., 2000) that have linked the trading activity of institutional investors to CEO replacements. Formally, we assume the following relationship:

$$\Pr(\text{Intervention}) = \max\left[\sum_{i}^{N} \alpha_i, 0\right] \tag{A1}$$

[2]We endogenize the acquisition of information by institutional investors in Section 4.

[3]More generally, S_M makes institutional investors update the probability of $\tilde{B}_M$ to $\frac{y}{y+(1-q)(1-y)}$. Alternatively, S_0 makes institutional investors update the probability of $\tilde{B}_M$ to zero.

[4]This assumption, made for simplicity, guarantees an interior solution, i.e. institutional investors would not like to sell more shares that they actually have.

[5]We assume that this fixed cost is very small but positive. Therefore, the trading cost only affects institutional investors' trading when net of the fixed cost institutional investors are indifferent between trading or not trading. This assumption will rule out equilibria in which institutional investors trade in state $\widetilde{G}$.

[6]If there is a net purchase of shares by institutional investors we will assume that no intervention will occur.

where α_i represents the shares sold by institutional investor i.

This formulation assumes away the possibility that institutional investors could be directly involved in corporate governance and requires further justification.[7] In practice, statutory constraints may limit the possibility of direct intervention by institutional investors, and potential lawsuits make direct interventions problematic. Admittedly, we take the extreme view that direct intervention is impossible and that the influence of institutional investors is exercised only through the latent threat to sell their shares. Implicitly, we are assuming that institutional investors find it impossible to "blow the whistle" and that the absence of hard evidence makes governance problems impossible to substantiate.

Notice that, by construction, trade occurs in this setting for reasons other than hedging or speculation. Assumption (A1) implies that trading has intrinsic value: by trading, institutional investors create such value through the inducement of necessary changes in governance. Neither hedging (agents are risk neutral) nor speculation (traders are rational) are required for trade to exist.

At $t = 4$, the firm generates a cash-flow that depends on the state reached at $t = 1$ and on whether an intervention has taken place at $t = 3$. Specifically, we assume that governance changes will affect the cash-flow in some but not in all states. In particular, while the cash-flows, with and without intervention, are G in state $\tilde{G}$ and zero in substate $\tilde{B}_0$, in substate $\tilde{B}_M$, the cash-flow is M if an intervention occurs and zero otherwise. We assume that the cash flow in the good state is always higher than in the bad state, i.e. $M < G$.

In two of the states the effect of governance is nil but for different reasons. In state $\tilde{G}$ the firm has a good project and is well run, therefore an intervention is unnecessary. In $\tilde{B}_0$ the firm is in deep difficulties and the intervention cannot improve matters. In $\tilde{B}_M$, however, appropriate governance changes do help. These changes are presumably costly to the incumbent managerial team (i.e. layoffs, closing plants, forced CEO turnovers, selling divisions, etc.) so implementing them may require board pressure. Assumption (A1) captures the idea that, unless pressured by the selling activity of institutional investors, the board does not act and that an increase in

[7] Alternatively (see, for example, Maug, 1999), one could consider the trade-off that a controlling shareholder has between intervening in a firm and trading their shares in the open market.

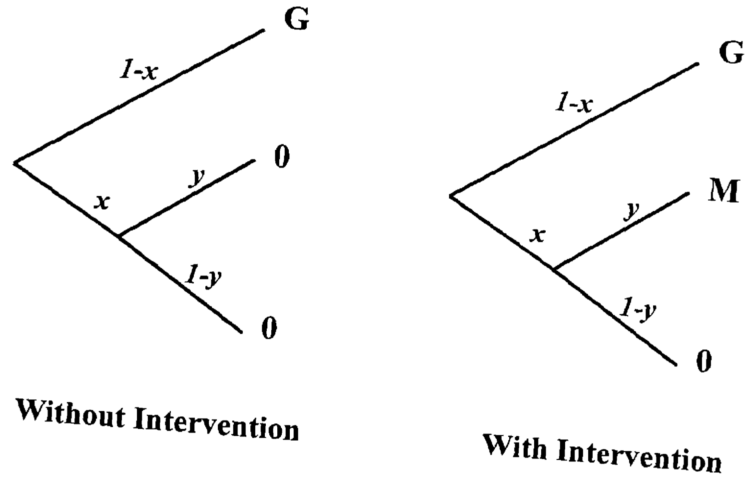

Figure 3-1:

the selling by institutional investors makes the board more reluctant to remain passive.[8]

3.3 Analysis of the Model

To solve the model we need to identify the quantities traded by institutional investors as well as the prices at which those trades take place.[9] To simplify the presentation, we will start by analyzing the case in which just one institutional investor is present, and then we will examine the case with multiple institutional investors. This allows us to discuss the nature of the equilibrium and to isolate the effect of the interaction among institutional investors.

3.3.1 Equilibrium with a Single Institutional Investor

There are three possible scenarios at $t = 2$. The institutional investor receives no signal, which reveals that the firm is in the good state ($\widetilde{G}$), or the institutional investor receives signal S (either S_M or S_0), which reveals that the firm is in the bad state ($\widetilde{B}$). The amount of shares

[8]The relation that we should observe between the effectiveness of the *Wall Street Rule* and the degree of independence of the Board of directors and of entrenchment in the managerial team is not clear. This relation might actually shed some light on whether the role of the institutional investors is to provide information to the board or to put pressure on the board.

[9]Off-equilibrium path beliefs are also required. See below.

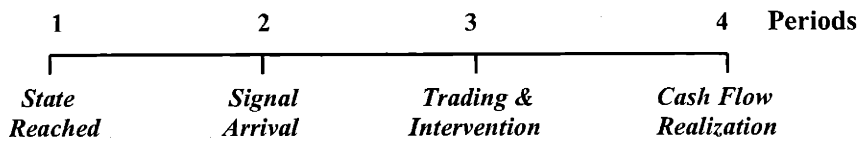

Figure 3-2:

sold by the institutional investor at $t = 3$ depends on its information. Let α_G, α_M and α_0 be the amount of shares sold if no signal, if signal S_M and if signal S_0 is received respectively. In general, three different quantities will represent the equilibrium: $(\alpha_G^*, \alpha_M^*, \alpha_0^*)$. However, the search for the optimal quantities can be simplified by noticing the following results:[10]

Result 16 *In equilibrium, the institutional investor does not trade in state $\tilde{G}$:*

$$\alpha_G^* = 0$$

Result 17 *In equilibrium, the amount of shares sold by the institutional investor in state $\widetilde{B}$ is independent of the signal:*

$$\alpha_M^* = \alpha_0^* = \alpha^*$$

By virtue of these results, the quantity α^* characterizes the equilibrium. Its value corresponds to the number of shares that the institutional investor sells in state $\widetilde{B}$ (i.e. when there are problems in the corporation). However, different off-equilibrium path beliefs can generate different values for α^*, and commonly used refinements like the intuitive criterion do not help us in selecting a unique equilibrium. Following Mailath, et al., (1993) we focus on the pure strategy PBE that maximizes the utility of the type who observes S_M (i.e. the utility of the

[10]All proofs are in the appendix.

"good" type).[11]

In this case, the refinement in Mailath, et al. (1993) is equivalent to imposing the following off-equilibrium path beliefs. Let α^* be the putative equilibrium quantity. Sales of shares α_s, above the putative equilibrium ($\alpha_s > \alpha^*$) will be interpreted as coming from an institutional investor who has observed signal S_0 (and hence will be priced at $p = 0$). Sales of shares below it ($\alpha_s \leq \alpha^*$) will be interpreted as coming from an "average investor" and therefore priced as $p = \alpha \cdot y \cdot M$. Following the refinement described above, the equilibrium of interest corresponds to the solution of the following program:

$$\max_{\alpha} \quad p \cdot \alpha + (\bar{\alpha} - \alpha) \cdot \tfrac{y}{y+(1-q)(1-y)} \cdot M \cdot \alpha$$

where p is the price per share. The first term captures the proceeds from selling α shares at price p and the second term is the expected value of the remaining shares (i.e. $(\bar{\alpha} - \alpha)$) conditional on receiving signal S_M. In equilibrium, the price per share is equal to its expected value:

$$p = \alpha \cdot y \cdot M$$

Substituting in the program we get:

$$\max_{\alpha} \quad y \cdot M \cdot \alpha^2 + (\bar{\alpha} - \alpha) \cdot \tfrac{y}{y+(1-q)(1-y)} \cdot M \cdot \alpha \ ,$$

which has as solution:

$$\alpha^* = \frac{\bar{\alpha}}{2(1-y)q}$$

Three effects, captured by three parameters of the model, affect the amount of shares traded in equilibrium. Proposition 8 summarizes them.

Proposition 8 *The amount of shares traded by the institutional investor increases with the size of its block, i.e.* $\bar{\alpha}$, *and with the ex-ante likelihood of reaching* $\tilde{B}_M$ *conditional on* $\tilde{B}$, *i.e.* y *, and decreases with the informativeness of the signal, i.e.* q.

[11] They refer to this refinement as the lexicographically maximum refinement concept. See Gomes (2000) for another application of this refinement in a context of a model of dividends based on reputation.

While the effect of the size is trivial, the effects of y and q are more interesting. If the intervention is ex-ante very unlikely to improve matters in the firm (i.e. low y), then the share price in equilibrium will be relatively low.[12] In such a case, an institutional investor who has received signal S_M would have to sell shares at a large discount and hence will have very limited incentives to do so. (Nonetheless, the incentive to sell shares is still present because these sales create value by pressuring to induce the desired governance changes.[13])

An increase in the precision of the signal (q) once again makes an institutional investor who has observed S_M hesitant to sell the undervalued shares. A high precision aggravates the asymmetry of information between the institutional investor (i.e. the adverse selection problem) which reduces the traded quantity in equilibrium, and hence, the effectiveness of the *Wall Street Rule* as a corporate governance mechanism. Alternatively, very low precision, by ameliorating the adverse selection problem, will make institutional investors less subject to adverse selection and the *Wall Street Rule* more effective.

The effect of the signal's precision on the *Wall Street Rule* illustrates an important dichotomy between different classes of information that we will explore in Section 3.4. In fact, the previous seemingly paradoxical result, that the precision of the signal reduces the effectiveness of the *Wall Street Rule,* captures an important intuition of the model. A signal of very low precision on the likelihood of substates $\tilde{B}_0$ and $\tilde{B}_M$ contains very useful information about the presence of state $\tilde{B}$ (and hence on the potential value of interventions in the firm).[14] A signal of high precision contains the previous information too, as well as information about the true substate: This makes the institutional investor less willing to sell and lowers the value created through intervention.

Finally, it is also noteworthy that the cash-flow generated after intervention does not affect the size of the optimal amount sold in equilibrium (i.e. α^* does not depend on M). The reason is that the M affects with the same intensity the two opposite forces that determine the amount of shares traded. Conditional on receiving signal S_M, the institutional investor profits from increasing sales (intervention becomes more likely) but, due to the adverse selection problem,

[12]In equilibrium the price is a weighted average of the cash-flows in substates $\widetilde{B}_0$ and $\widetilde{B}_M$.

[13]This implies that there might be self-fulfilling expectations and non-monotonicity in the selling activity of institutional investors.

[14]In our model the precision of the signal does not affect a fundamental aspect of it: that it allows the distinction between states $\tilde{B}$ and $\tilde{G}$.

loses with respect to the "true" value of the shares (the shares are sold at the average price in the pooling equilibrium).

3.3.2 Equilibrium with Multiple Institutional Investors

We now examine the case with multiple institutional investors. Consider N institutional investors each owning $\bar{\alpha}_i$ $(i = 1, ..., N)$ shares. We assume that if the firm is at $\tilde{G}$ no institutional investor receives a signal. Alternatively, if the firm is in $\tilde{B}$, institutional investor i receives signal $S_i \in \{S_M, S_0\}$. As in the case of a single institutional investor, we assume that $\text{Prob}(S_M|\widetilde{B}_M) = 1$ and that $\text{Prob}(S_0|\widetilde{B}_0) = q_i \in [0, 1]$. (We allow for different informativeness in the signals received by institutional investors.)

Just as in the case with one institutional investor, two preliminary results simplify the search for the equilibrium:

Result 18 *In equilibrium, no institutional investor trades in state $\tilde{G}$: $\alpha^*_{iG} = 0$*

$$\alpha^*_{iG} = 0$$

for $i = 1, ..., N$.

Result 19 *In equilibrium, the amount of shares sold by institutional investor i in state $\widetilde{B}$ is independent of its signal:*

$$\alpha^*_{iM} = \alpha^*_{i0} = \alpha^*_i$$

for $i = 1, ..., N$.

As in the single institutional investor case, the previous results narrow down the set of pure PBE but still leave multiple possible equilibria. Like we did earlier, we follow Mailath et al. (1993) and consider the refinement that chooses the PBE that maximizes the utility of the "good type" (i.e. substate S_M). However, we must extend such a refinement to accommodate the multiple investor and type case. To do so, we assume that each institutional investor, upon receiving signal S_M, maximizes its utility, taking the strategy of the other institutional investors as given. Formally, institutional investor i solves:

$$\max_{\alpha_i} \quad \left[p\alpha_i + (\bar{\alpha}_i - \alpha_i)\frac{y}{y+(1-q_i)(1-y)}M(\alpha_i + \alpha_{-i})\right]$$

where α_{-i} is the total number of shares sold by the other investors, q_i is the precision of the signal received by institutional investor i, and p is the price per share. In equilibrium p is the expected value of the firm:

$$p = y \cdot M \cdot (\alpha_i + \alpha_{-i}).$$

Solving the program, we obtain the following first-order condition for the optimal number of shares sold by institutional investor i:

$$\alpha_i^{**} = \max\left\{\frac{\bar{\alpha}_i}{2(1-y)q_i} - \frac{\alpha_{-i}^{**}}{2}, 0\right\}$$

Notice that, in contrast with the single institutional investor case, if $\frac{\bar{\alpha}_i}{2(1-y)q_i} - \frac{\alpha_{-i}^{**}}{2} < 0$, institutional investor i, upon receiving signal S_M, would like to *buy* stock at the *current price* because it is underpriced. However, if it intends to buy stock it would convey its information to the market, and, therefore, the price would increase which would eliminate such incentive to buy (in equilibrium institutional investors will be indifferent about whether or not to buy shares of the firm). Proposition 9 considers the factors that affect the optimal amount sold by each institutional investor:

Proposition 9 *The amount of shares sold by institutional investor i, (i.e. α_i^{**}) increases with the size of its block, (i.e. $\bar{\alpha}_i$) and with the ex-ante likelihood of being in state $\tilde{B}_M$ conditional on reaching $\tilde{B}$ (i.e. y), and decreases with the informativeness of its signal, (i.e. q_i) and the amount of shares sold by the other institutional investors, (i.e. α_{-i}).*

Similar to the effects that appear in the single institutional investor case, with multiple institutional investors the factors that affect the optimal sales by investors other than i affect indirectly the optimal quantity sold by institutional investor i. The probability of intervention increases with the number of shares sold by the other institutional investors, and so does the discount suffered by the institutional investors when trading. This effect makes the number of shares traded by an institutional investor a decreasing function of the number of shares traded by the other institutional investors.

To clarify further the effects of the interaction among multiple institutional investors consider the symmetric case (i.e., $\bar{\alpha} = \bar{\alpha}_i = \bar{\alpha}_j$ and $q = q_i = q_j$). In such a case, the amount of shares sold by each institutional investor becomes:

$$\alpha^{**} = \alpha_i^{**} = \alpha_j^{**} = \frac{\bar{\alpha}}{(N+1)(1-y)q}$$

The optimal sale, i.e. α^{**}, resembles that of the model with just one institutional investor. The size of the endowment, $\bar{\alpha}$, the likelihood of a profitable intervention, y, and the informativeness of the signal, q, matter for the same reasons as before. Furthermore, a free-rider effect arises in the case of multiple investors. This free-rider problem occurs because while the intervention benefits all institutional investors, the cost of selling underpriced equity is only borne by the institutional investor selling the shares. Proposition 10 compares the size of the intervention as the number of institutional investors owning shares in the firm increases.

Proposition 10 *With multiple and symmetric institutional investors, the number of shares sold by institutional investors decreases with the number of institutional investors for equivalent size of ownership.*

3.4 On the Optimal Number of Institutional Investors

According to the analysis in the previous section, the *Wall Street Rule* loses effectiveness as the number of institutional investors increases. This seems at odds with the evidence that shows that, frequently, multiple institutional investors own sizable blocks of shares in the same firm. In this section, we modify our setting slightly and show that a more careful treatment of the effects of the information in a firm can offer some implications on the optimal number of institutional investors in a firm.

In previous sections information played a key role, since selling stock was the means by which institutional investors conveyed information to the market. The problem was that the asymmetry of information between institutional investors and the market forced institutional

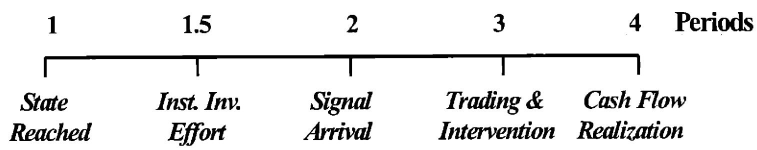

Figure 3-3:

investors to sell stock at a discount. In this section, we examine institutional investors' incentives to acquire such information and explore the implications for ownership that emanate from it.

Until now, institutional investor i received, exogenously, a signal of a precision q_i in state $\tilde{B}$. To endogenize the acquisition of information we distinguish between two "types" of information: (i) We refer to *productive information* when the information adds value to the firm; (ii) We refer to *speculative information* when the information does not produce any value for the firm and simply creates large asymmetries of information between traders of the firm's stock. In our model below, these two types of information should not be seen as separate but rather as the two sides of the process of information acquisition.

To model these issues we modify our basic set up as follows. We add an additional stage between period 1 and 2 (i.e. $t = 1.5$) at which institutional investors simultaneously decide the amount of unobservable effort e that they will spend acquiring information about the firm.

We model the productive side of information assuming a direct effect on the firm's cash-flows. In particular, we assume that the cash-flow in state $\tilde{G}$ grows with the amount of effort spent in information acquisition. For convenience, we consider the function $G(e)$, that relates cash-flow to effort, with the following properties: $G(0) > M$, $G'(e) > 0$, $Lim_{e \to 0} G'(e) = \infty$, $Lim_{e \to \infty} G'(e) = 0$ and $G''(e) < 0$.[15]

[15]Our assumption that the effort only increases the amount of cash-flow in state $\widetilde{G}$ is made for simplicity. An alternative formulation could have assumed that effort increases the cash-flow in all states by an amount Δ increasing in e (i.e. $\Delta'(e) > 0$).

To model the speculative side of information, we assume that the informativeness of the signal also depends on the level of effort e. Specifically, we consider a function $q(e)$ with the following properties: $q'(e) > 0$, $q''(e) < 0$, and $Lim_{e \to \infty} q(e) = 1$.[16] We refer to this effect as *speculative* because, as we will show, it reduces the firm's value not directly but indirectly through its negative effect on the *Wall Street Rule.*

3.4.1 Equilibrium with a Single Institutional Investor

Solving the model requires examining the effort decision at $t = 1.5$ and the trading decision at $t = 2$. We proceed backwards and consider first the decision to trade. Trading occurs (i) after the effort (e) has been exerted, (ii) after the signal S has been observed, and (iii) taking into account the conjectured effort that the market expects the investor to have exerted (i.e., e^e).

Moreover, as in the case of exogenous precision, it is easy to show that pooling is the only possible type of pure PBE in the trading stage. Furthermore, once again, we follow Mailath et al. (1993) and choose among the pure PBE the one that maximizes the utility of the good type (i.e. substate $\widetilde{B}_M$). The equilibrium number of shares sold at $t = 3$ is given by the following equation:

$$\alpha^*(e^e) = \frac{\bar{\alpha}}{2q(e^e)(1-y)}$$

where e^e is the expected level of effort. This equation confirms that the amount of shares traded by the institutional investor decreases with the expected effort spent acquiring information.

To solve the model we need to find the levels of effort exerted by the institutional investor at $t = 1.5$. Three factors could affect an institutional investor's decision to exert effort: (a) the effect of effort on state $\tilde{G}$'s cash-flow (i.e. $G(e)$); (b) the (private) cost of effort for the institutional investor (i.e. e); and, (c) the gains of trade that the institutional investor could obtain by affecting the precision of its signal (i.e., $q(e)$). However, as we show next, for the equilibrium of interest trading effects do not affect the effort decision of the institutional investor.

In particular, the institutional investor maximizes the difference between the ex-ante value of its equity and the cost of effort. The institutional investor takes into account the subsequent equilibrium in the trading stage: the price per share (p) will be equal to $\alpha M y$ if $\alpha = \alpha^{**}(e^e)$

[16]For simplicity we will consider the case in which $q(0) > 2(1-y)$.

and *zero* otherwise,[17] and the number of traded shares will be equal to $\alpha^*(e^e)$. Mathematically, the institutional investor solves the following program:

$$\max_{e} \ (1-x)\overline{\alpha}G(e) + x[p(e^e)\cdot\alpha^* + y(\overline{\alpha}-\alpha^*)\alpha^*] - e$$

where:

$$p(e^e) = \begin{cases} \alpha \cdot M \cdot y & \text{if } \ \alpha = \alpha^*(e^e) \\ 0 & \text{otherwise} \end{cases}$$

and:

$$\alpha^*(e^e) = \frac{\bar{\alpha}}{2q(e^e)(1-y)}$$

The program gives the following first-order condition for maximum:

$$(1-x)\overline{\alpha}G'(e) = 1$$

Proposition 11 *The amount of effort, e, increases with the size of the ownership, i.e.* $\overline{\alpha}$, *and with the probability that the firm does not receive bad news,* $(1-x)$.

The institutional investor, when deciding how much effort to spend gathering information, takes into account the direct cost of the effort and the *productive side* of information. However, the institutional investor fails to internalize the effect that information has on the level of trading, and, therefore, on the probability of intervention in the case that the firm reaches state $\widetilde{B}$.

Corollary 5 *The effectiveness of the Wall Street Rule decreases with the size of the ownership, i.e.* $\overline{\alpha}$, *and with the probability that the firm does not receive bad news, i.e.* $(1-x)$.

As the institutional investor increases the effort spent gathering information, the precision of its signal is improved, and the institutional investor, upon receiving signal S_M, faces a bigger discount when trading. This in turn reduces the amount of trading and obstructs the *Wall Street Rule* as a corporate governance mechanism. This is the main trade-off that information

[17] If the market observes that the institutional investor is selling an amount of shares different from the one expected in equilibrium, it assumes that it is the "bad type", and, therefore, the price is *zero*.

acquisition produces in the model. As we show next, the information gathered by the investor can be above or below the level that maximizes firm value.

3.4.2 Optimal Level of Effort

The question that remains is: what is the optimal level of effort constrained to playing the subsequent pure PBE in the trading stage? In other words, we want to find the optimal level of effort that an institutional investor that owns the whole firm, i.e. $\overline{\alpha} = 1$, and can commit to a certain level of effort will exert. Notice that the ex-ante value of the firm is equal to:

$$(1-x)G(e) + x \cdot y \cdot M \cdot \alpha - e$$

where we constrained α to be the pure PBE that maximizes the utility of the "good type" when trading:

$$\alpha = \frac{\overline{\alpha}}{q(e)(1-y)}.$$

The constrained first best is the solution to the following program:

$$\max_{e} \quad (1-x)G(e) + x \cdot y \cdot M \frac{\overline{\alpha}}{q(e)(1-y)} - e$$

When compared with the program of an institutional investor we can identify two main differences. On the one hand, the institutional investor has too little incentive to become informed, since it only receives a share of the benefits; this is captured by the first term, which in the case of an institutional investor is multiplied by its share (i.e. $\overline{\alpha} \leq 1$). On the other hand, the institutional investor has too much incentive to become informed, since it cannot commit to reducing the level of information. Therefore, when it has to trade, the asymmetry of information decreases the amount of shares sold and the probability of intervention. The net effect may be too much or too little effort (i.e. information acquisition) with respect to the constrained optimum.[18]

[18]We have assumed that the probability of being informed does not depend on the level of effort. This is an aspect of the informative side of the information that we have tried to capture with the function $G(e)$. Essentially, there is trade-off between the frequency and the size of the intervention. In order to intervene it is necessary to be informed, however, too much information may create large information asymmetries that limit the size of the intervention. The optimal level of information should balance these two effects.

Result 20 *The institutional investor may acquire too much or too little information with respect to the constrained first best.*

As the ownership of the institutional investor increases, the institutional investor acquires more information and it faces greater adverse selection when trading, which reduces its incentive to do so. If the level of ownership is large enough, the institutional investor acquires too much information since it cannot commit otherwise.

Result 21 *If the ownership of the single institutional investor is large enough, the institutional investor acquires at least as much information as the constrained first best and more in any interior solution (i.e., $\alpha^* < \overline{\alpha}$).*

3.4.3 Equilibrium with Multiple Institutional Investors

As we have discussed in the previous sections, there are multiple pure PBE during the trading stage and our refinement selects the pure PBE that maximizes the utility of the"good type" (i.e. an institutional investor that receives signal S_M), taking the strategy of the other institutional investors as given. In equilibrium, institutional investor i will sell the following amount of shares[19]:

$$\alpha_i^* = \max\left\{\frac{\bar{\alpha}_i}{2(1-y)q(e_i^e)}, 0\right\}$$

where e_i^e is institutional investor i's expected level of effort, which in equilibrium must be equal to the actual effort (i.e. $e_i = e_i^e$), and α_{-i}^* is the number of shares traded by the other institutional investors. Throughout this section, and in order to simplify the exposition, we will concentrate on the symmetric case. Under this assumption the equilibrium during the trading stage simplifies to:

$$\alpha_i^* = \frac{\bar{\alpha}_i}{(N+1)(1-y)q(e_i^e)}$$

where N is the number of institutional investors.

At $t = 1.5$, institutional investors decide simultaneously the effort spent acquiring information. Specifically, each institutional investor maximizes the difference between the ex-ante

[19]This equilibrium is derived in the same way as in Section 3, where q_i was exogenous.

value of its equity and the cost of effort, taking the level of effort of the other institutional investors as given. Each institutional investor takes into account the subsequent equilibrium in the trading stage: the price per share, p, will be equal to $(\alpha_i + \alpha_{-i})My$ if $\alpha_j = \alpha_j^{**}(e_j^e)$ for all j and *zero* otherwise, and the number of traded shares will be equal to $\alpha_i^*(e^e)$. Mathematically, each institutional investor i solves the following program:

$$\max_{e_i} \ (1-x)\overline{\alpha}_i G(e_i + e_{-i}) + x[p\alpha_i^* + y(\overline{\alpha}_i - \alpha_i^*)(\alpha_i^* + \alpha_{-i}^*)] - e_i$$

where:

$$p = \begin{cases} (\alpha_i + \alpha_{-i})My & \text{if } \alpha_i = \alpha_i^{**}(e_i^e) \ \ \forall i \\ 0 & \text{otherwise} \end{cases}$$

$$\alpha^* = \frac{\bar{\alpha}_i}{(N+1)q(e_i^e)(1-y)}$$

The first order condition becomes:

$$(1-x)\overline{\alpha}_i G'(N \cdot e_i) = 1$$

Proposition 12 *For a given level of institutional investor ownership, as the number of institutional investors increases, the total amount of resources spent acquiring information decreases.*

For a given level of institutional investor ownership, as the number of institutional investors increases, the free-riding problem is aggravated and the total amount of resources spent acquiring information decreases. This increases the effectiveness of the *Wall Street Rule* as a corporate governance mechanism because it reduces the discount faced by institutional investors when trading. However, there is a counter-balance effect because as the number of institutional investors increases for a given level of effort and institutional ownership, the volume of trading decreases. The net effect depends on which one of these two effects dominate (i.e. the free-rider problem when gathering information or when trading).

Proposition 13 *The effectiveness of the Wall Street Rule as a corporate governance mechanism may decrease or increase with the number of institutional investors.*

3.5 The Interaction of the *Wall Street Rule* with Other Governance Mechanisms

In this section, we explore the interaction between the *Wall Street Rule* and other Corporate Governance Mechanisms. In particular, we study the effect of leverage on of the *Wall Street Rule*. Changes in the Capital Structure may affect both the costs and benefits of intervention and therefore influence institutional investors' incentives and the effectiveness of the *Wall Street Rule*. In order to capture the riskiness of debt we make the following changes to our cash-flow structure:

State\Value of equity	If no Intervention	If Intervention
$\widetilde{G}$	$G-D$	$G-D$
$\widetilde{B}_M$	$Max\,[B_M - D, 0]$	$Max\,[M + B_M - D, 0]$
$\widetilde{B}_0$	$Max\,[B_0 - D, 0]$	$Max\,[B_0 - D, 0]$

where D is the level of debt in the firm and $B_0 < B_M, < B_M + M < G$. Furthermore, to simplify the exposition, we will assume that institutional investors are perfectly informed about the true state of the firm (i.e. $q = 1$). Once again, there will be multiple equilibria and we will focus on the pure PBE that maximizes the utility of the "good type".

In equilibrium the price of equity will be:

$$\begin{aligned} p &= y\left[\alpha \text{Max}\left[M + B_M - D, 0\right] + (1-\alpha)\text{Max}\left[B_M - D, 0\right]\right] \\ &\quad + (1-y)\text{Max}\left[B_0 - D, 0\right] \end{aligned}$$

The institutional investor solves the following program in substate $\widetilde{B}_M$ (i.e. the "good type"):

$$\max_{\alpha} \alpha s + (\overline{\alpha} - \alpha)\left\{\alpha \text{Max}\left[M + B_M - D, 0\right] + (1-\alpha)\text{Max}\left[B_M - D, 0\right]\right\}$$

whose f.o.c. is:

$$\alpha = Min\left\{ \begin{array}{c} \frac{\overline{\alpha}\{\text{Max}[M+B_M-D,0]-\text{Max}[B_M-D,0]\}-(1-y)\{\text{Max}[B_M-D,0]-\text{Max}[B_0-D,0]\}}{2(1-y)\{\text{Max}[M+B_M-D,0]-\text{Max}[B_M-D,0]\}}, \\ \overline{\alpha} \end{array} \right\}$$

Proposition 14 *If the firm cannot repay its debt in the bad substate (i.e.* $B_0 < D < B_M$*) the effectiveness of the Wall Street Rule increases with the amount of debt.*

The intuition for this result is as follows: if $B_0 < D < B_M$ the value of the intervention for the good type is M, which is independent of the level of debt. Meanwhile, the cost of intervention (i.e. the difference between the value of equity in the good and bad substates) decreases with the level of debt.

Another way to see this is to look at the optimization problem under the parametric assumption $B_0 < D < B_M$:

$$\max_{\alpha} \overline{\alpha} \left[\alpha M + B_M - D\right] - (1-y)\alpha \left[\alpha M + B_M - D\right]$$

The first term is the value of equity if there is a probability α of intervention and the second term is the cost of selling underpriced securities in order to induce intervention in the firm. While the marginal benefit of intervention (i.e. $\overline{\alpha} M$) is independent of the level of debt, the marginal cost of intervention (i.e. $(1-y)\left[2\alpha M + B_M - D\right]$) decreases with the level of debt.

Corollary 6 *For high or low enough levels of debt (i.e.* $D \notin [B_0, B_M]$*) the effectiveness of the Wall Street Rule is independent of the amount of debt.*

Particularly interesting is the case where $B_M < D < B_M + M$. In this range the institutional investor faces the following optimization problem:

$$\max_{\alpha} \overline{\alpha}\alpha \left[M + B_M - D\right] - (1-y)\alpha^2 \left[M + B_M - D\right]$$

While the marginal cost of intervention now decreases with the level of debt, the marginal benefit of intervention for the equity holders also decreases with the level of debt. In equilibrium these two forces offset each other and the amount of shares sold is independent of the level of debt.

3.6 Concluding Remarks

This paper has examined the *Wall Street Rule* as a corporate governance mechanism. We have shown that the effectiveness of the *Wall Street Rule* is non-monotonic in the number of institutional investors. On the one hand, as the number of institutional investors increases, so does the importance of the free-rider problem during the trading stage. On the other hand, the more institutional investors, the less effort spent acquiring information, and the smaller the adverse selection when trading. As the number of institutional investors increases, the first effect reduces and the second effect increases the effectiveness of the *Wall Street Rule.*

We have also considered the interaction between the *Wall Street Rule* and the firm's capital structure. We have seen that for medium levels of debt (i.e. when debt can be repayed in substate $\widetilde{B}_M$ but not in substate $\widetilde{B}_0$) the effectiveness of the *Wall Street Rule* increases with leverage.

There are several ways in which to extend the analysis. First, throughout we have assumed that institutional investors could not directly intervene in corporate governance and that there was a connection between the selling activity of institutional investors and the likelihood of "intervention" in the firm. While these assumptions have allowed us to simplify the analysis and focus on the workings of the *Wall Street Rule* as a corporate governance mechanism, some questions remain unanswered: Why are institutional investors reluctant to intervene directly in corporate governance? Why does selling by institutional investors induce changes in corporations? The answers to these questions will allow us to further understand the role that institutional investors play in corporate governance.

A second way in which the analysis can be extended is by studying the relation between the *Wall Street Rule* and other mechanisms of corporate governance (i.e. the board of directors) as well as the characteristics of the institutional investors (i.e. their degree of specialization).

Finally, we also plan to test our model by studying the relation between changes in corporations (e.g. CEO turnovers, spinoffs , layoffs, etc.) and intuitional investors' ownership and characteristics.

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Appendix A

Chapter 1: Proofs

Lemma A1:

Under assumptions (A4)-(A9) the updating process takes the following form:

$$E(\eta_i \mid \Omega_2^{Mkt}) = \alpha m_i + (1-\alpha)(\eta_i + \varepsilon_{1i1} + \varepsilon_{2i1} + a_{i1} - a_{i1}^{hF})$$

$$\text{where } \alpha \equiv \frac{\sigma_{\varepsilon_1}^2 + \sigma_{\varepsilon_2}^2}{\sigma_{\varepsilon_1}^2 + \sigma_{\varepsilon_2}^2 + \sigma_\eta^2}$$

$$E(\eta_i \mid \Omega_2^{HQ}) = \beta m_i + \gamma(\eta_i + \varepsilon_{1i1} + a_{i1} - a_{i1}^{hF}) + (1-\beta-\gamma)S_{i1}$$

$$\text{where } \beta \equiv \frac{\sigma_{\varepsilon_1}^2 \sigma_u^2}{\sigma_u^2\sigma_\eta^2 + (\sigma_u^2 + \sigma_\eta^2)\sigma_{\varepsilon_1}^2} \text{ and } \gamma \equiv \frac{\sigma_\eta^2 \sigma_u^2}{\sigma_u^2\sigma_\eta^2 + (\sigma_u^2 + \sigma_\eta^2)\sigma_{\varepsilon_1}^2}$$

Proof of Proposition 3:

Under assumptions (A4)-(A9), and using Lemma A1, managerial incentives in stand-alone and multidivisional firms are given by the following two expressions:

$$g'(a_{i1}^{SF}) = \frac{\sigma_\eta^2}{\sigma_\eta^2 + \sigma_{\varepsilon_2}^2}$$

$$g'(a_{i1}^{MF}) = \frac{1}{N}\frac{\sigma_\eta^2}{\sigma_\eta^2 + \sigma_{\varepsilon_2}^2} + \frac{N-1}{N}\frac{\sigma_\eta^2 \sigma_u^2}{\sigma_u^2\sigma_\eta^2 + (\sigma_u^2 + \sigma_\eta^2)\sigma_{\varepsilon_1}^2}$$

Comparing a_{i1}^{SF} and a_{i1}^{MF}, we obtain the result in the proposition:

$$\text{For } \sigma_\eta^2 > 0, \quad a_{i1}^{MF} > a_{i1}^{SF} \quad \text{iff} \quad \sigma_u^2 \frac{\sigma_{\varepsilon 2}^2}{\sigma_{\varepsilon 1}^2} > \sigma_\eta^2$$

Lemma A2:

Under assumptions (A4)-(A6), (A7[i]) and (A8)-(A10), the updating process takes the following form:

$$\begin{aligned} E(\eta_i \mid \Omega_2^{Mkt}) &= \alpha_i m_i + (1-\alpha_i)(\eta_i + a_{i1} + \varepsilon_{2i1} - a_{i1}^{RSMF}) + \\ &+ \mu_i (m_j - \eta_j - a_{j1} - \varepsilon_{2j1} + a_{j1}^{RSMF}) \end{aligned}$$

$$\begin{aligned} \text{where } 1-\alpha_i &\equiv \frac{\sigma_{\eta_i}^2(\sigma_{\eta_j}^2 + \sigma_{\varepsilon_{2j}}^2)}{(\sigma_{\eta_i}^2 + \sigma_{\varepsilon_{2i}}^2)(\sigma_{\eta_j}^2 + \sigma_{\varepsilon_{2j}}^2) - \sigma_{\varepsilon_{2i}\varepsilon_{2j}}^2} \\ \mu_i &\equiv \frac{\sigma_{\varepsilon_{2i}\varepsilon_{2j}}\sigma_{\eta_i}^2}{(\sigma_{\eta_i}^2 + \sigma_{\varepsilon_{2i}}^2)(\sigma_{\eta_j}^2 + \sigma_{\varepsilon_{2j}}^2) - \sigma_{\varepsilon_{2i}\varepsilon_{2j}}^2} \\ a_{i1}^{RSMF} &\equiv \text{Equilibrium action for division i in period 1} \end{aligned}$$

Proof of Proposition 4:

As we saw in the general model, managerial incentives for multidivisional firms are given by the following expression:

$$\begin{aligned} g'(a_{i1}^{RSMF}) &= \frac{1}{N}\frac{\partial E\left[(N-1)E(\eta_i \mid \Omega_2^{HQ}) - \sum_{j\neq i} E(\eta_j \mid \Omega_2^{HQ}) \mid \Omega_1, a_{i1}^{RSMF}\right]}{\partial a_{i1}} + \\ &+ \frac{1}{N}\sum_{j=1}^{N} \frac{\partial \left\{E\left[E(\eta_j \mid \Omega_2^{Mkt}) \mid \Omega_1, a_{i1}^{RSMF}\right]\right\}}{\partial a_{i1}} \end{aligned}$$

Under assumptions (A4)-(A6), *(A7[i]), (A8)-(A10)* and for $N = 2$, this expression boils down to:

$$g'(a_{i1}^{RSMF}) = \frac{1}{2}\sum_{j=1}^{2} \frac{\partial \left\{E\left[E(\eta_j \mid \Omega_2^{Mkt}) \mid \Omega_1, a_{i1}^{RSMF}\right]\right\}}{\partial a_{i1}}$$

By Lemma A2, then:

$$2g'(a_{i1}^{RSMF}) = \frac{\sigma_{\eta_i}^2(\sigma_{\eta_j}^2 + \sigma_{\varepsilon_{2j}}^2)}{(\sigma_{\eta_i}^2 + \sigma_{\varepsilon_{2i}}^2)(\sigma_{\eta_j}^2 + \sigma_{\varepsilon_{2j}}^2) - \sigma_{\varepsilon_{2i}\varepsilon_{2j}}^2} - \frac{\sigma_{\varepsilon_{2i}\varepsilon_{2j}}\sigma_{\eta_j}^2}{(\sigma_{\eta_i}^2 + \sigma_{\varepsilon_{2i}}^2)(\sigma_{\eta_j}^2 + \sigma_{\varepsilon_{2j}}^2) - \sigma_{\varepsilon_{2i}\varepsilon_{2j}}^2}$$

(If the right hand side is negative then $a_{i1}^{RSMF} = 0$ and $a_{i1}^{RSMF} < a_{i1}^{MF}$)

Under assumptions (A4)-*(A10)* and using Lemma A1 we obtain the level of incentives for "unrelated" multidivisional firms:

$$2g'(a_{i1}^{MF}) = \frac{\sigma_{\eta_i}^2}{\sigma_{\eta_i}^2 + \sigma_{\varepsilon_{2i}}^2}$$

Comparing $a_{i1}^{RSMF}$with a_{i1}^{MF} yields the result in the proposition:

$$a_{i1}^{RSMF} > a_{i1}^{MF} \text{ iff } \sigma_{\varepsilon_{2i}\varepsilon_{2j}} > \sigma_{\eta_j}^2(1 + \frac{\sigma_{\varepsilon_{2i}}^2}{\sigma_{\eta_i}^2})$$

Lemma A3:

Under assumptions (A4)-(A6), ($A7^{ii}$) and (A8)-(A10), the updating process takes the following form:

$$E(\eta_i \mid \Omega_2^{Mkt}) = \beta_i m_i + (1-\beta_i)(\eta_i + a_{i1} + \varepsilon_{2i1} - a_{i1}^{ESMF}) +$$
$$-\upsilon_i(m_j - \eta_j - a_{j1} - \varepsilon_{2j1} + a_{j1}^{ESMF})$$

$$\begin{aligned}
\text{where } 1-\beta_i &\equiv \frac{\sigma_{\eta_i}^2(\sigma_{\eta_j}^2 + \sigma_{\varepsilon_{2j}}^2) - \sigma_{\eta_i\eta_j}^2}{(\sigma_{\eta_i}^2 + \sigma_{\varepsilon_{2i}}^2)(\sigma_{\eta_j}^2 + \sigma_{\varepsilon_{2j}}^2) - \sigma_{\eta_i\eta_j}^2} \\
\upsilon_i &\equiv \frac{\sigma_{\eta_i\eta_j}\sigma_{\varepsilon_{2i}}^2}{(\sigma_{\eta_i}^2 + \sigma_{\varepsilon_{2i}}^2)(\sigma_{\eta_j}^2 + \sigma_{\varepsilon_{2j}}^2) - \sigma_{\eta_i\eta_j}^2} \\
a_{i1}^{ESMF} &\equiv \text{Equilibrium action for division i in period 1}
\end{aligned}$$

Proof of Proposition 5:

As we saw in the general model, managerial incentives for multidivisional firms are given by the following expression:

$$g'(a_{i1}^{RSMF}) = \frac{1}{N}\frac{\partial E\left[(N-1)E(\eta_i \mid \Omega_2^{HQ}) - \sum_{j\neq i} E(\eta_j \mid \Omega_2^{HQ}) \mid \Omega_1, a_{i1}^{RSMF}\right]}{\partial a_{i1}} + $$
$$+\frac{1}{N}\sum_{j=1}^{N}\frac{\partial\left\{E\left[E(\eta_j \mid \Omega_2^{Mkt}) \mid \Omega_1, a_{i1}^{RSMF}\right]\right\}}{\partial a_{i1}}$$

Under assumptions (A4)-(A6), *(A7*[ii]*)*, *(A8)-(A10)* and for $N = 2$, this expression boils down to:

$$g'(a_{i1}^{ESMF}) = \frac{1}{2}\sum_{j=1}^{2}\frac{\partial\left\{E\left[E(\eta_j \mid \Omega_2^{Mkt}) \mid \Omega_1, a_{i1}^{ESMF}\right]\right\}}{\partial a_{i1}}$$

By Lemma A3, then:

$$2g'(a_{i1}^{ESMF}) = \frac{\sigma_{\eta_i}^2(\sigma_{\eta_j}^2 + \sigma_{\varepsilon_{2j}}^2) - \sigma_{\eta_i\eta_j}^2}{(\sigma_{\eta_i}^2 + \sigma_{\varepsilon_{2i}}^2)(\sigma_{\eta_j}^2 + \sigma_{\varepsilon_{2j}}^2) - \sigma_{\eta_i\eta_j}^2} + \frac{\sigma_{\eta_i\eta_j}\sigma_{\varepsilon_{2j}}^2}{(\sigma_{\eta_i}^2 + \sigma_{\varepsilon_{2i}}^2)(\sigma_{\eta_j}^2 + \sigma_{\varepsilon_{2j}}^2) - \sigma_{\eta_i\eta_j}^2}$$

Under assumptions (A4)-*(A10)* and using Lemma A1 we obtain the level of incentives for "unrelated" multidivisional firms:

$$2g'(a_{i1}^{MF}) = \frac{\sigma_{\eta_i}^2}{\sigma_{\eta_i}^2 + \sigma_{\varepsilon_{2i}}^2}$$

Comparing a_{i1}^{ESMF} with a_{i1}^{MF} yields the result in the proposition:

$$a_{i1}^{ESMF} > a_{i1}^{MF} \text{ iff } \sigma_{\eta_i\eta_j} < \sigma_{\varepsilon_{2j}}^2(1 + \frac{\sigma_{\eta_i}^2}{\sigma_{\varepsilon_{2i}}^2})$$

Lemma A4:

Under assumptions (A4)-(A6), (A7[iii]), (A8)-(A9), and (A10[i]) the updating process takes the following form:

$$E(\eta_i \mid \Omega_2^{HQ}) = \alpha_i m_i + (1-\alpha_i)(\eta_i + a_{i1} + \varepsilon_{1i1} - a_{i1}^{RSMF^*}) +$$
$$+\mu_i(m_j - \eta_j - a_{j1} - \varepsilon_{1j1} + a_{j1}^{RSMF^*})$$

$$\text{where } 1-\alpha_i \equiv \frac{\sigma^2_{\eta_i}(\sigma^2_{\eta_j}+\sigma^2_{\varepsilon_{1j}})}{(\sigma^2_{\eta_i}+\sigma^2_{\varepsilon_{1i}})(\sigma^2_{\eta_j}+\sigma^2_{\varepsilon_{1j}})-\sigma^2_{\varepsilon_{1i}\varepsilon_{1j}}}$$

$$\mu_i \equiv \frac{\sigma_{\varepsilon_{1i}\varepsilon_{1j}}\sigma^2_{\eta_i}}{(\sigma^2_{\eta_i}+\sigma^2_{\varepsilon_{1i}})(\sigma^2_{\eta_j}+\sigma^2_{\varepsilon_{1j}})-\sigma^2_{\varepsilon_{1i}\varepsilon_{1j}}}$$

$$a_{i1}^{RSMF*} \equiv \text{Equilibrium action for division i in period 1}$$

Lemma A5:

Under assumption (A4)-(A6), (A7[iv]), (A8)-(A9), and (A10[i]) the updating process takes the following form:

$$E(\eta_i \mid \Omega_2^{Mkt}) = \beta_i m_i + (1-\beta_i)(\eta_i + a_{i1} + \varepsilon_{1i1} - a_{i1}^{ESMF*}) + \\ -v_i(m_j - \eta_j - a_{j1} - \varepsilon_{1j1} + a_{j1}^{ESMF*}) \qquad (27)$$

$$\text{where } 1-\beta_i \equiv \frac{\sigma^2_{\eta_i}(\sigma^2_{\eta_j}+\sigma^2_{\varepsilon_{1j}})-\sigma^2_{\eta_i\eta_j}}{(\sigma^2_{\eta_i}+\sigma^2_{\varepsilon_{1i}})(\sigma^2_{\eta_j}+\sigma^2_{\varepsilon_{1j}})-\sigma^2_{\eta_i\eta_j}}$$

$$v_i \equiv \frac{\sigma_{\eta_i\eta_j}\sigma^2_{\varepsilon_{1i}}}{(\sigma^2_{\eta_i}+\sigma^2_{\varepsilon_{1i}})(\sigma^2_{\eta_j}+\sigma^2_{\varepsilon_{1j}})-\sigma^2_{\eta_i\eta_j}}$$

$$a_{i1}^{ESMF*} \equiv \text{Equilibrium action for division i in period 1}$$

Lemma A6:

Under assumption (A4)-(A6), (A7[v]), (A8)-(A9), and (A10[i]) the updating process takes the following form:

$$E(\eta_i \mid \Omega_2^{Mkt}) = \alpha_1 + \alpha_2(\eta_i + a_{i1} + \varepsilon_{1i1} - a_{i1}^{ESMF*}) + \alpha_3(\eta_i + u_{i1}) + \alpha_4(\eta_j + u_{j1})$$

$$\text{where } \alpha_2 = \frac{\left[(\sigma^2_{\eta_i}+\sigma^2_{u_i})(\sigma^2_{\eta_j}+\sigma^2_{u_j})-\sigma^2_{u_iu_j}\right]\sigma^2_{\eta_i}-\sigma^4_{\eta_i}(\sigma^2_{\eta_j}+\sigma^2_{u_j})}{\left[(\sigma^2_{\eta_i}+\sigma^2_{u_i})(\sigma^2_{\eta_j}+\sigma^2_{u_j})-\sigma^2_{u_iu_j}\right](\sigma^2_{\eta_i}+\sigma^2_{\varepsilon_i})-\sigma^4_{\eta_i}(\sigma^2_{\eta_j}+\sigma^2_{u_j})}$$

and α_1, α_3, and α_4 are other constant coefficients.

Proof of Proposition 6:

Under assumptions (A4)-(A6), (A8), (A9), (A10[i]) and any one of (A7[iii]), (A7[iv]) or (A7[v]) managerial incentives are given by:

$$g'(a_{i1}^{*}) = \frac{1}{N}\frac{\partial E\left[(N-1)E(\eta_i \mid \Omega_2^{HQ}) - \sum_{j\neq i} E(\eta_j \mid \Omega_2^{HQ}) \mid \Omega_1, a_{i1}^{*}\right]}{\partial a_{i1}}$$

Under assumptions (A4)-*(A9)* and (A10$^{\text{i}}$), and using Lemma A1 we obtain the level of incentives for "unrelated" multidivisional firms (for $N = 2$) and for $\sigma_u^2 = \infty$:

$$g'(a_{i1}^{MF}) = \frac{1}{2}\frac{\sigma_{\eta i}^2}{\sigma_{\eta_i}^2 + \sigma_{\varepsilon_{1i}}^2}$$

(i) Under assumptions(A4)-(A6), (A7$^{\text{iii}}$), (A8), (A9) and (A10$^{\text{i}}$), managerial incentives are determined by the following equation:

$$g'(a_{i1}^{RSMF^*}) = \frac{1}{N}\frac{\partial E\left[(N-1)E(\eta_i \mid \Omega_2^{HQ}) - \sum_{j\neq i} E(\eta_j \mid \Omega_2^{HQ}) \mid \Omega_1, a_{i1}^{RSMF^*}\right]}{\partial a_{i1}}$$

Using Lemma A4 and for $N = 2$, the previous equation simplifies to:

$$2g'(a_{i1}^{RSMF^*}) = \frac{\sigma_{\eta_i}^2(\sigma_{\eta_j}^2 + \sigma_{\varepsilon_{1j}}^2)}{(\sigma_{\eta_i}^2 + \sigma_{\varepsilon_{1i}}^2)(\sigma_{\eta_j}^2 + \sigma_{\varepsilon_{1j}}^2) - \sigma_{\varepsilon_{1i}\varepsilon_{1j}}^2} + \frac{\sigma_{\varepsilon_{1i}\varepsilon_{1j}}\sigma_{\eta_i}^2}{(\sigma_{\eta_i}^2 + \sigma_{\varepsilon_{1i}}^2)(\sigma_{\eta_j}^2 + \sigma_{\varepsilon_{1j}}^2) - \sigma_{\varepsilon_{1i}\varepsilon_{1j}}^2}$$

Comparing $a_{i1}^{RSMF^*}$ with a_{i1}^{MF} it is easy to see that $a_{i1}^{RSMF^*} > a_{i1}^{MF}$.

(ii) Under assumptions(A4)-(A6), (A7$^{\text{iv}}$), (A8), (A9) and (A10$^{\text{i}}$), managerial incentives are determined by the following equation:

$$g'(a_{i1}^{ESMF^*}) = \frac{1}{N}\frac{\partial E\left[(N-1)E(\eta_i \mid \Omega_2^{HQ}) - \sum_{j\neq i} E(\eta_j \mid \Omega_2^{HQ}) \mid \Omega_1, a_{i1}^{ESMF^*}\right]}{\partial a_{i1}}$$

Using Lemma A5 and for $N = 2$, this equation simplifies to:

$$2g'(a_{i1}^{RSMF^*}) = \frac{\sigma_{\eta_i}^2(\sigma_{\eta_j}^2 + \sigma_{\varepsilon_{1j}}^2) - \sigma_{\eta_i\eta_j}^2}{(\sigma_{\eta_i}^2 + \sigma_{\varepsilon_{1i}}^2)(\sigma_{\eta_j}^2 + \sigma_{\varepsilon_{1j}}^2) - \sigma_{\eta_i\eta_j}^2} - \frac{\sigma_{\eta_i\eta_j}\sigma_{\varepsilon_{1i}}^2}{(\sigma_{\eta_i}^2 + \sigma_{\varepsilon_{1i}}^2)(\sigma_{\eta_j}^2 + \sigma_{\varepsilon_{1j}}^2) - \sigma_{\eta_i\eta_j}^2}$$

Comparing $a_{i1}^{ESMF^*}$ with a_{i1}^{MF} it is easy to see that $a_{i1}^{ESMF^*} > a_{i1}^{MF}$.

(iii) Under assumptions (A4)-*(A9)* and (A10$^{\text{i}}$), and using Lemma A1 we obtain the level of incentives for "unrelated" multidivisional firms (for $N = 2$):

$$2g'(a_{i1}^{MF}) = \frac{\sigma_{\eta_i}^2 \sigma_{u_i}^2}{\sigma_{u_i}^2 \sigma_{\eta_i}^2 + (\sigma_{u_i}^2 + \sigma_{\eta_i}^2)\sigma_{\varepsilon_{1i}}^2}$$

Under assumptions(A4)-(A6), (A7$^{\text{v}}$), (A8), (A9) and (A10$^{\text{i}}$), and using Lemma A6 managerial incentives under correlated learning errors are determined by the following expression:

$$\begin{aligned} 2g'(a_{i1}^{CEMF}) &= \frac{\left[(\sigma_{\eta_i}^2 + \sigma_{u_i}^2)(\sigma_{\eta_j}^2 + \sigma_{u_j}^2) - \sigma_{u_iu_j}^2\right]\sigma_{\eta_i}^2 - \sigma_{\eta_i}^4(\sigma_{\eta_j}^2 + \sigma_{u_j}^2)}{\left[(\sigma_{\eta_i}^2 + \sigma_{u_i}^2)(\sigma_{\eta_j}^2 + \sigma_{u_j}^2) - \sigma_{u_iu_j}^2\right](\sigma_{\eta_i}^2 + \sigma_{\varepsilon_{1i}}^2) - \sigma_{\eta_i}^4(\sigma_{\eta_j}^2 + \sigma_{u_j}^2)} = \\ &= \frac{\sigma_{\eta_i}^2 \sigma_{u_i}^2 - \frac{\sigma_{u_iu_j}^2 \sigma_{\eta_i}^2}{(\sigma_{\eta_j}^2 + \sigma_{u_j}^2)}}{\sigma_{u_i}^2 \sigma_{\eta_i}^2 + (\sigma_{u_i}^2 + \sigma_{\eta_i}^2)\sigma_{\varepsilon_{1i}}^2 - \frac{\sigma_{u_iu_j}^2 (\sigma_{\eta_i}^2 + \sigma_{\varepsilon_{1i}}^2)}{(\sigma_{\eta_j}^2 + \sigma_{u_j}^2)}} \end{aligned}$$

After some algebra we obtain that $a_{i1}^{CEMF} < a_{i1}^{MF}$.

Proof of Proposition 7:

(i) In stand-alone firms, headquarters' assessment of the division does not affect the level of investment, therefore, division managers do not spend time in influence activities ($a_{i1}^{SF} = T$).

(ii) Under the new assumptions in the subsection, the updating process takes the following form:

$$E(\eta_i \mid \Omega_2^{Mkt}) = \alpha m_i + (1-\alpha)(\eta_i + \varepsilon_{1i1} + \varepsilon_{2i1} + a_{i1} - a_{i1}^{MF})$$

$$\text{where } \alpha \equiv \frac{\sigma_{\varepsilon_1}^2 + \sigma_{\varepsilon_2}^2}{\sigma_{\varepsilon_1}^2 + \sigma_{\varepsilon_2}^2 + \sigma_{\eta}^2}$$

$$E(\eta_i \mid \Omega_2^{HQ}) = \beta m_i + \gamma(\eta_i + \varepsilon_{1i1} + a_{i1} - a_{i1}^{MF}) + (1-\beta-\gamma)(\eta_i + \varepsilon_{1i1} + G(i_{i1}) - G(i_{i1}^{MF})$$

$$\text{where } \beta \equiv \frac{\sigma_{\varepsilon_1}^2 \sigma_u^2}{\sigma_u^2 \sigma_\eta^2 + (\sigma_u^2 + \sigma_\eta^2)\sigma_{\varepsilon_1}^2} \text{ and } \gamma \equiv \frac{\sigma_\eta^2 \sigma_u^2}{\sigma_u^2 \sigma_\eta^2 + (\sigma_u^2 + \sigma_\eta^2)\sigma_{\varepsilon_1}^2}$$

Division manager maximize the following objective function:

$$\begin{aligned} &Max_{a_{it} \text{ st } 0<a_{it}<T}\ I_{i2}^{MF} \Longleftrightarrow \\ &Max_{a_{it} \text{ st } 0<a_{it}<T}\ E\left(\frac{E(\eta_i \mid \Omega_2^{Mkt})}{N} + \frac{(N-1)\,E(\eta_i \mid \Omega_2^{HQ})}{N} | \Omega_1, a_{it}, i_{it}\right) \end{aligned}$$

This maximization gives the following f.o.c's:

$$\frac{(1-\alpha)}{(N-1)(1-\beta-\gamma)} + \frac{\gamma}{(1-\beta-\gamma)} = G'(i_{it}^{MF}) \quad \text{and} \quad T = a_{it}^{MF} + i_{it}^{MF}$$

From the first f.o.c., and given $G' > 0$, $G'' < 0$, $G'(0) = \infty$ and $G'(T) = 0$, i_{it}^{MF} is greater than zero and increasing in the number of divisions N.

Appendix B

Chapter 2: Proofs

Proof of Lemma 2:

$$V_{vc}^{'}(N_{vc}) = \left\{ \begin{array}{c} -[1-q_1 r_{vc}]^{N_{vc}} p(X-I)Ln(1-q_1 r_{vc}) \\ +[1-(1-q_2)r_{vc}]^{N_{vc}} (1-p)I \; Ln(1-(1-q_2)r_{vc}) \end{array} \right\}$$

$$V_{vc}^{'}(N_{vc}) > 0 \text{ iff } \left(\frac{1-(1-q_2)r_{vc}}{1-q_1 r_{vc}}\right)^{N_{vc}} < \frac{Ln(1-q_1 r_{vc})p(X-I)}{Ln(1-(1-q_2)r_{vc})(1-p)I}$$

This means that if $V_{vc}^{'}(N_{vc}^{*}) > 0$ then $V_{vc}^{'}(x) > 0$ for all $1 < x < N_{vc}^{*}$ and if $V_{vc}^{'}(N_{vc}^{**}) < 0$ then $V_{vc}^{'}(x) < 0$ for all $x > N_{vc}^{**}$.

Proof of Result 2*:*

If $V_{vc}(x) < V_f$ for all $x \in [1, N]$ an entrepreneur always obtains higher expected revenues in a firm than in the venture capital market. Therefore, as long as there is a firm, there will be no entrepreneurs seeking financing in the venture capital market. This, in turn, implies that all investors will decide to form firms.

If $V_{vc}(N) > V_f$ and there is no venture capital market, a group of investors can form a venture capital market that will attract all entrepreneurs and make every investor in that group better off.

If $V_{vc}(N) < V_f$ and $V_{vc}(x) > V_f$ for some x in $[1, N]$, we cannot have an equilibrium without a venture capital market because a group of investors can deviate and form a venture capital market attracting all the entrepreneurs. As long as $V_{vc}(N_{vc}) > V_f$, there will be no entrepreneurs joining firms and all financiers will have incentive to become VCs. This will continue until $V_{vc}(N_{vc}) = V_f$; more investors decide to be VCs until the adverse selection is strong enough to just compensate the extra matching of the venture capital market. When this occurs, entrepreneurs become indifferent about the venture capital market and joining a firm. In equilibrium, entrepreneurs are distributed proportionally between the firms and the venture capital market in order to make the investors indifferent about becoming a VC or creating a firm.

Proof of Corollary 3:

We need to prove the existence and uniqueness of $N_{\min}$ and $N_{\max}$.

In lemma 1 we proved that if $V_{vc}'(N_{vc}^*) > 0$ then $V_{vc}'(x) > 0$ for all $1 < x < N_{vc}^*$ and if $V_{vc}'(N_{vc}^{**}) < 0$ then $V_{vc}'(x) < 0$ for all $x > N_{vc}^{**}$.

By assumption $V_{vc}(x) > V_f$ *for some* $x \geq 1$, we also know that $V_{vc}(1) < V_f$ and for some $z > 1$ large enough $V_{vc}(z) < V_f$. This guarantees the existence and uniqueness of $N_{\min}$ and $N_{\max}$.

Proof of Corollary 4:

$$\begin{aligned} V &= \Pr(\text{Implemented}|\text{G}) \cdot p \cdot (G - I) + \Pr(\text{Implemented}|\text{B}) \cdot (1-p) \cdot (-I) \\ &= \Pr(\text{Implemented}|\text{G}) \left\{ p \cdot (G - I) + \frac{\Pr(\text{Implemented}|\text{B})}{\Pr(\text{Implemented}|\text{G})} \cdot (1-p) \cdot (-I) \right\} \end{aligned}$$

$$\frac{\partial V}{\partial p} = \Pr(\text{Implemented}|\text{G}) \left[G - I \left(1 - \frac{\Pr(\text{Implemented}|\text{B})}{\Pr(\text{Implemented}|\text{G})} \right) \right]$$

In there is a venture capital market (i.e. $V_{vc}(N_{vc}) \geq V_f$) the ratio of the probability of implementing a good and a bad project is larger than within the firm:

$$\frac{1 - (1 - (1 - q_2) r_{vc})^{Nvc}}{1 - (1 - q_1 r_{vc})^{N_{vc}}} > \frac{1 - q_2}{q_1} \text{ for } N_{vc} > 1$$

$$\left(\textit{Note}\text{: For } N > 1\ \frac{1-A^N}{1-B^N} = \frac{1-A}{1-B} \underset{i\to\infty}{Lim} \prod_{j=1}^{i} \frac{1+A^{\sqrt[2^j]{N}}}{1+B^{\sqrt[2^j]{N}}} \right)$$

If there is a venture capital market (i.e. $V_{vc}(N_{vc}) \geq V_f$), and given that the ratio of the probability of implementing a bad and a good project is larger than within the firm, then the probability of implementing a good project must be larger in the venture capital market:

$$\begin{aligned} V_{vc}(N_{vc}) &\geq V_f \text{ and } \left(\frac{\Pr(\text{Implemented}|\text{B})}{\Pr(\text{Implemented}|\text{G})}\right)_{vc} > \left(\frac{\Pr(\text{Implemented}|\text{B})}{\Pr(\text{Implemented}|\text{G})}\right)_f \\ &\Rightarrow \text{ implies that } \Pr(\text{Implemented}|\text{G})_{vc} > \Pr(\text{Implemented}|\text{G})_f \end{aligned}$$

The last two expressions imply that if $V_{vc}(N_{vc}) \geq V_f$ then:

$$\frac{\partial V_{vc}(N_{vc})}{\partial p} > \frac{\partial V_f}{\partial p}$$

For $N_{\min}$ and $N_{\max}$ we have that $V_{vc}(N_{\min}) = V_{vc}(N_{\max}) = V_f$, therefore:

$$\frac{\partial V_{vc}(N_{\min})}{\partial p} > \frac{\partial V_f}{\partial p} \text{ and } \frac{\partial V_{vc}(N_{\max})}{\partial p} > \frac{\partial V_f}{\partial p}$$

Furthermore, from the previous proof, we now:

$$\frac{\partial V_{vc}(N_{\max})}{\partial N_{vc}} < 0 < \frac{\partial V_{vc}(N_{\min})}{\partial N_{vc}}$$

Differentiating the equality $V_{vc}(N_{vc}) = V_f$ w.r.t. p and N_{vc} gives the following:

$$\frac{dN_{vc}}{dp} = \frac{-\frac{\partial V_{vc}(N_{vc})}{\partial N_{vc}}}{\frac{\partial V_{vc}(N_{vc})}{\partial p} - \frac{\partial V_f}{\partial p}}$$

Since we have just seen that:

$$\frac{\partial V_{vc}(N_{\min})}{\partial p} > \frac{\partial V_f}{\partial p} \text{ and } \frac{\partial V_{vc}(N_{\max})}{\partial p} > \frac{\partial V_f}{\partial p}$$

$$\frac{\partial V_{vc}(N_{\max})}{\partial N_{vc}} < 0 < \frac{\partial V_{vc}(N_{\min})}{\partial N_{vc}}$$

This implies that $N_{\max}$ is increasing and $N_{\min}$ is decreasing in p.

The proofs for G and I follow a similar reasoning.

Proof of Result 4*:*

If there is a venture capital market, i.e. $N_{vc} > 1$, this implies that $V_{vc}(N_{vc}, d_I) \geqslant V_f \iff$

$$\begin{aligned} & d_I \left\{ \begin{array}{c} \left(1 - [(1-q)r_{vc} + (1-r_{vc})]^{N_{vc}}\right) p(X-I) \\ - \left(1 - [qr_{vc} + (1-r_{vc})]^{N_{vc}}\right)(1-p)I \end{array} \right\} + \\ & +(1-d_I) \cdot r_{vc} \left\{ \left(1-(1-q)^{N_{vc}}\right) p(X-I) - \left(1-q^{N_{vc}}\right)(1-p)I \right\} \\ \geqslant \;& r_f(pq(X-I) - (1-p)(1-q)I) \end{aligned}$$

But since projects financed after a second round of screening have a negative expected value $(q_1 = q_2)$ and $r_f > r_{vc}$ then:

$$r_{vc} \left\{ \left(1-(1-q)^{N_{vc}}\right) p(X-I) - \left(1-q^{N_{vc}}\right)(1-p)I \right\} < r_f(pq(X-I) - (1-p)(1-q)I)$$

and since $V_{vc}(N_{vc}, d_I) \geqslant V_f$ this implies that

$$\begin{aligned} & \left\{ \begin{array}{c} \left(1 - [(1-q)r_{vc} + (1-r_{vc})]^{N_{vc}}\right) p(X-I) \\ - \left(1 - [qr_{vc} + (1-r_{vc})]^{N_{vc}}\right)(1-p)I \end{array} \right\} > \\ & +(1-d_I) r_{vc} \left\{ \left(1-(1-q)^{N_{vc}}\right) p(X-I) - \left(1-q^{N_{vc}}\right)(1-p)I \right\} \end{aligned}$$

Proof of Result 5*:*

We need to proof the following:

$$\begin{aligned} & \left\{ \begin{array}{c} \left(1 - [(1-q)r_{vc} + (1-r_{vc})]^{N_{vc}}\right) p(X-I) \\ - \left(1 - [qr_{vc} + (1-r_{vc})]^{N_{vc}}\right)(1-p)I \end{array} \right\} \\ < \;& \left(1-(1-r_{vc})^{N_{vc}}\right) \{pq(X-I) - (1-p)(1-q)I\} \end{aligned}$$

We can write the "left hand side" of the inequality in the following way:

$$\left\{ \begin{array}{c} \left(1-[(1-q)r_{vc}+(1-r_{vc})]^{N_{vc}}\right)p(X-I) \\ -\left(1-[qr_{vc}+(1-r_{vc})]^{N_{vc}}\right)(1-p)I \end{array} \right\}$$

$= \ \text{Pr(Project undertaken by the first expert that evaluates it)} \times$

Expected value of a project taken by the first expert that evaluates it $+$

Pr(Project undertaken after it has been rejected by another expert) $\times$

Expected value of a project taken after it has been rejected by another expert

$= \ (1-(1-r_{vc})^{N_{vc}})\{pq(X-I)-(1-p)(1-q)I\}+$

$+$ Pr(Project taken after it has been rejected by another expert) $\times$

Expected value of a project undertaken after it has been rejected by another expert

Since $q_1 = q_2$, all projects undertaken after they have been rejected by another expert have a negative expected value.

Proof of Result 6*:*

Let's define $\Pr ob(G|i)$ ($\Pr ob(B|i)$) as the probability that a good (*bad*) project arrives to VC i. Then VC i solves the following program:

$$\arg \max_{r_{vc}^i \in [0,1]} r_{vc}^i \left[\Pr ob(G|i)q(r_{vc}^i)(X-I) - \Pr ob(B|i)(1-q(r_{vc}^i))I\right]$$

The program gives the following f.o.c. for a maximum:

$$q'(r_{vc}^i)r_{vc}^i + q(r_{vc}^i) = \frac{1}{\frac{\Pr ob(G/\ i)}{\Pr ob(B/\ i)}\frac{X-I}{I}+1}$$

Given our assumptions $q'(r_{vc}^i)r_{vc}^i + q(r_{vc}^i)$ is decreasing in r_{vc}^i, which completes the proof for the VC.

The firm solves the following program:

$$\arg \max_{r \in [0,1-\Delta]} (r+\Delta)\left[pq(r)(G-I)-(1-p)(1-q(r))I\right]$$

The program gives the following f.o.c. for an interior maximum:

$$q'(r)(r+\Delta)+q(r)=\frac{1}{\frac{p}{1-p}\frac{X-I}{I}+1}$$

As before, $q'(r)(r+\Delta)+q(r)$ is decreasing in r which completes the proof for the firm.

Proof of Result 7:

In the previous proof I obtained the following f.o.c.:

$$q'(r_{vc}^{i})r_{vc}^{i}+q(r_{vc}^{i})=\frac{1}{\frac{\Pr ob(G|\ i)}{\Pr ob(B|\ i)}\frac{X-I}{I}+1}$$

$\frac{\Pr ob(G|\ i)}{\Pr ob(B|\ i)}$ is decreasing in q_{-i} and in r_{vc}^{-i} *ceteris paribus.*

Proof of Result 8:

In the proof of result 6, I obtained the following f.o.c.:

$$q'(r)(r+\Delta)+q(r)=\frac{1}{\frac{p}{1-p}\frac{X-I}{I}+1}$$

Differentiating the f.o.c.:

$$\frac{dr}{d\Delta}=\frac{-q'(r)}{q''(r)(r+\Delta)+2q'(r)}<0$$

Proof of Result 12:

$$\arg\max_{e}\text{Value to Entrepreneur}_{VC}\times\left\{\begin{array}{c}p(e)[1-(1-r_{vc}q_1)^{N_{vc}}]\\+l(1-p(e))[1-(1-r_{vc}(1-q_2))^{N_{vc}}]\end{array}\right\}-e$$

It gives the following f.o.c. for maximum:

$$\text{Value to Entrepreneur}_{VC}\times p'(e)\{[1-(1-r_{vc}q_1)^{N_{vc}}]-l[1-(1-r_{vc}(1-q_2))^{N_{vc}}]\}=1$$

The ex-ante expected value of a project is:

$$V=X\cdot\Pr(X\cap\text{Project is Implemented})-I\cdot\Pr(\text{Project is Implemented})-e^{*}$$

Therefore the value that ex-post goes to the entrepreneur:

$$\begin{aligned}\text{Value to Entrepreneur} &= \delta\left\{\begin{array}{l} X - \frac{I}{\Pr(X|\text{Project is Implemented})} \\ -\frac{e^*}{\Pr(X \cap \text{Project is Implemented})}\end{array}\right\} \\ &\quad + \frac{e^*}{\Pr(X \cap \text{Project is Implemented})} \\ &= \frac{\delta V + e^*}{\Pr(X \cap \text{Project is Implemented})}\end{aligned}$$

In the case of the venture capital market V_{vc} is equal to:

$$\begin{aligned}V_{vc} &= p(e^*_{vc})[1-(1-r_{vc}q_1)^{N_{vc}}] + l(1-p(e^*_{vc}))[1-(1-r_{vc}(1-q_2))^{N_{vc}}](X-I) \\ &\quad -(1-l)(1-p(e^*_{vc}))[1-(1-r_{vc}(1-q_2))^{N_{vc}}] - e^*_{vc}\end{aligned}$$

$$(\delta V_{vc} + e^*_{vc})\frac{p'(e)\{[1-(1-r_{vc}q_1)^{N_{vc}}] - l[1-(1-r_{vc}(1-q_2))^{N_{vc}}]\}}{p(e^*_{vc})[1-(1-r_{vc}q_1)^{N_{vc}}] + l(1-p(e^*_{vc}))[1-(1-r_{vc}(1-q_2))^{N_{vc}}]} = 1 \Longrightarrow$$

where e^*_{vc} is the equilibrium effort of entrepreneurs in the market.

$$\frac{p'(e)(\delta V_{vc} + e^*_{vc})}{p(e) + \frac{l[1-r_{vc}(1-q_2)^{N_{vc}}]}{[1-(1-r_{vc}q_1)^{N_{vc}}] - l[1-(1-r_{vc}(1-q_2))^{N_{vc}}]}} = 1 \Longrightarrow$$

Proof of Result 13:

$$\arg\max_e \text{Value to Entrepreneur}_f \times r_f\{p(e)q_1 + l(1-p(e))(1-q_2)\} - e$$

Following the same steps as in the proof of result 12, the program gives the following f.o.c. for maximum:

$$\frac{p'(e)(q_1 - l(1-q_2))\}}{p(e^*_f)q_1 + l(1-p(e^*_f))(1-q_2)}(\delta V_f + e^*_f) = 1 \Longrightarrow$$

$$\frac{p'(e)(\delta V_f + e_f^*)}{p(e) + \frac{1}{\frac{q_1}{l(1-q_2)} - 1}} = 1$$

where

$$V_f = r_f\{[p(e_f^*)q_1 + l(1-p(e_f^*))(1-q_2)](X-I) - [(1-l)(1-p(e_f^*))(1-q_2)]I\} - e_f^*$$

and e_f^* is the equilibrium effort of the entrepreneurs in the firm.

Proof of Result 14:

From the previous results we have the following f.o.c. for a maximum:

$$(\delta V_{vc} + e_{vc}^*) \frac{p'(e)\{[1-(1-r_{vc}q_1)^{N_{vc}}] - l[1-(1-r_{vc}(1-q_2))^{N_{vc}}]\}}{p(e_{vc}^*)[1-(1-r_{vc}q_1)^{N_{vc}}] + l(1-p(e_{vc}^*))[1-(1-r_{vc}(1-q_2))^{N_{vc}}]} = 1$$

$$\frac{p'(e)(q_1 - l(1-q_2)\}}{p(e_f^*)q_1 + l(1-p(e_f^*))(1-q_2)}(\delta V_f + e_f^*) = 1$$

In equilibrium we must have that $e_f = e_f^*$ and $e_{vc} = e_{vc}^*$ which gives the following expression:

$$(\delta V_{vc} + e_{vc}^*) = \frac{p(e_{vc}^*)[1-(1-r_{vc}q_1)^{N_{vc}}] + l(1-p(e_{vc}^*))[1-(1-r_{vc}(1-q_2))^{N_{vc}}]}{p'(e_{vc}^*)\{[1-(1-r_{vc}q_1)^{N_{vc}}] - l[1-(1-r_{vc}(1-q_2))^{N_{vc}}]\}}$$

which simplifies to:

$$(\delta V_{vc} + e_{vc}^*) = \frac{p(e_{vc}^*)}{p'(e_{vc}^*)} + \frac{l}{p'(e_{vc}^*)\left(\frac{[1-(1-r_{vc}q_1)^{N_{vc}}]}{[1-(1-r_{vc}(1-q_2))^{N_{vc}}]} - l\right)}$$

In equilibrium we must also have that $e_f = e_f^* M$, which, following similar steps as in the venture capital case, gives the following expression:

$$(\delta V_f + e_f^*) = \frac{p(e_f^*)}{p'(e_f^*)} + \frac{l}{p'(e_f^*)\left(\frac{q_1}{(1-q_2)} - l\right)}$$

Furthermore if in equilibrium there are both entrepreneurs and VCs in the market ($N > N_{vc} > 1$), it implies that $V_{vc} = V_f$.

$$(\delta V_f + e^*_{vc}) = \frac{p(e^*_{vc})}{p'(e^*_{vc})} + \frac{l}{p'(e^*_{vc})\left(\frac{[1-(1-r_{vc}q_1)^{N_{vc}}]}{[1-(1-r_{vc}(1-q_2))^{N_{vc}}]} - l\right)}$$

$$(\delta V_f + e^*_f) = \frac{p(e^*_f)}{p'(e^*_f)} + \frac{l}{p'(e^*_f)\left(\frac{q_1}{(1-q_2)} - l\right)}$$

which in turn implies:

$$\begin{aligned}&\frac{p(e^*_{vc})}{p'(e^*_{vc})} + \frac{l}{p'(e^*_{vc})\left(\frac{[1-(1-r_{vc}q_1)^{N_{vc}}]}{[1-(1-r_{vc}(1-q_2))^{N_{vc}}]} - l\right)} - e^*_{vc} \\ = \;& \frac{p(e^*_f)}{p'(e^*_f)} + \frac{l}{p'(e^*_f)\left(\frac{q_1}{(1-q_2)} - l\right)} - e^*_f\end{aligned}$$

Both sides have a similar structure:

$$\frac{p(x)}{p'(x)} + \frac{1}{p'(x)}A - x$$

where $A > 0$. Differentiating with respect to A:

$$\left(\frac{(p'(x))^2 - p''(x)p(x)}{(p'(x))^2} - \frac{l \cdot p''(x)}{(p'(x))^2\left(\frac{[1-(1-r_{vc}q_1)^{N_{vc}}]}{[1-(1-r_{vc}(1-q_2))^{N_{vc}}]} - l\right)} - 1\right) dx = \frac{1}{p'(x)}dA$$

which simplifies to:

$$\left(\frac{-p''(x)p(x)}{(p'(x))^2} - \frac{l \cdot p''(x)}{(p'(x))^2\left(\frac{[1-(1-r_{vc}q_1)^{N_{vc}}]}{[1-(1-r_{vc}(1-q_2))^{N_{vc}}]} - l\right)} - 1\right) dx = \frac{1}{p'(x)}dA$$

Therefore $\frac{dx}{dA} < 0$.

Given that the following inequality holds for $N_{vc} > 1$:

$$\frac{[1-(1-r_{vc}q_1)^{N_{vc}}]}{[1-(1-r_{vc}(1-q_2))^{N_{vc}}]} < \frac{q_1}{(1-q_2)}$$

then it follows that $e^*_{vc} < e^*_f$.

If $l = 0$ then the two f.o.c. for maximum become:

$$\frac{p'(e^*_f)}{p(e^*_f)}(\delta V_f + e^*_f) = 1$$

$$\frac{p'(e^*_{vc})}{p(e^*_{vc})}(\delta V_{vc} + e^*_{vc}) = 1$$

If in equilibrium there are both entrepreneurs and VCs in the market, it implies that $V_{vc} = V_f$, which in turn implies that $e^*_{vc} = e^*_f$.

Proof of Result 15*:*

The ex-ante expected value of a project is:

$$\begin{aligned} V &= X\,\Pr(X \cap \text{Project is Implemented} \cap \text{Project Comes Up}) \\ &\quad - I\,\Pr(\text{Project is Implemented} \cap \text{Project Comes Up}) - \overline{e}^* \end{aligned}$$

(Note: This expression applies to both firms and VCs; they will just have different probabilities. So if we omit the subindex vc (for VC) or f (for firm), the expressions apply to both with their respective probabilities.)

The ex-post value for an entrepreneur (VFE) is:

$$\begin{aligned} \text{VFE} &= \delta \left\{ \begin{array}{l} X - \frac{I}{\Pr(X|\text{Project is Implemented}\cap\text{Project Comes Up})} \\ - \frac{\overline{e}^*}{\Pr(X\cap\text{Project is Implemented}\cap\text{Project Comes Up})} \end{array} \right\} + \\ &\quad + \frac{\overline{e}^*}{\Pr\left(X\cap\text{Project is Implemented}\cap\text{Project Comes Up}\right)} \end{aligned}$$

$$= \frac{\delta V + \overline{e}^*}{\rho(\overline{e}^*)\,\Pr\left(X \cap \text{Project is Implemented} | \text{Project Comes Up}\right)}$$

The entrepreneur maximizes the following program:

$$\arg\max_{\overline{e}} \text{VFE} \times \rho(\overline{e})\,\Pr\left(X \cap \text{Project is Implemented} | \text{Project Comes Up}\right) - \overline{e}$$

The program can be rewritten as:

$$\arg\max_{\overline{e}} \frac{\delta V + \overline{e}^*}{\rho(\overline{e}^*)} \rho(\overline{e}) - \overline{e}$$

The f.o.c. for maximum in the program is:

$$(\delta V + \overline{e}^*) \frac{\rho'(\overline{e})}{\rho(\overline{e}^*)} = 1$$

Since in equilibrium $\overline{e}_f = \overline{e}_f^*$, $\overline{e}_{vc} = \overline{e}_{vc}^*$ and $V_f = V_{vc}$ this implies that $\overline{e}_f^* = \overline{e}_{vc}^*$.

Appendix C

Chapter 3: Proofs

Proof of Result 16:

Under state $\widetilde{G}$, if the investor does not sell any shares it obtains $\overline{\alpha}G$. If it sells $\alpha \in (0, \overline{\alpha}]$ shares it obtains at most $\overline{\alpha}G-$ Cost of Trading (in a Perfect Bayesian Equilibrium where type G could separate itself from the other types). Since the cost of trading is positive, for all $\alpha \in (0, \overline{\alpha}]$, the investor will never be willing to sell shares in state $\widetilde{G}$. So in any Perfect Bayesian Equilibrium (PBE) $\alpha_G^* = 0$.

Proof of Result 17:

If the institutional investor receives a signal S_M, it has incentives to sell part of his block in order to induce some probability of intervention (this is true at any price). Given Result 1, type S_0 (i.e. an institutional investor that has received signal S_0) has incentive to imitate type S_M because as long as the price of the stock is positive this will allow type S_0 to obtain some positive return.

Proof of Result 18:

Similar to the proof of Result 16.

Proof of Result 19:

Similar to the proof of Result 17.