THREE ESSAYS ON THE STRATEGIC INTERACTION BETWEEN PRODUCTION AND FINANCIAL DECISIONS

by

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ABSTRACT

This thesis consists of three essays in the theory of Industrial Organization. More specifically, the thesis focuses on the interaction of financial structure and market structure. The intellectual starting point of this thesis is the Modigliani-Miller theorem. Modigliani & Miller (1958) show that in the presence of perfect financial and output markets, financial structure has no effect on the value of the firm. This thesis departs from a Modigliani-Miller economic environment by assuming that firms have more information about their projects than financiers have. In imperfect output markets, this departure from Modigliani-Miller world implies that there may exist important strategic interactions between production and financial decisions. In the three essays of this thesis, we derive theoretical links between financial structure and output market competition.

We show that in the presence of asymmetric information in output and financial markets, firms may affect the outcome of various oligopolistic and entry games by choosing an appropriate financial policy. We explicitly introduce financial variables in these types of games to show that they may have an important role to play in the resolution of the output competition. The presence of asymmetric information is usually a sufficient condition for financial structure relevance to the firm's market value. However, this is not necessary. It is shown elsewhere that taxes or bankruptcy costs may also affect financial decisions. Throughout this thesis, we abstract from these important determinants of financial structure to focus on asymmetric information in output and financial markets to show that a firm's financial policy may be used strategically in oligopolies. The three essays may be united under the common theme of asymmetric information and strategic financial decisions.

In the first essay, the choice of a lender in a debt contract becomes a determinant of the extent of competition in downstream industries. We show that in the presence of imperfect output markets and asymmetric information in financial markets, members of an industry may achieve a partial collusion in the output market by borrowing from the same bank. In an oligopoly, debt is pro-competitive as it gives incentives to the borrowing firm to undertake an aggressive output strategy. This aggressiveness is translated into an increased output. As both firms borrow, the industry becomes more competitive. The industry also becomes riskier and firms' debt value is decreased. A common lender can better control these incentive effects and hence, limit the extent of competition in the output market. This model finds a natural interpretation in an international trade context. In this framework, the result shows that freeing financial markets from trade barriers may decrease the competitiveness of international oligopolies by allowing firms to borrow from the same lender.
In the second essay, we develop a theoretical link between firms' financial structure and their output market structure. In the presence of asymmetric information about the incumbent's cost level, an incumbent's financial structure may constitute a signal of its efficiency and prevent potential entrants from coming into the market. A market, threatened by entry, is occupied by one of two possible types of incumbent. The firm's type is completely characterized by its cost level. Only the own firm knows with certainty its true type while the entrant and financiers are uncertain of it. Entry is profitable for the entrant if and only if the market is occupied by the high cost type incumbent. The low cost firm chooses a financial structure that credibly distinguishes itself from the high cost incumbent. From the observation of the incumbent's financial policy, the entrant can correctly infer the incumbent's type. If it observes a financial structure consistent with the low cost incumbent's financial strategy, it stays out of the market. Otherwise, it enters. In equilibrium, financial structure allows credible revelation of all private information and entry occurs in the same circumstances as with perfect information.

In the third essay, we give a formal representation of Telser (1966)'s 'deep pocket' argument. We propose that entrants are financially vulnerable because they must signal their value to financiers before entering the market. We assume that there are two possible types of entrant threatening to enter a monopoly market. The entrant's type is parametrized by its cost level. This information is private to each entrant as other players are uncertain of the entrant's true type. Entry is profitable only for the low cost entrant. But if the high cost type can misrepresent as a low cost firm, there exist financial structures which yield positive equity value. The low cost firm must avoid these structures to credibly reveal its type to financiers, secure sufficient funds and finance its entry. In equilibrium, the low cost entrant must issue debt to signal its quality to investors. It enters the market heavily leveraged. This provides incentives for the incumbent to engage in a price war to financially exhaust the entrant and cause its bankruptcy. The price war may be interpreted as the incumbent's predatory response to the entrant's leveraged entry. We argue that a diversified pool of indistinguishable entrants is sufficient to justify the 'deep pocket' argument put forward by Telser (1966). We base our explanation on the presence of asymmetric information in financial and output markets.
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CHAPTER I

INTRODUCTION

This thesis consists of three essays in the theory of Industrial Organization. More specifically, the thesis focuses on the interaction of financial structure and market structure. The intellectual starting point of this thesis is the Modigliani-Miller theorem. Modigliani & Miller (1958) show that in the presence of perfect financial and output markets, financial structure has no effect on the value of the firm. Financial structure becomes irrelevant to investment and output decisions. One condition for markets to be perfect is that all agents must be equally informed of market conditions and actions of the different players involved in the game. The perfectness assumption is quite restrictive in the context of financial relationships and is often relaxed in the prevalent literature. This thesis departs from a Modigliani-Miller economic environment by assuming that firms have more information about their projects than financiers have. In imperfect output markets, this departure from Modigliani-Miller world implies that there may exist important strategic interactions between production and financial decisions. In the three essays of this thesis, we derive theoretical links between financial structure and output market competition.

Recent developments in the theory of games with incomplete information allow us to characterize models in which the perfect information assumption is relaxed. In general, these models are used to show that financial variables may be relevant to the firm's market value. We show that in the presence of asymmetric information in output and financial markets, firms may affect the outcome of various oligopolistic and entry games by choosing an appropriate financial policy. We explicitly introduce financial variables in these types of games to show that they may have an important role to play in the resolution of the output competition. The presence of asymmetric information is usually a sufficient condition for financial structure relevance to the firm's market value. However, this is not necessary. It is shown elsewhere that taxes or bankruptcy costs may also affect financial decisions. Throughout this thesis, we abstract from these important determinants of financial structure to focus on asymmetric information in output and financial markets to show that a firm's financial policy may be used strategically in oligopolies.

There is empirical support for the recent theoretical work on financial structure relevance to output games. By looking at the business press, one can draw inferences that a firm's financial structure is important to investors and financiers. A firm's debt equity ratio is often critical in the investors' assessment of its value. We present several examples of financial structure relevance to a firm's market value. These examples are taken from various
business journals. We consider the case of Versatile Corporation. One of its subsidiaries, Versatile Shipyards Inc., has a letter of intent from the government of Canada to design and build an icebreaker. However, the final contract depends on Versatile Corp. restructuring its finances: the corporation is heavily leveraged. It must be able to provide assurance to shareholders and the government that it is financially stable and apt to complete the ship building contract. To lower its debt equity ratio, Versatile Corp. has sold some of its other subsidiaries. It has also arranged for the sale of $90 million of its secured debt to Hees International Corporation. This transaction is secured by Versatile's last two major assets: 100% of Versatile Shipyards Inc. and 51% of Bralorne Resources Limited. As the corporation's heavy debts put its back against the wall, the deal underlines its willingness to pursue a risky strategy to secure the ship building contract. The sale of assets and the restructuration of its debt increase Versatile's chances of getting the icebreaker contract from the government. In the light of these facts, Versatile's financial structure is clearly relevant to its production strategies and firm's market value. This was reflected in the stock market as the price of its common shares jumped 20 cents to 90 cents following the announcement of the purchase of secured debt by Hees. It takes a longtime to build an icebreaker. Versatile's bankruptcy may be costly to the government in terms of delays. One may speculate that lowering Versatile's debt renders the corporation less vulnerable to bankruptcy and, if awarded, increases its chances of completing the contract.

Hostile takeovers may be avoided by an appropriate restructuration of the debt equity ratio. Takeovers are often perceived as being bad by the prey's managers. Under the threat of a takeover, managers may offer to buy out existing shares from stockholders and to give them a free issue of new stock. To carry out this strategy, the firm borrows enough money to repulse almost any raider. This is known as a leveraged recapitalization. Recently, it has been undertaken by Safeway Inc. and Harcourt, Brace, Jovanovitch and Allegis Corporation. This strategy is successful only if debt renders the raider's prey unattractive. For debt to affect a firm's value, there must exist some imperfections in financial markets such as taxes or bankruptcy costs. The presence of such imperfections may be sufficient to make a leveraged recapitalization successful.

In the oil industry, investors are interested in companies with strong balance sheets and avoid those with heavy debt loads. This is not surprising: given the high variance of the output price, a heavily leveraged company would face a high risk of bankruptcy. But again, it must be the case that financial markets are imperfect for financial structure to matter. With perfect financial markets, heavy debts do not alter the value of the firm. In the event

of bankruptcy, if the firm has positive value, it is refinanced costlessly. If it has negative value, the debt is not renewed and the firm liquidates its assets. In any event, the efficient outcome is reached at no deadweight costs.

These examples illustrate the fact that empirically, financial decisions are an important determinant of the firm's value. A firm's debt equity ratio may affect its production decisions and the value of its assets. In some cases, the economic environment of the industry may impose constraints on the choice of an optimal financial policy. This provides strong empirical motivations for the study of strategic interactions between real and financial variables. This research topic is of fairly recent vintage and much remains to be done to properly understand how firms interact strategically. The present thesis constitutes a small step in this direction.

The three essays may be united under the common theme of asymmetric information and strategic financial decisions. In the first essay, the choice of a lender becomes a determinant of the extent of competition in downstream industries. We show that in the presence of imperfect output markets and asymmetric information in financial markets, members of an industry may achieve a partial collusion in the output market by borrowing from the same bank. In an oligopoly, debt is pro-competitive as it gives incentives to the borrowing firm to undertake an aggressive output strategy. This aggressiveness is translated into an increased output. As both firms borrow, the industry becomes more competitive. The industry also becomes riskier and firms' debt value is decreased. A common lender can better control these incentive effects and hence limit the extent of competition in the output market. This model finds a natural interpretation in an international trade context. In this framework, the result shows that freeing financial markets from trade barriers may decrease the competitiveness of international oligopolies by allowing firms to borrow from the same lender.

The last two essays are closely related. In the Industrial Organization literature, models of entry games are numerous. In many models, financial structure plays an implicit role which is often overlooked in the formal treatment of the model. Sometimes, costly entry deterring strategies are derived in equilibrium without explicit consideration of financial markets. In other cases, financial constraints are exogenously imposed such that entry deterrence becomes a credible strategy. No conditions are given with respect to the economic environment for these assumptions to be plausible or reasonable. We argue that the explicit modelling of firms' financial decisions is often necessary. Financial structure may have a strategic role to play in entry games. In the presence of asymmetric information in output and financial markets, we suggest that financial structure may act as a simultaneous signal of the firm's quality in each market. As a signal to financiers, financial structure provides
the firm with an opportunity to secure funds and finance at actuarially fair prices. The same signal may also be observed by firms in the output market. Thus, financial structure may become an important determinant of the output market structure and competition.

In the second essay, we develop a theoretical link between firms' financial structure and their output market structure. In the presence of asymmetric information about the incumbent's cost level, an incumbent's financial structure may constitute a signal of its efficiency and prevent potential entrants from coming into the market. A market, threatened by entry, is occupied by one of two possible types of incumbent. The firm's type is completely characterized by its cost level. Only the own firm knows with certainty its true type while the entrant and financiers are uncertain of it. Entry is profitable for the entrant if and only if the market is occupied by the high cost type incumbent. The low cost firm chooses a financial structure that credibly distinguishes itself from the high cost incumbent. From the observation of the incumbent's financial policy, the entrant can correctly infer the incumbent's type. If it observes a financial structure consistent with the low cost incumbent's financial strategy, it stays out of the market. Otherwise it enters. In equilibrium, financial structure allows credible revelation of all private information and entry occurs in the same circumstances as with perfect information.

In the third essay, we give a formal representation of Telser (1966)'s 'deep pocket' argument. He proposes that if entrants are financially vulnerable, the incumbent preys upon them to exhaust their financial resources and induce their exit from the market. It is argued that such a story cannot hold with perfect financial markets. If entry is a profitable strategy, entrants should always be able to secure funds to finance it. Even if predation lowers the profitability of entry, it is equally costly to the predator. Hence, it is usually a short-lasting strategy. Predation should not affect the long run profitability of entry. With perfect financial markets, the entrant's financial weakness cannot be explained in a satisfactory manner. Despite this criticism, Telser's argument is still often invoked to justify predation. However, to our knowledge, no satisfactory formal representation of it has been offered. We try to fill this gap with our third essay.

We assume that there are two possible types of entrant threatening to enter a monopoly market. The entrant's type is parametrized by its cost level. This information is private to each entrant as other players are uncertain of the entrant's true type. Entry is profitable only for the low cost entrant. But if the high cost type can misrepresent as a low cost firm, there exist financial structures which yield positive equity value. The low cost firm must avoid these structures to credibly reveal its type to financiers, secure sufficient funds and finance its entry. In equilibrium, the low cost entrant must issue debt to signal its quality to investors. It enters the market heavily leveraged. This provides incentives for
the incumbent to engage in a price war to financially exhaust the entrant and cause its bankruptcy. The price war may be interpreted as the incumbent's predatory response to the entrant's leveraged entry. We argue that a diversified pool of indistinguishable entrants is sufficient to justify the 'deep pocket' argument put forward by Telser (1966). We base our explanation on the presence of asymmetric information in financial and output markets.

In the last two essays, financial signalling plays a crucial role in equilibrium. It confers a strategic advantage to the high quality firm in the output competition by truthfully revealing its type to other agents. This signal is called dissipative as resources are devoted to its production. The high quality firm must engage in some costly activity to credibly distinguish itself from the low quality firm. The costs of this activity are such that misrepresentation by the low quality firm is not profitable. In equilibrium, the same market structure as with perfect information is achieved. However, the distribution of rents among players is different as the signal is costly for the high quality firm.

In the next chapter, we survey the pertinent literature in Industrial Organization and Financial Economics and relate it to the three essays. Then, we present in turn the three essays in the following three chapters. The first essay studies the collusive incentives of concentrated banking contracts in oligopolistic industries. In the second essay, we link theoretically the output market structure to the incumbent's financial structure. In the last essay, we give a formal justification for Telser (1966)'s 'deep pocket' argument. The conclusion follows.
CHAPTER II
SURVEY OF THE LITERATURE

1. Introduction

This thesis is concerned with potential strategic interactions between the firm's production and financial decisions. In the presence of asymmetric information in financial markets, the firm's financial structure becomes relevant to its market valuation. In imperfect output markets, firms may use their financial structure strategically and affect the output market competition. This thesis belongs to the field of Industrial Organization as we study the strategic implications of different financial instruments. We show that an appropriate choice of a financial policy may affect the extent of competition in the output market. It also belongs to Financial Economics as we take explicitly into account financial decisions in strategic games to motivate firms' financial choices. Interactions between financial and production decisions are caused by the presence of asymmetric information in financial markets. In the first essay, we characterize the collusive properties of the choice of a lender in a duopoly. In the last two essays, we model entry games characterized by asymmetric information in financial and output markets, explicitly considering how financial structure may affect their outcome.

This survey is structured as follows. To put this thesis in perspective with respect to the existing literature, we survey in Section 2 the main articles on informational problems in financial markets. As a first step, we study the impact of asymmetric information on financial markets, abstracting from all strategic interactions between production and financial decisions. The presence of asymmetric information alters the organization and complexion of financial markets. We show that these informational problems can create incentives for firms to deviate from the optimal production plan. Financiers anticipate the firm's incentives and price its securities accordingly. In other cases, control or sorting devices may be used to eliminate informational problems. Collateral, long term relationships and signalling represent such mechanisms. These three types of mechanisms are studied in turn below. The subsection on financial signalling is particularly relevant to the last two essays in which we show that financial signalling may have a strategic value.

In Section 3, we introduce imperfect output markets in the analysis of financial markets. In oligopolies, firms have incentives to play strategically. In the presence of asymmetric information in financial markets, firms may use their financial policy to influence the extent of competition in the output market. In various oligopoly games, it is shown that financial structure may affect the output competition. Firms anticipate these effects when they
choose their financial policy. They may use their financial choices strategically to influence the output market competition to their advantage. This confers a strategic role to financial policies. There is a growing literature on this topic which is surveyed in Section 3. The survey draws a contrast between existing papers and this thesis. In our three essays, we use the assumption of imperfect information in financial and output markets to derive strategic properties of financial decisions.

To underline the contribution of our last two essays, it is necessary to present a survey of the treatment of entry games in Industrial Organization. In these entry games, financial markets play an important, often silent, role. In most papers, the author abstracts from the financial side of the firm. Entry deterring and predatory strategies are derived in equilibrium. These strategies are usually costly for the entry deterring or preying firm. Abstracting from the financial side of the firm may be more than a trivial simplification. In Section 4, we present a brief survey of the relevant literature on entry games. The conclusion follows.

2. Imperfect Information in Financial Markets

In this section, we focus on informational problems in financial markets to provide formal explanations for the relevance of financial decisions to firms’ market valuation. We temporarily abstract from strategic interactions between production and financial decisions. In this section, a firm may be seen as a competitive productive unit. This firm owns a project requiring external financing. The owner or manager of a financed project typically possesses more information about the project’s quality than outside investors. This may create adverse incentives in the financial relationship and affect the security’s price or even the availability of funds. These incentives may also affect the firm’s financial choices. In this case, financial structure is not an arbitrary choice and is determined by the nature of the incentives induced by the informational problems. We plan to focus on informational problems in financial markets to derive their effects on the determination of firm’s financial choices. Some important determinants of the financial policy are abstracted from (taxes, bankruptcy costs, etc.). The effects of these factors on financial choices are well known and abstracting from them helps us to focus on the effects of asymmetric information.

In the finance literature, a firm is often seen as a collection of relationships between managers, stockholders and debtholders. These relationships between managers, stockholders and debtholders are called agency relationships. In most models of financial contracts,
stockholders act as agents of debtholders. If this is the case, debtholders may be seen as principals for stockholders. In many cases, these relationships are characterized by asymmetries in the distribution of the relevant information. These asymmetries may be the result of the non-observability of a parameter of the firm's profitability, of the non-enforceability of the stockholders or managers' actions, or similarly, the result of the difficulty to monitor the owners' behaviour. Because of these asymmetries, financial contracts are often characterized by adverse incentive effects, creating a dependence of the quality of the asset on its price (Akerlof, 1970).

With imperfect information or control of the agent's actions, the firm's financial policy may give incentives to the agent, the stockholders, to deviate from the optimal production plan. Even if this raises the value of the firm accruing to shareholders, it may decrease the aggregate firm's value. This generates costs which are called agency costs. In the presence of competitive financial markets, these costs are borne by the firm's initial shareholders. They choose the financial policy that minimizes agency costs (Jensen & Meckling, 1976). This provides a formal explanation for the existence of an optimal debt-equity ratio.

Informational problems lower the firm's value. Myers (1984) suggests a 'pecking order' of different financing means. Myers (1984) claims that risky debt is less costly to use than equity and is thus preferred by project owners. This partial ordering is supported by Stiglitz (1985a). Although debt may result in valuable market opportunities being passed over (Myers, 1977), it may still be preferred to equity. Issuing new shares may have adverse effects on equity markets which are costly to the emitting firm (Myers & Majluf, 1984).

In the credit market, the riskiness of a pool of applicants becomes dependent on the market equilibrium interest rate. The relationship between price and quality affects the equilibrium in two ways. First, rationing may occur in equilibrium: at the quoted interest rate, the demand for loans exceeds the quantity the banks are willing to supply. Second, with different distinguishable groups of borrowers, we may have more than one equilibrium price. The Law of Supply and Demand does not hold in the usual way, as the price mechanism may fail to clear the market.

The literature on credit rationing is extensive considering its fairly recent development. It has mostly concentrated on the treatment of loan markets. We reserve some comments on 'equity rationing' to the end. There are some major motivations for studying credit rationing. The first is to understand the failure of the Walrasian auction to clear the market in the presence of asymmetric information. Economists are preoccupied by the impact of asymmetric information on the efficiency of markets and the credit market is one example we also abstract from the fact that there may be many stockholders or debtholders. Each type of securityholder is treated as a single economic agent.
of an economic environment characterized by asymmetric information. But this study may be applied to many other markets as well. For a comprehensive survey, see Stiglitz (1985b).

Secondly, economists are motivated by the macroeconomic implications of credit rationing. With asymmetric information, restraining credit is likely to affect the supply of loans more than the interest rate. This could affect the effectiveness of the monetary policy. An exogenous shock on the LM curve which increases the risk-free interest rate may cause the collapse of a segment of the credit market, thus generating social costs. This is shown to be the case by Mankiw (1986) in a model of the student loan market. He argues that government intervention is warranted to prevent such collapses resulting in the loss of the surplus generated by the market. These macroeconomic implications will appear clearer as we proceed with this survey. Understanding how asymmetric information affects the optimal financial structure constitutes a third motivation behind the studies of credit rationing.

We find in the literature two types of rationing. The first type represents rationing on the number of loans: among ex ante undistinguishable borrowers, some do receive credit, others do not. This type is referred to as ‘true rationing’ by Stiglitz & Weiss (1981). True rationing is the consequence of the assumption that the investment project has fixed size. If we assume that the investment has variable size and is risky, the debt contract may entail rationing on the size of the loan. In this case, all entrepreneurs obtain funds but the loan they get may be smaller than the amount they would borrow given the equilibrium interest rate. This type of rationing is described in Jaffee & Russell (1976). Gale & Hellwig (1985) propose that rationing is more likely to occur on the size of the loan since any firm being completely rationed would eventually obtain funds by visiting many banks. In their model, the riskiness of the loan comes from the size of the investment. They show that the first best (perfect information) level of investment exceeds the second best (imperfect information) level. This is due to the incentive effects of the size of the loan: as the size of the loan increases, borrowers opt for riskier projects. Banks ration credit and firms cannot invest as much as they want. We follow Stiglitz & Weiss (1981) in assuming a fixed investment project and look at the conditions for ‘true rationing’ to occur.

Informational asymmetries can affect the efficiency of financial markets, which in turn alters production plans. There are mechanisms and sorting devices that facilitate the transmission of information credibly from the firm to its investors. This permits financiers to achieve better control of their contracts. Depending on the type of asymmetry present, collateral, long term relationships and financial signalling can lead to an improvement in the efficiency of financial relationships. These sorting devices are studied in turn at the end of this section.

We now present a simple model of a credit relationship to structure the presentation
of the different concepts presented in the literature. There are many two-point projects yielding random returns of 0 or \( R \). These projects are characterized by the high return \( R \).

A firm chooses its most preferred project by picking \( R \). The firm must borrow one dollar to finance the project. A bank agrees to sign a one period\(^6\) debt contract with the firm. The bank is assumed to be incapable of observing the project chosen by the firm. The non-observability of the project creates an asymmetry in the relationship: the bank cannot monitor the project or impose its choice to the entrepreneur. The interest rate on this loan is \( r \). We assume for now that if the borrower has sufficient funds at the end of the period, it has to repay the loan (interest and capital). Default occurs when the value of the return is 0 and thus is not sufficient to reimburse the debt. In this case, the lender becomes the project's residual claimant. The probability of default is \( 1 - p(R) \) with \( p'(R) < 0 \) and for simplicity, \( p''(R) = 0 \). This last assumption means that projects with higher returns have a higher probability of bankruptcy. We call these projects 'risky'. All players are risk neutral.

The borrower's expected profits (equity value) are:

\[
E\Pi = \max\{ R - (1 + r), 0 \}
\]

The lender's expected returns (debt value) are:

\[
E\rho = \min\{ 1 + r, R \}
\]

Under these assumptions, each agent's returns look like the curves depicted in Figure 1. Even with risk neutrality, the limited liability of borrowers alters the agent's return function. The borrower has now a convex profit function, while the lender's return function becomes concave. This means that agents have different attitudes towards the riskiness of the chosen project. Since borrowers only care about the higher tail of the distribution of the project's returns, they tend to prefer high risk projects. Lenders' returns are bounded above by the interest rate. They are only interested in the lower tail of the distribution of the project's returns. Hence, they prefer low risk projects. This difference in attitude towards risk is at the origin of the conflict between borrowers and lenders.

The banking industry acts as an intermediary between borrowers and depositors of funds. We assume that the credit industry is competitive. Hence, banks earn zero profit in equilibrium. We consider two concepts of competition for our industry. In one case, banks compete for depositors. The debt contract maximizes the bank's expected returns and the rate paid on deposits adjusts competitively such that banks earn zero profit in equilibrium. Depositors have market power and extract all rents from lenders through the interest rate paid on deposits. Under the second concept, the supply of funds is perfectly elastic.

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\(^6\) Most papers restrict their attention to short term debt contracts. We survey long term relationships below.
FIGURE 1
Borrower's and Lender's Return in a Debt Contract

and lenders compete for borrowers. The cost of funds is exogenous and the debt contract maximizes the borrower's expected profits subject to a zero profit constraint for the bank. We show below the implications of these assumptions for the extent of credit rationing. We present the analysis in two parts. In the first part, we assume away any control or sorting mechanisms of the firm's actions. We show the implications of information problems on functioning of financial markets. In the second part, we modify the economic environment to allow banks to use control and selection devices in the debt contract to reduce the adverse effects of informational asymmetries.
2.1 Absence of Control or Sorting Devices

In this section, we analyse the consequences of informational asymmetries assuming away all sorting or control devices. This section is particularly relevant to our first essay in which we model a similar financial environment. The results of this essay rely on the incentive effects of the interest rate in debt contracts. As the interest rate increases, the entrepreneur chooses riskier projects. The intuition behind this result is explained below.

We assume that the firm picks the project $R$ to maximize the value of its equity:

$$\max_{R} p(R) \{ R - (1 + r) \}$$  \hspace{1cm} (2.3)

The First Order Condition (FOC) is:

$$p' \{ R^\ast - (1 + r) \} + p(R^\ast) = 0$$  \hspace{1cm} (2.4)

The Second Order Condition (SOC) is satisfied: $2p' < 0$. Totally differentiating the FOC (2.4), we obtain:

$$\frac{dR^\ast}{dr} = \frac{p'}{2p'} > 0$$  \hspace{1cm} (2.5)

As the interest rate increases, the firm opts for a higher return project. The marginal cost of increasing $R$ is to face a riskier project and lose $R - (1+r)$. If the interest rate increases, this cost becomes smaller. The firm chooses a project with a higher probability of default. As seen in Figure 1, because of the limited liability clause, the borrower effectively becomes a risk lover. Hence, as the interest rate goes up, the riskiness of the financed project increases. This type of incentives created by the interest rate is often referred to as moral hazard.

Higher interest rates may also result in adverse selections in the pool of borrowers of a lender. Suppose that we have two types of entrepreneur: type $a$ is the safe type while type $b$ can only invest in a risky project, i.e., $p^a(R^a) > p^b(R^b)$ and $R^a < R^b$. Suppose their respective equity is valued equally:

$$m^a = p^a \{ R^a - (1 + r) \} = p^b \{ R^b - (1 + r) \} = M$$  \hspace{1cm} (2.6)

We can compute the impact of the interest rate on the value of equity of these two projects:

$$\frac{dE\Pi^i}{dr} = -p^i \hspace{1cm} i = a, b$$  \hspace{1cm} (2.7)

The safe project suffers more from an increase in the interest rate than the risky project. Since $p^a > p^b$, as the lending rate increases, the safe projects drop out of the loan market before the risky ones. This increases the riskiness of the lender’s pool of borrowers.

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Due to adverse selection and moral hazard, increases in the interest rate alter the riskiness of the undertaken projects by entrepreneurs. The bank is sensitive to the level of risk of projects it finances. The expected value of the debt is:

\[ \rho(r) = p(R)(1 + r) \]  

Maximization by choice of \( r \) gives the following FOC:

\[ \frac{d\rho}{dr} = p(R^*(r)) + p' \frac{dR^*}{dr} = 0 \]  

The first term represents the marginal profit due to an increase in interest payments. The second term reflects the drop in profits due to an increase in the riskiness of the project. It illustrates the bank’s lack of control on the firm’s actions. If the bank has full control, the interest rate has no effect on the choice of financed projects. The bank would maximize (2.8) with respect to \( r \) and \( R \), imposing its choice of project to the firm. But the information structure precludes the bank from doing this.

In (2.9), it is possible that the extra profits from an increase in the lending rate be more than offset by an increase in the riskiness of the project. Because of this possibility, the bank’s return function may not be monotonic. If banks compete for depositors (first concept of competition), the lender’s supply of funds, \( L' \), is non-monotonic, as shown in Figure 2a.7 In the fourth quadrant, we have the lender’s return as function of the interest rate. In the third quadrant, the supply of funds is determined as a function of the rate of return paid on deposits which is equal to the bank’s return. In the first quadrant, the supply of loans can be determined as a function of the interest rate. Then, we can characterize the loan market equilibrium. Banks maximize their return by charging \( r^* \). This rate determines the supply of funds \( L' \). The Walrasian rate for which the demand for loans equals the supply is \( r^w \). Rationing occurs if the Walrasian interest rate, \( r^w \), is larger than \( r^* = \text{argmax } \rho(r) \). The bank prefers to charge \( r^* \) and ration credit rather than increase its rate to clear the market and by so doing, lower its returns by augmenting the riskiness of its loans. The extent of rationing is determined by the distance \( L^D - L' \). As is made clear by the figure, it is important to note that credit rationing is not necessarily present in credit markets. If \( r^* \geq r^w \), no rationing occurs in equilibrium even when banks compete for depositors. Models have been constructed in which rationing emerges in equilibrium. But to characterize such an equilibrium, one has to consider both sides of the market: the demand for loans as well as the supply of funds from deposits. Williamson (1987) derives such a model which allows to represent the extent of rationing in credit markets.

If banks compete for projects and face an elastic supply of funds, the loan supply becomes perfectly elastic even if the bank has non-monotonic returns. This is illustrated

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7 This figure is taken from Stiglits and Weiss (1981).
FIGURE 2
Loan Market Equilibrium

2a. Competition for Deposits

2b. Competition for Projects
in Figure 2b. No rationing occurs in equilibrium. In this case, \( r^w = r^* \). Banks have access to an unlimited supply of funds at the equilibrium market rate. They agree to finance any project yielding a return at least equal to the cost of funds. Hence, there is no rationing in equilibrium.  

In Williamson (1987), moral hazard and adverse selection are absent. In our previous model, we assume that a borrower has to repay the loan if its project is successful. Or similarly, one may assume that the lender can observe costlessly if the project is successful or not, without being able to observe its exact return. In Williamson's model, the lender cannot observe freely if the project is successful or not and the borrower is not obliged to repay the loan even if it is successful. Every borrower has the same unique investment opportunity. The return on the investment is distributed over an interval \([0, R_0]\). Ex post, in case of default on the loan, the lender may incur a cost \( c \) to observe and keep the return from the project. These monitoring costs create an ex post asymmetry between the lender and the borrower (while before, the asymmetry was ex ante). Default occurs when the realization of \( R \) cannot cover the debt \( 1 + r \). As the interest rate increases, the probability of default increases and thus the expected monitoring costs rise. This increase may offset larger expected interest payments. In this case, the bank may have a non-monotonic return function and rationing becomes a possibility, as illustrated in Figure 2a.

In summary, asymmetric information is not a sufficient condition for credit rationing to occur. Further, the asymmetry does not have to be ex ante, which means that moral hazard or adverse selection effects are not necessary for the presence of credit rationing. Ex post asymmetries may also generate equilibrium rationing. Rationing may occur if banks compete for deposits and face an upward sloping supply of funds curve. As the supply of funds increases, the extent of rationing decreases and eventually disappears. If the supply of funds is perfectly elastic, no rationing occurs as every borrower is able to obtain a loan. The rationing equilibrium is competitive. Having a large number of banks all earning zero profit is consistent with credit rationing. It is a consequence of lenders being profit maximizers. Even with a large number of lending firms, rationing may still persist as no bank is willing to increase its lending rate to clear the market. Doing so would result in loss of profits: a bank increasing its rate lowers its returns and is not able to pay the rate required by the depositors. It loses its sources of funds and has to withdraw from the market.

In Garella & Gabszewicz (1984), there are only two banks in the industry. However, Bertrand type competition drives their profits down to zero. There are two types of borrower: safe and risky. If both banks face the same information set ex ante, then a Nash equilibrium exists. But if one bank has superior information, no equilibrium exists.

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8 We show below that if collateral is used, rationing becomes a possibility even with an elastic supply of funds.
as the informed bank always tries to take advantage of its better information rendering any potential equilibrium unsustainable. They suggest that there exist strong incentives for banks to cooperate since every equilibrium yields zero profit. Cooperation is easier to achieve in a concentrated banking industry. In our first essay, we show how the correlation of the borrowers’ returns facilitates an implicit collusion of the output market by concentrating financial institutions. This also allows banks to increase their returns.

At this point, there are two questions one may ask. First, what is the empirical importance of credit rationing? As pointed out by Stiglitz & Weiss (1985) and Baltensperger & Devinney (1985), and proven formally by Riley (1986), true rationing hits only the marginal group of borrowers among distinguishable groups. For a given deposit rate, every low risk group obtains credit. Every high risk group is cut off from the market as it cannot generate a high enough expected return for the bank. Only the marginal group may experience rationing depending on the availability of funds. Empirically, the extent of rationing may not be important. These remarks lead us to the second question: can rationing be eliminated by the use of sorting mechanisms such as collateral, long term relationships or signals sent by borrowers. These sorting devices may increase the bank’s effective control over its borrowers’ actions, reducing their incentives and the extent of rationing. We study in turn these three possibilities in the following subsections.

2.2 Introduction of Collateral

Although the next two subsections are not directly relevant to our research, they are included for completeness and by way of comparison with the subsection on financial signalling which is related to our last two essays.

In order to secure a loan, a bank may require that borrowers put up some assets as collateral against the loan. In case of default on the loan, the bank keeps the collateral put up by the firm. Collateral increases the cost of bankruptcy of borrowers. It has some positive effects on the firm’s incentives. With collateral, the borrowers’ expected profits are:

\[ E\Pi = \max \{ R - (1 + r), -C \} \]

where \( C \) is the collateral specified by the debt contract. The FOC to (2.10) is:

\[ p' [ R^* - (1 + r) + C ] + p(R^*) = 0 \]

This yields the following comparative statics result:

\[ \frac{dR^*}{dC} = \frac{-p'}{2p'} < 0 \]

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Collateral has positive incentive effects on the riskiness of the chosen project. Note that the derivative in (2.12) is equal in value and opposite in sign to the interest rate effect computed in (2.5). Increasing the collateral by one dollar is equivalent to decreasing the debt by a dollar for controlling the firm’s incentives. This suggests that collateral and equity are close substitutes in financing of projects.

Collateral may also have an impact on the quality of the pool of borrowers. Wette (1983) shows that collateral may have adverse selection effects when all agents are risk neutral. This is illustrated in Figure 3.\(^9\) An increase in collateral from \(C_1\) to \(C_2\) reduces profits in the lower part of the distribution. Hence some low profit projects may become unprofitable. Because of the limited liability clause, expected profits are a convex function of the project’s return. Hence, expected profits increase with risk. This means that low profit, low risk projects may be abandoned by entrepreneurs as a result of the increase in collateral. Thus, collateral may increase the riskiness of the pool of borrowers. Stiglitz & Weiss (1981) derive a similar result assuming increasing borrowers’ risk aversion. Collateral may have adverse selection effects if wealthy individuals undertake riskier projects. If the required amount of collateral cannot be afforded by poor entrepreneurs, they may be excluded from the credit market, thus increasing the average riskiness of the pool of borrowers. These adverse selection effects of collateral may potentially offset its positive incentive effects and lower the value of debt. This may restrict the use of collateral in debt contracts.

In the above models, uninformed agents, banks, move first. They offer a single debt contract to all agents. Borrowers either accept or reject the proposed contract. Collateral is not used to sort borrowers. In more sophisticated models of credit markets, collateral constitutes an additional tool used by banks to sort borrowers. Informed agents, borrowers, move first. Each type of borrower may demand a different debt contract to distinguish itself from other types. In some equilibria, different types of borrower select different debt contracts. Private information is revealed through financial choices. Banks can sort borrowers by observing their financial choices. To sort borrowers, there must be at least two variables in the debt contract. The interest rate in conjunction with collateral constitute a valid debt contract with potential sorting properties.

Assuming a perfectly elastic supply of funds (second concept of competition in which banks compete for borrowers), Besanko & Thakor (1984) and Bester (1985) show that there exists a perfect sorting equilibrium if the required collateral is not constrained by the wealth of the borrowers, i.e., all borrowers can afford the equilibrium level of collateral. Low risk borrowers have a low probability of bankruptcy. They have a good chance of being able to pay back the loan. Hence, they opt for a contract with low interest rate and high collateral.

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\(9\) This figure is taken from Wette (1983).
requirements. High risk individuals face a high probability of bankruptcy. There is a good chance that they go bankrupt and lose the collateral. They prefer a contract with high interest rate and low or null collateral. Neither type gains from misrepresenting as being the other type. If banks compete for borrowers, collateral serves as a perfect sorting function and eliminates rationing at each contract.

However, there exist conditions for which collateral does not perfectly sort borrowers. In the same paper, Besanko & Thakor (1984) show that if collateral is constrained by the borrower's wealth, rationing may occur. In equilibrium, the bank reduces the collateral required from low risk individuals. This new contract attracts some high risk borrowers and the bank has to ration credit at this new contract to keep high risk people indifferent between their original contract and this new contract granted to low risk borrowers. Thus, rationing may persist even with an elastic supply of funds. In this case, low risk borrowers are rationed. Whether some borrowers are constrained by the equilibrium level of collateral is an empirical question.

Stiglitz & Weiss (1985) assume that borrowers are risk averse. As before, collateral has some positive incentive effects but also potential adverse selection effects. They assume

\[ (1+r-C_2) \quad (1+r-C_1) \quad (1+r) \]

\[ (1+r-C) \]

\[ 45^\circ \]

In the previous section, we show that with an elastic supply of funds, no rationing occurs. The use of collateral may reverse this conclusion.
that banks compete for deposits (first concept of competition), and define two types of borrower: rich and poor. Stiglitz & Weiss show that there exists an equilibrium in which poor and rich borrowers have the same debt contract. No private information is revealed through financial choices. Such an equilibrium is called 'pooling'. The pooling equilibrium level of collateral is at the maximum level a poor borrower can offer. They show that this equilibrium entails some rationing. There also exists an equilibrium in which each type of borrower chooses a different debt contract. This choice of contract reveals all private information as each type can be distinguished in equilibrium. This type of equilibrium is called 'separating'. The separating equilibrium is characterized by rationing at every contract. In this case, collateral worsens the rationing problem. Without collateral, only the marginal group may experience credit rationing. The introduction of collateral may extend rationing to all distinguishable groups of borrowers.

Three conclusions can be drawn from the analysis of collateral. First, it is hard to judge the efficiency of collateral in credit contracts. There exist conditions in which it acts as a perfect screening mechanism and no rationing occurs. There are also conditions for which rationing prevails and its extent may even be worse than without collateral.

The second conclusion is drawn from Bester (1985):

"Signalling mechanisms eliminate demand rationing in competitive equilibrium. This suggests that theories which attempt to explain rationing by adverse selection effects also have to provide an explanation why screening devices cannot be adopted."

Thirdly, the existence of separating equilibria shows one consequence of the presence of asymmetric information in credit markets. More than one equilibrium price can prevail on the market as, in conjunction with collateral, interest rates serve sorting purposes. For ex ante undistinguishable projects, there may be more than one quoted interest rate. By their choice of a debt contract, entrepreneurs fully reveal their type in equilibrium. A multiprice system serves to sort different types of borrowers.

Finally, we note that the different equilibria summarized in this section are usually not of the Nash type. With asymmetric information, pooling or separating Nash equilibria may not exist. The concept of equilibrium has to be extended. The different authors often use the notion of a Wilson Anticipatory Equilibrium (WAE). A contract is a WAE if no new contract exists which, if offered, makes positive profits even when all contracts losing money as a result of this entry are withdrawn. Contrary to a Nash equilibrium, a WAE allows for some reaction by other players to the newly offered contract. A WAE rules out free entry or the possibility of hit and run. To rationalize the use of the WAE concept, one can think
of small sunk costs associated with the production of a new contract.

Allen (1981) asks the question whether collateral is a valid solution to the problem of rationing. He argues that collateral can restrict the access to credit markets to wealthier borrowers. If behaviour or returns are correlated through time, default becomes a signal of future defaults. As a result, defaulters are denied credit in future periods and there is no need for collateral. The threat of cutting the credit line in the future would serve the purpose of controlling borrowers' incentives. The next section looks at multiperiod models.

2.3 Long Term Relationships

Conceptual problems arise in the treatment of multiperiod financial relationships. Assumptions have to be made to determine what happens following bankruptcy. Is the defaulter allowed to come back? At what cost? What is the information structure characterizing the firm-financiers relationship? Some authors (Stiglitz & Weiss, 1983 and Allen, 1983) assume that the borrower is liable for all past loans. A lender chooses not lend to past defaulters as their solvability is seriously questioned. Giammarino (1985) proposes a model of financial distress with asymmetric information about the firm's value between the firm and its creditor. In the event of bankruptcy, the parties involved in the debt contract may negotiate a reorganization of the firm's financial structure. It is shown that there are circumstances in which deadweight bankruptcy costs cannot be avoided. This is the direct consequence of imperfect information present in the model. Despite these contributions, the theory of long term credit relationships is still at an early stage. It is one of the reasons why most authors consider one period models. This section summarizes some contributions to the theory of multiperiod financial contracts.

Collateral is a means of increasing the bank's control in the measure that it constitutes a punishment for the defaulter. As argued above, collateral may have some adverse selection effects. If the lender is able to link many periods in the debt contract, the borrower's future rents may be used as a threat to control incentives. The creditors may link the present to the future through reputational effects or long term explicit contracts.

Reputation effects are relied upon mostly when legal enforcement of quality is not feasible or when the cost of writing a contingent contract is prohibitive. They are effective if some future rents are threatened. If an agent does not care about the future, he does not expand any resources to establish a reputation. A necessary condition for reputation effects

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11 One may suggest that banks require larger equity commitments and lower collateral from the borrower; however, Stiglitz & Weiss (1985) show that this additional tool has no effect on the bank's returns, if collateral is already used. Hence equity requirements are redundant instruments when collateral is already used.
to take place is that agents' characteristics are correlated in time such that behaviour today carries some information about future behaviour or actions.

In general, the punishment in the event of bankruptcy is endogenous to the credit relationship. Allen (1983) assumes that old debts must be reimbursed before new debts can be serviced. As a result, in an infinite period model, defaulters are denied access to credit in the future. The threatened future rents (or punishment to defaulters) are endogenous and represent the value of future loans in terms of production. At least two periods are usually required for the punishment to be endogenized in the problem. In our third essay, to avoid all difficulties of multiperiod financial contracts, we assume that bankruptcy costs are exogenous. This allows us to shrink the model to a one period framework.

Spatt (1985) builds a two period model where banks live one period and borrowers, two periods. Their returns are positively correlated for both periods. In this setting, since they live only one period, banks cannot punish their defaulters in the second period. Default in the first period is observed by new banks in the second period. This conveys statistical information about the borrower's quality. The punishment to defaulters becomes an endogenous market response. It may take the form of a higher interest rate in the second period or simply rationing of credit. Considering the punishment they face, borrowers may still decide to default in the first period even if they have enough liquidity. This may happen if they get a bad draw in the first period and as a consequence do not expect much from second period returns. These returns represent the expected punishment. If they are expectedly low, borrowers do not care about the reputation they establish by defaulting. In this model, the penalties to default as well as the incentives to establish a reputation are endogenous.

If legal enforcement of quality is feasible, explicit contracts may apply to more general situations than reputational effects: for instance, for an explicit contract to be feasible, no correlation is needed between periods. But a contract is effective if some future rents are threatened. In Stiglitz & Weiss (1983), a bank offers two period contingent contracts. In equilibrium, if the borrower defaults in the first period, he faces a probability of being rationed in the second period. Even if he can obtain a loan, he pays a higher interest rate than if he had not defaulted in the initial period. The bank's ability of linking two periods by writing such a contract enables it to charge a higher interest rate in the first period without altering the firm's incentives. The threat of termination (rationing) is effective if rationed borrowers cannot move freely to another lender. This can be achieved by limiting the ex post competition. For example, as in Allen (1983), past loans may be assumed to have seniority over current and future contracts. In this case, no lender is willing to lend to a first period defaulter even if he is believed to be more efficient than a first time borrower.
In this model, the penalties for default are of the same type as in the reputation models. However, borrowers' returns need not be correlated in time.

As seen in this section, credit rationing may become an optimal response in a multi-period setting. The threat of termination of a principal-agent relationship, implicit (as in a reputation model) or explicit (as in a contracting model), constitutes an additional tool to control the agent's incentives. However, as with collateral, credit rationing is not necessarily eliminated from long term debt contracts. In the case of collateral, it may worsen the extent of rationing, while intertemporal links can provide a motivation for rationing by punishing past defaulters. Note also that there is no guarantee that first time borrowers are not rationed as two period contracts need not to be available to every applicant. This would depend on the type of competition in the credit industry and the availability of funds.

Collateral and long term relationships are means of reducing the moral hazard inherent in the credit relationship. If only adverse selection problems are present, the financial policy adopted by the firm may have signalling properties and contribute to the sorting of different types of borrower. The next section is devoted to financial signalling.

2.4 Financial Signalling

In this section, we assume that there are at least two types of borrower which are undistinguishable ex ante. The literature on financial signalling is concerned with the characterization of equilibria in which financial choices perfectly sort borrowers. In equilibrium, all private information becomes public knowledge through the choice of a financial policy. As mentioned above, this situation corresponds to a separating equilibrium. When outside investors are uninformed of the firm's true value (and insiders are), it is in the interest of high value firms to credibly signal their quality to financial markets to avoid misrepresentation by low value firms. A credible signal permits actuarially fair pricing of each firm's securities. A signal is credible if it imposes deadweight costs on the firm trying to send a false signal (to misrepresent). However, the signal does not have to be costly for firms sending it to truthfully reveal their value.

This section is particularly relevant to our last two essays. In an entry game, each player has private information about its type. We show that financial signalling, by separating firms in financial markets, has a strategic value as it also conveys information to the output market, and thus affects the resulting output equilibrium. In this section, signalling sorts firms but has no strategic value. The output market is introduced only to generate random returns. In our essays, these same returns are in turn affected by the firm's financial choices.

There are two kinds of signalling models. In the first class of models, signalling is
costly (dissipative signalling). The sender incurs costs to signal its true value. In Leland & Pyle (1977), the entrepreneur's financial contribution to his own project constitutes the signal of the project's value. Owners of good projects must invest more than they otherwise would in their own project to signal their value to outside investors. Owners of bad projects do not want to invest that much in their own project even if they were mistaken for owners of good projects. In this case, the signal is credible and separation of both types of project occurs in equilibrium. Since entrepreneurs are risk averse, this lack of diversification represents the cost of revealing the project's true value. In Bhattacharya (1979), the level of dividends conveys information to the market about future cash flows. High value firms give large dividend pay out to shareholders to signal their value to financiers. Signalling costs come from the fact that dividends are taxed at higher rates than capital gains. In these models, a signalling equilibrium exists when the gain from truthfully revealing its private information exceeds the signalling costs.

The second class consists of models with costless (non-dissipative) signalling. In these models, truthful signalling is costless but misrepresentation is costly. In equilibrium, no false signal occurs and signalling remains costless. In Ross (1977), shareholders provide the firm's manager with a payment incentive schedule contingent on the solvency of the firm. In the event of default, bankruptcy costs are imposed on him. The manager chooses the firm's debt level to maximize its remuneration. The manager's incentive schedule is such that when he maximizes his return, the chosen financial structure reveals the true value of the firm to outside investors. The high value firm's manager picks a debt level such that it would bring bankruptcy to a low value firm trying to misrepresent. This makes misrepresentation a non-profitable strategy for the low value firm's manager. Consequently, the debt level reveals the true value of the firm. When returns are non-stochastic, signalling is costless since no default occurs in equilibrium. As pointed out by Bhattacharya (1979), bankruptcy costs also have to be imposed on shareholders, otherwise they may pay the manager to give a false signal and realize an immediate capital gain.

Bhattacharya (1980) presents a different version of his (1979) dividend model. Dividends remain a signal of future cash flow. But the assumption of tax differentials between dividends and capital gains is removed. This implies that signalling becomes costless. Misrepresentation is not profitable for low value firms: if they announce a large dividend payment (like do high value firms), they must make up the difference between their cash flow and the promised dividend. This is assumed to be costly. Hence false signalling does not occur in equilibrium. Signalling is costless for high value firms since they can meet the promised dividend pay out.

Heinkel (1982) builds a model with costless signalling. He assumes a positive correlation
between credit risk and firm's value. With perfect information, this would mean that for a given loan, high value firms would pay a higher interest rate than do low value firms. Alternatively, for a given stock issue, stock prices would be higher for high value than low value firms. With asymmetric information, high value firms use debt and low value, equity. By assumption, neither gains from misrepresentation. Low value firms do not want to misrepresent and face a high interest rate. High value firms do not want to misrepresent as stock prices are low. In equilibrium, each firm's securities are fairly priced and signalling is costless.

These papers have many common features. Except for Leland & Pyle (1977), they all assume risk neutrality of the players. In the former, risk aversion plays a critical role by allowing separation of firms in equilibrium. Apart from Heinkel (1982) and Leland & Pyle (1977), the incentive signalling cost structure is based on ex post observable variables. In Leland & Pyle (1977), the signal is based on ex ante diversification costs. In Heinkel (1982), a type of 'single crossing property' is imposed to reach the costless signalling equilibrium.

In Chapters IV and V of the thesis, we show that firms may use financial signalling strategically in the presence of imperfect information in output markets. We diverge from the above papers by linking the firm's value to its financial structure. In the surveyed papers, production activities are included just to generate random returns. In our essays, we show that these returns may be affected by the firm's financial choices. With imperfect information in both financial and output markets, financial signalling may serve the dual purpose of conveying information in both markets. The revealed information affects the type of competition in the output market. Hence, financial signalling may become value creating through the information it conveys to the output market. Our signalling models belong to the first class surveyed in this section. The signal involves real resources. We have costly (dissipative) signalling. We close this section on imperfect information in financial markets with some concluding remarks.

2.5 Remarks

This section shows that the presence of imperfect information in financial markets generally invalidates Modigliani & Miller (1958)'s financial structure's irrelevance result. Credit rationing and signalling incentives have an impact on the firm's financial choices. These choices affect the perceived value of the firm and hence the financial prices it faces. The value of the firm is no longer independent of its financial structure and in general, an optimal debt equity ratio exists.
Throughout this section, we assume (unless otherwise specified) that the borrower has to repay its loan if the return from the project is sufficient to cover it. There are few papers who are concerned with the incentive-compatibility properties of debt contracts. Williamson (1987) and Gale & Hellwig (1985) show that a debt contract in which the lender is the residual claimant in the event of bankruptcy is incentive-compatible. Because the borrower loses the project's return if it defaults on its loan, it declares bankruptcy if and only if \( R < 1 + r \). In this case, the loss of the project's return acts as a pecuniary penalty to induce truthful behaviour by the borrower. In Diamond (1984), only the entrepreneur can freely observe the project's return. The contract specifies non-pecuniary penalties imposed on the borrower and proportional to the shortfall from the face value of the debt. He shows that such a contract is incentive-compatible. However, the existence and enforcement of such penalties is doubtful.

In this section, we focus on credit markets. However, equity markets are also affected by the presence of asymmetric information. The literature on this topic is less abundant but some important contributions have nonetheless been made. Myers (1984) and Myers & Majluf (1984) describe a situation in which a firm's inside securityholders have more information than outsiders about the firm's value. In equity markets, some firms are overvalued and others are undervalued. Financiers interpret a new stock issue as an attempt by an overvalued firm to realize a capital gain. The new issue becomes a bad signal to financiers and consequently is priced at a low level. Some firms prefer to pass over valuable investment opportunities rather than sell away a share of their assets at a low price. The presence of asymmetric information affects the efficiency of the outcome. In a similar framework, Giammarino & Lewis (1985) allow for firms to signal their value to financial markets. They show that an issue of new shares may convey information to the market. There are circumstances in which each firm's type is revealed and no investment opportunity is passed over. Interestingly, there are equilibria in which a form of rationing exists as financiers randomize between the different securities offered to them. In their model, in contrast to Myers & Majluf (1984), a successful issue of new shares does not necessarily signal that the firm is of low value. Some high value firms can successfully signal their quality to financiers and emit a new stock issue. In these two papers, equity financing is assumed to be the only financing tool. In our second and third essay, we show that a mix of debt and equity financing constitutes a cheaper signal for high value firms if bankruptcy costs are not too high. This suggests that only considering equity financing is not a trivial assumption as debt financing reduces signalling costs. Therefore, debt cannot be assumed away without good reasons.

Most of the theories surveyed above assume that the output market is competitive. Although financial structure is relevant to the firm's market value, it does not alter the
type of competition in the industry. With imperfect output markets, there exist strategic interactions between members of the same industry. Firms may make financial choices explicitly considering how they may affect their rival's and their own production plan. The next section is devoted to models studying the strategic value of financial choices in the presence of imperfect output markets.

3. Strategic Value of Financial Structure

Imperfections in the output market open new avenues for financial structure relevance. Moving away from the assumption of perfect competition leaves firms with room for strategic play. Firms may try to use their financial structure to increase their market power. It creates interactions between production and financial decisions. In our three essays, we are interested by these interactions and financial structure's strategic value. In the first essay, a common lender is shown to facilitate collusion of firms in a duopoly. As seen above, interest rates have incentive effects. In a duopoly, one firm's incentives affect its rival's output and profits. Each firm's response to an increase in its lending rate affects the other firm's output strategy and profits. This means that their debt values are correlated through the output market. A common lender partially endogenizes these effects and hence facilitates the collusion of the industry. In the second essay, a monopolist incumbent is threatened by an entrant. There is asymmetric information in financial and output markets. The incumbent may be one of two types. The profitability of entry to the entrant critically depends on the type of the incumbent. Financial structure acts as a common signal to financiers and entrant of the profitability of entry. The low cost incumbent can use its financial structure as a signal of the unprofitability of entry. It becomes a successful entry deterrent. In the third essay, we give a formal representation of Telser (1966)'s 'deep pocket' argument. There are two types of entrant. Low cost entrants must take on debt to signal their value to financial markets. They enter the industry heavily leveraged. This yields incentives to the incumbent to engage in a price war to try to provoke the entrant's bankruptcy. By considering imperfect output markets, we derive potential strategic functions for the firm's financial policy.

According to Kraus & Litzenberger (1973), the firm's financial structure reflects a tradeoff between tax advantages of debt and expected bankruptcy costs. However, there is empirical evidence that bankruptcy costs are low (Warner, 1977 and Haugen & Senbet, 1978). Hence, this theory cannot explain very well low debt equity ratios empirically observed. Allen (1985) reconciles these facts with the theory. He argues that if output markets are imperfect, expected bankruptcy costs may be high. In a two period model, these costs are endogenized through imperfections in the output market. Two firms compete in a
duopoly. In each period, they must finance a fixed expenditure before starting production. Financing and output decisions are made concurrently. After the first period, if both firms are in the same financial state, solvent or insolvent, they play a Nash game in the second period. If only one firm goes bankrupt in the first period, they play a Stackelberg game in the second period in which the solvent firm acts as the leader. The rationale behind this assumption is that a bankrupt firm is delayed in its investment decisions because of time spent settling the default problem. Hence, bankruptcy is costly in terms of foregone profits in the second period. Bankruptcy costs amount to the difference between Nash profits and the follower's profits in the Stackelberg equilibrium.¹²

Two polar cases emerge in equilibrium. Under the assumption of no fixed cost of capacity, a symmetric equilibrium in capacity, output, and debt exists with firms borrowing positive amounts of debt. With large fixed costs of capacity, since the bankrupt firm acts as the Stackelberg follower in the second period, its profits are too low to cover the fixed costs and it has to withdraw from the market. The only equilibrium is asymmetric with one firm going for the tax advantages of debt, and the other for the strategic advantage of equity of driving its rival out of the market if demand turns out to be low. Even if bankruptcy is costless in itself, imperfections in the output market can bring large indirect bankruptcy costs in terms of foregone future profits. These indirect costs may, in some cases, be large enough to offset the tax advantages of debt. By modelling an imperfect output market, Allen (1985) provides a potential explanation for some low debt equity ratios empirically observed.

In Allen's model, bankrupt firms may leave the market and liquidate their assets in case of default. Titman (1984) considers a model where a bankrupt firm may liquidate in bankrupt states. His model represents a monopolist selling a durable good requiring some maintenance in the future. Liquidation imposes costs on customers: service on the durable good is provided at the lowest cost by the monopolist. Consumers anticipate a possible liquidation and their demand reflects these expectations. The firm bears the costs of liquidation ex ante through a lower selling price. Financial structure sends a signal to consumers about the probability of liquidation. The firm uses it to precommit itself to an optimal liquidation decision and minimizes liquidation costs, taking into account the impact of the probability of liquidation on the level of demand. If expected liquidation costs are large, the firm may choose a low debt equity ratio despite the tax advantages of debt.

Brander & Lewis (1986, 1988) base their results on the incentive effects of the firm's leverage. In the preceeding section, we show that the firm's limited liability induces it to

¹² In our third essay, we indirectly appeal to Allen's rationale. We assume that a firm's bankruptcy confers gains to its rival. This assumption may be justified by Allen's argument. These gains may represent the difference between Nash profits and the leader's profits in the Stackelberg equilibrium.
choose riskier projects. Brander & Lewis (1986, 1988) apply this analysis to an oligopoly to derive strategic aspects of the firm's financial structure. In their first paper (1986), they abstract from bankruptcy costs to focus on the strategic aspects of the firms' limited liability. They model a two stage sequential duopoly game. In the first stage, the firm chooses its financial structure. In the second stage, it picks its output, given its choice of financial structure in the first stage. Because both decisions are sequential, foresighted managers take into account the impact of the debt level on output when they pick a debt equity ratio. The firm's limited liability induces managers to choose a riskier strategy (as in the credit rationing literature). This is translated into an increased output. In a standard Cournot duopoly, debt shifts the firm's reaction function out, increasing its own output and decreasing the rival firm's output. With symmetric firms, the own effect is dominant and the aggregate output of the industry rises. Debt precommits the firm to an aggressive stance in the output market. Because firms make financial and production decisions sequentially, financial structure has an important strategic role to play in the resolution of the output market equilibrium. In a perfect equilibrium, positive amounts of debt are borrowed. In a symmetric duopoly, both firms act in the same way and the resulting output equilibrium is more competitive than in a full equity duopoly. As both firms issue debt, the competitiveness of the industry is increased and both firms are worse off than if they abstain from debt. Firms are caught in a financial version of the Prisoner's Dilemma. This result is contingent on the assumed type of competition in the industry. As pointed out by Shapiro (1986), if firms compete in prices, they reach a corner solution as firms finance only by equity. Debt is pro-competitive; with Bertrand competition (contrary to Cournot rivalry), aggressive behaviour by one firm entails an aggressive response by its rival. Debt confers no strategic advantage to the borrowing firm. It only results in a lower price, and hence, is avoided by both firms in equilibrium.

Our first essay is closely related to this paper by Brander & Lewis (1986). We rely on the moral hazard effects derived in their paper to show that if both firms borrow from the same bank, debt loses some of its competitive value. A common lender uses the interest rate to control the incentives of both firms. This is possible because each firm's debt value is correlated through the output market. The lender exploits this correlation by lowering its interest rate. A partial collusion is generated by the concentration of lenders of the members of the output industry. This result holds for a competitive credit industry in which banks compete for projects.

Maksimovic (1985) obtains results similar to Brander & Lewis (1986)'s for a variety of financial instruments. For example, if a firm can sign a contract with its suppliers such that the input price takes the form of a two-part tariff with a fixed fee and a lower marginal cost, the firm's reaction function is shifted out. This type of contract is value creating for the
firm. However, if both firms adopt this financial policy, they may be worse off than if they abstain from doing it. The important point is that alternative financial packages may affect production decisions and firm’s value. As in Brander & Lewis (1986), financial structure serves to precommit the firm to a more aggressive stance in the output market by shifting its reaction function out.

In a companion paper, Brander & Lewis (1988) focus on the effects of bankruptcy costs on the firm’s production decisions, abstracting from the limited liability effects derived in their other paper. They use a similar theoretical construction as in their first paper: a two stage sequential duopoly model. Bankruptcy occurs when a firm cannot meet its current debt obligations. Two types of bankruptcy costs are considered. With fixed bankruptcy costs, the firm does not care by how much it misses if it goes bankrupt. Only the breakeven state carries extra weight. In equilibrium, output is increasing in the own debt level and decreasing in the rival’s debt. At low debt levels, the equilibrium output is smaller than the output of a full equity firm. For higher debt levels, the leveraged firm produces more.

If bankruptcy costs are proportional to the amount of the shortfall from the face value of the debt, the firm puts more weight on the insolvent states. The relation between the own output and debt level is U-shaped, while the relation between the own output and the rival’s debt is an inverted U. Contrary to the fixed costs case, the leveraged output is always below the full equity Cournot output. At low debt levels, output is decreasing in the debt level. As debt increases, positive marginal returns states are added to bankrupt states. Since there is more weight on these states, output rises with leverage. Bankruptcy costs change the relative weights that the firm puts on each state of nature. Independently of the type of bankruptcy costs, if debt is important, they induce the firm in adopting an aggressive strategy in the output market.

Maksimovic (1986) argues that financial structure may facilitate non-dissipative punishment in models of oligopolistic interactions. Consider a multiperiod game in which the threat of price wars sustains a collusive equilibrium. Shareholders have control over the firm’s strategies. If, in equilibrium, price wars occur with positive probability, the firm’s value decreases and its financial securitites’ price is affected. Maksimovic (1986) shows that the firm may choose a financial structure such that punishment does not affect the value of the firm. The firm chooses a face value of the debt coupon high enough that a price war makes bankruptcy very likely. In this case, debtholders would take over the assets of the firm. Since stockholders would lose control of the firm, the price war, mutually costly for the ‘punisher’ and the ‘punishee’, would be stopped as the defectors (stockholders) from

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13 In Maksimovic (1985), the term financial structure covers a much broader range of instruments than the debt equity ratio.
the collusive equilibrium would already be punished by the firm’s bankruptcy. The choice of an appropriate financial structure allows the firm to punish defectors without decreasing its value. Financial structure acts as a non-dissipative mechanism supporting a collusive equilibrium. It transfers the punishment from defection from the production sector to the financial sector.

In most of the papers just surveyed, debt has a strategic value while equity provides residual financing. Few papers look at the strategic properties of equity shares. Reynolds & Snapp (1986) show that if a firm increases its ownership of a rival firm through the stock market, its reaction function is shifted in. In a duopoly, suppose that each firm holds shares of its rival. When choosing its output strategy, each firm would take into account its effect on the value of its portfolio through the change in the value of its outstanding shares of the rival’s equity. These firms would not act as aggressively in the output market and the resulting equilibrium would be more collusive than in the absence of such portfolio diversification. In particular, if each firm owns equal share proportions of each member of the industry, the collusive output is produced. Bresnahan & Salop (1986) obtain similar results for a variety of institutional joint ventures. The common problem of these two papers is that the portfolio of each firm is exogenous. Suppose two firms in a duopoly trade shares of each other to sustain a collusive outcome. It would be in the interest of each firm to trade away its rival’s shares given that the rival keeps its portfolio intact. It is doubtful that the ownership of equal share proportions of each firm of the industry is an equilibrium in the financial stage of the game.

Manning (1986) analyses the impact of the concentration of ownership of a monopoly on its output strategy. The manager maximizes stockholders’ wealth when choosing the price of the good. If stockholders represent a large proportion of the market demand for the good, a tradeoff between a high and a low market price has to be made. With a high market price, the managers can pay out large dividends to stockholders. With a low market price, the consumers’ surplus is larger. If ownership is completely diffused, the competitive price maximizes the stockholders’ wealth as it maximizes the sum of the producer’s and consumers’ surpluses. Manning (1986) concludes that contestability for corporate control may achieve efficiency for a monopoly.

Strategic interactions between production and financial sectors are derived for firms possessing a certain degree of market power. Financial structure plays a strategic role in the output equilibrium. Dotan & Ravid (1985) show that there may be interactions between firm’s value and financial structure for competitive firms. In the presence of taxes and bankruptcy costs, debt affects the choice of capacity through its impact on the breakeven state: it affects the probability that depreciation tax benefits are used, hence changing the
user cost of capital. Debt influences the capacity chosen by the firm. In equilibrium, it is shown that the optimal capacity is a decreasing function of the debt level.

These papers represent pioneering work in the theory of strategic aspects of financial decisions. They provide finance students with another type of rationale for financial structure relevance to production decisions. These new theories complicate the analysis of the determination of the optimal financial structure. In each paper, important abstractions are made to facilitate the derivation of the results. These abstractions help to focus on a given aspect of the choice of an optimal financial structure. But it seems that integration of all theories is impossible and that case by case studies are more useful in explaining empirical facts. We conclude our literature survey with a review of different models of entry game in which financial structure is not taken explicitly into account but often plays an important implicit role.

4. Finance and Entry Games

In Industrial Organization, models of entry game are numerous. Entry deterrence models describe an incumbent's strategy to prevent entry. For example, the incumbent may precommit before entry to an aggressive strategy if entry occurs, may threaten to prey upon the entrant or may practice limit pricing. These models describe pre-entry strategies by the incumbent aiming at keeping entrants out. In predation models, the incumbent tries to induce the exit of a rival already present in the industry. The incumbent may engage in a price war with the entrant to impose losses on it and hoping that it exits the industry. In many cases, underlying the argumentation, are implicit assumptions about financial markets. The explicit introduction of financial variables may provide a more complete treatment of entry games and give a better understanding of many entry situations.

In our last two essays, we consider the possibility of financial signalling in entry games. In the second essay, an incumbent signals to a potential entrant about the profitability of entry with its financial choices. In this case, financial structure becomes a determinant of output market structure. In the third essay, the entrant signals to financiers about the profitability of its entry. By doing so, the low cost entrant must take on debt. This opens the door for the incumbent to prey upon the entrant and increase its probability of bankruptcy. This provides a formal representation for Telser (1966)'s 'deep pocket' argument. This section briefly surveys some entry models found in the literature.

For a long time, economists have been preoccupied with entry deterring strategies. Limit pricing is studied extensively in the literature. The incumbent charges a low pre-entry price in the hope of keeping entrants out of the market. However, with perfect
information, this strategy is not rational. The pre-entry price is irrelevant to the entry decision. The entrant considers the elements of post-entry competition when making its entry decision. Hence, limit pricing does not make sense in a world of perfect information. The development of the theory of games with imperfect information has provided a rationale for the practice of limit pricing. Milgrom & Roberts (1982a) assume that an entrant is uncertain of its post-entry profitability and that the incumbent has perfect information. The entrant’s profitability is contingent on the incumbent’s marginal cost level. They show that the efficient incumbent has incentives to signal its private information to prevent entry.

The signal observed by the potential entrant is the level of the pre-entry price. It conveys information about the incumbent’s cost level. The incumbent charges a low pre-entry price to signal to the entrant that it has low cost and that entry has a negative value. The signal is correctly interpreted by the entrant and, in equilibrium, entry occurs in the same circumstances as if perfect information prevails. The entrant associates a low price with the incumbent having low costs and consequently with an unprofitable entry. A high price encourages entry.

The presence of asymmetric information is sufficient to rationalize the use of limit pricing strategies by incumbents. Matthews & Mirman (1983) apply a similar analysis to the case of stochastic demand. They show that entry may occur or be prevented in different circumstances than with perfect information. This is the direct consequence of the demand being stochastic. The entrant observes a noisy signal and only statistic inference may be made of its post-entry profitability. There are circumstances in which the entrant comes into the market and entry is unprofitable, and others in which the entrant stays out and its entry would be profitable.

Limit pricing is costly for the incumbent in terms of foregone profits. One possible extension of these models is to introduce asymmetric information in financial markets. This may result in firms being financially constrained. Limit pricing strategies may affect the price of securities issued by the incumbent. In conjunction with financial constraints, limit pricing may affect the equilibrium probability of entry. In our second essay, financial variables replace price in signalling about the profitability of entry. We show that an incumbent’s financial policy may constitute a signal of the post-entry profitability. Financial signalling has the advantage of handling relatively well a stochastic demand. Contrary to Matthews & Mirman (1983), we show that entry occurs in the same circumstances as with perfect information. Even if demand is stochastic, the financial signal is observed before the resolution of market uncertainty. The entry decision is not affected by the realization of the state of nature. In a separating equilibrium, entry occurs in the same circumstances as with perfect information.

An incumbent may also deter entry by precommitting to a given strategy. By doing so, credible threats may be made relative to post-entry competition. In many cases, these
threats are strong enough to deter entry. Dixit (1980) is a good example. Prior to entry, an incumbent may invest in capacity to decrease its marginal cost. This investment is irreversible and it shifts the incumbent's reaction function out (lower marginal cost). This precommits the incumbent to an aggressive stance in the output stage of the game. For a sufficient capacity investment, entry has a negative return. The entrant stays out and the investment in capacity successfully deters entry. As Dixit (1980) points out, introducing financial constraints may be a useful extension of his model. How do financial constraints affect a firm's strategy and its rival's optimal response? What are the equilibrium strategies if we allow for credit rationing? What is the effect of credit rationing on the probability of entry and output market structure?

Financial constraints are discussed more explicitly in models of predation. An incumbent reacts to entry by engaging in a price war to impose losses on its rival to induce its exit. With perfect information, this strategy is ineffective. A price war is costly to both parties, hence it cannot last forever. As pointed out by McGee (1980), if a firm knows it is preyed upon, surely it wants to stay in the market as the price war is of finite length. With perfect information, predation cannot be rationalized. Again, the development of models with asymmetric information allows for a formal representation of predation. If the entrant is uncertain of whether the price war is the result of predation or the incumbent having low costs, predation can be explained. Kreps & Wilson (1982a) and Milgrom & Roberts (1982b) assume that the entrant is uncertain of the incumbent's cost level. The low cost incumbent charges a low price following entry because it is efficient and rational to do so. In these circumstances, the entrant wishes to exit the market. This gives incentives to the high cost incumbent to disguise itself as a low cost firm by charging a low price following entry and induce the entrant's exit of its market. As the incumbent establishes a reputation for being efficient, it discourages future invasions of its market. With asymmetric information, predation becomes a rational strategy to undertake as it serves the purpose of establishing a reputation for the incumbent of being efficient. Predation is costly in the short run but yields future benefits by slowing or stopping the frequency of entry. Predation becomes an investment in reputation. The high cost incumbent preys upon entrants as long as the long run benefits outweigh the short run costs. Easley, Masson & Reynolds (1985) apply a similar analysis to a multimarket monopolist. Entrants are uncertain of the profitability of entry in each market. The monopolist preys in every market to induce exit and discourage entry in its other markets. With imperfect information, predation is rationalized as a profit maximizing strategy. It serves the need of establishing a reputation for being efficient.

McGee (1958) and Telser (1966) point out that predation is costly and that a merger may be a cheaper mean for eliminating a rival. But they conjecture that predation may still be used to lower the acquisition price. Saloner (1985) provides a formal model of this
argument assuming imperfect information of the entrant about the incumbent's cost level.
In the first period, the incumbent preys upon the entrant to establish the reputation that
it is a low cost firm. At the end of the period, both firms bargain over a merger price. The
entrant's selling price depends on its beliefs about the incumbent's cost. If the incumbent
is believed to have low cost, the entrant's firm is not worth as much as if the incumbent
has high cost. This gives incentives for the incumbent to establish a reputation for being
efficient. If the merger fails, both firms play a Nash game in the last period, the outcome
of which is also affected by the entrant's beliefs about the incumbent's cost. The entrant's
output is decreasing in its beliefs about the incumbent's cost. This provides additional
incentives for the incumbent to prey in the first period. Predation becomes a tool for
softening up and possibly buying out a rival firm.

The incumbent and entrant need ample financial resources to engage in a price war and
sustain losses while remaining solvent. Telser (1966) and Benoit (1984) assume that the
prey is financially constrained and derive an equilibrium in which predation occurs. The
incumbent has a 'deep pocket' (or long purse) while the entrant is financially constrained.
The predator tries to financially exhaust its rival and induce its exit. With perfect finan­
cial markets, the financial constraint cannot be justified, and hence, predation cannot be
successful. If the entrant has a positive net present value, it can always secure financing
to sustain temporary losses during the price war and stay in the market. Fudenberg & Ti­
role (1985) provide a formal model of the 'deep pocket' argument. They base their model on
a recent paper by Gale & Hellwig (1985). With imperfect information in financial markets,
Gale & Hellwig (1985) show that the optimal debt contract involves a minimum equity in­
vestment by the borrower. Predation lowers the prey's cash flow, hence reducing its ability
to provide the equity investment and lowering its chances of securing a loan in the next
period. Without a loan to finance its fixed costs, the entrant has to exit. Predation becomes
a profit maximizing strategy for the incumbent as it forces the entrant out of its market.
But it does not explain why the entrant does not finance in equity markets. In this model,
an issue of new shares would render predation inoffensive.

In our third essay, we provide a formal explanation for the 'deep pocket' argument
without introducing asymmetries in financial requirements of the entrant and incumbent,
or restricting firms to use the credit market to finance. The entrant and incumbent have
an equal fixed cost to finance in credit or equity markets. We base our explanation on
the presence of asymmetric information about the entrant's profitability. We assume that
there are two types of entrant parametrized by their cost level. Financiers are uncertain of
the entrant's cost and cannot observe it directly. Efficient entrants signal their quality in
financial markets by issuing debt. This opens the door for predation by the incumbent as
the entrant is vulnerable to bankruptcy. We show that despite the entrant's anticipation of
predation, it chooses to signal its quality and finance with debt. We base the 'deep pocket' argument on asymmetric information about entrants' type. It is rationalized through the need for good entrants to signal their quality in financial markets. One interesting feature of our model is that we allow the entrant to finance in equity markets if it wishes to. But we show that debt is a more effective signal than equity despite its predatory disadvantage.

5. Conclusion

Financial markets have an important role to play in modern economies. The presence of asymmetric information in these markets may affect the firm’s optimal financial structure. Asymmetric information may result in moral hazard and adverse selection problems in financial relationships. In some cases, these problems may be overcome by the use of collateral, long term relationships or signalling. Despite the use of these sorting devices, asymmetric information may still have an impact on output markets. With imperfect output markets, the firm's financial policy acquires a strategic value. In turn, these strategic considerations affect the firm’s financial choices. Modigliani & Miller (1958)’s separation result does not hold anymore and interactions between financial and production sides of the firm become important.

We point out some of these interactions and show how our research contributes to the existing literature. Essay 1 shows how the choice of a lender may affect the competitiveness of the output industry. Concentrated financial contracts result in a more collusive output market. This is the consequence of asymmetric information in financial markets and imperfections in the output market. In the second essay, we demonstrate that financial structure may be related to the output market structure. In an entry deterrence game, the incumbent uses its financial structure to signal about the profitability of entry. The incumbent’s financial policy becomes an entry deterring signal. Hence the incumbent’s financial choices become a determinant of entry and of output market structure. In the third essay, we rationalize the 'deep pocket' argument by assuming asymmetric information about types of entrant in financial markets. Financiers are uncertain of the entrant's cost. Efficient entrants signal their quality by issuing debt. This renders them vulnerable to predation as the incumbent engages in a price war in the hope of decreasing the entrant’s cash flow, causing default on its loan and inducing its exit. We now present in turn these three essays.
CHAPTER III

COLLUSION AND THE BANKING STRUCTURE OF A DUOPOLY

1. Introduction

In their seminal paper, Modigliani & Miller (1958) show that under the assumptions of competition and perfect information, the firm’s financial structure choice is irrelevant to its market value and independent of its investment decisions. As seen in the preceding literature survey, empirical facts show the importance of financial decisions for firms’ market value. For example, there is empirical evidence that some banks concentrate their activities in relatively few industries. This cannot be explained on the grounds of portfolio diversification. There may be two motivations behind such a concentration: speculation and economies of scale in the treatment of information. Banks may speculate and choose to concentrate in industries that are expected to be highly profitable to increase returns from their loans. However, if these industries have a high degree of risk, banks face a larger probability of bankruptcy than if they are completely diversified. The presence of economies scale may also explain the fact that banks concentrate in few industries. When making a loan to a firm, a bank gathers industry specific information to assess the riskiness of the loan and determine the lending rate. Lending to members of the same industry allows banks to economize on information costs.

Although these two motivations may explain the fact that banks concentrate in industries, one may wonder if they are strong enough to completely explain such concentration. There may be other reasons based on informational problems explaining banks’ concentration. Furthermore, it would be interesting to know how the structure of the financial sector affects the performance of downstream output firms. It is believed that the organization of financial markets has an impact on the structure and performance of output markets. It is also believed that the competitiveness of the banking sector can influence the outcome of output markets. These are some of the motivations behind the fact that the financial sector is regulated.

A partial answer to these questions appears in this essay. We present a model in which the performance of an industry is affected by the concentration of the financial sector in the industry. As members of an industry borrow from the same bank, the output market becomes more collusive. This implies that a firm’s choice of lender affects the performance of the industry. If it borrows from the same lender as its rivals, a firm may facilitate the collusion of its industry. The choice of a lender becomes a strategic variable for the firm.
Because of this collusion effect, lenders have incentives to concentrate in few industries. A decrease in the extent of competition reduces the industry's risk level and increases the bank's expected return. Thus, we suggest another explanation for the concentration of banks in industries. As the choice of lender affects the firms' actions, it also affects the riskiness of the loan and the bank's return.

To derive these results, we focus on asymmetric information in financial markets and imperfect output markets. Firms are better informed about the different projects available to them than are lenders. The bank's lack of information about the firm's actions results in the bank having incomplete control over the firm's production decision. Because of the limited liability clause in debt contracts, we know from Chapter II that the firm chooses a riskier strategy than the bank would impose if it had perfect control. Debt gives the firm incentives to choose a risky project. These incentive problems can be thought of as agency problems in the credit contract between a firm and a bank. It is the presence of these agency problems that cause a departure from the Modigliani-Miller result. This is shown formally in Stiglitz & Weiss (1981). If a similar analysis is applied to oligopolistic industries, Brander & Lewis (1986) show that, with the limited liability aspect of debt, a firm may credibly precommit to an aggressive stance in its output market by issuing debt. For example, the limited liability aspect of debt induces managers to pursue riskier strategies in the output market. This aggressiveness is translated by an outward shift in the firm's reaction function, thus increasing its own output and decreasing its rival's output. In a duopoly, as both firms use debt for strategic purposes, the industry output increases and both firms end up worse off than under the full equity solution. Firms are caught in a financial version of the Prisoner's Dilemma. Maksimovic (1985) obtains similar results for a variety of financial instruments.

Our analysis is based upon these incentive effects of debt in oligopolistic output markets. Debt has a strategic value and increases the competitiveness of the industry. We show that, in a duopoly, if both firms borrow from the same lender, the competitive effects of debt are reduced and the industry becomes more collusive. The bank's return from one loan is correlated with the return from the other firm's loan through the output market. The interest rate that one firm faces affects the other firm's loan return. As one firm's interest rate goes up, its output increases and its rival's output decreases. This decreases the rival firm's market value and its debt's expected value.

Banks are residual claimants in bankrupt states. If a firm chooses a risky strategy, it affects the rival firm's debt value by decreasing the return on the loan in bankrupt states. When each firm borrows from a different lender, these adverse effects represent externalities which are not taken into account in the determination of the lending rates. A common
lender endogenizes these externalities when choosing its lending rates. This lender takes this correlation into account in choosing the interest rate of each loan. Effectively, it picks a low interest rate to limit the firm's incentives to choose a risky output. This leads to partial collusion of the industry and increases the expected return from each loan. It is through the incentive effects of debt that the concentration of the financial sector in the industry affects its competitiveness. A more concentrated financial sector can better control these incentives and restrain the extent of competition induced by debt.

The presence of asymmetric information in financial markets prevents banks from having complete control over firms' production decisions. In imperfect output markets, debt is pro-competitive. By concentrating in an industry, a lender can partially control the firms' incentives. This suggests another explanation for banks concentrating their activities in few industries. Even if the model is not designed to completely characterize banks' portfolio decisions, we may still draw conclusions about the effects of concentration on banks' expected returns. Banks can increase the value of their loans by lending to firms of the same industry. This is achieved through a reduction in the strategic incentives of debt.

This essay also has implications for the theory of financial structure. The choice of lender is usually not considered as a relevant element of a firm's financial policy. In general, the debt equity ratio and dividends constitute the set of financial choices available to the firm. We show that the choice of lender may be a relevant variable to the firm's market value in the presence of imperfect output markets. This comes from the fact that a common lender can better control the firms' debt incentives. In this model, we do not characterize the firm's debt equity ratio choice. We assume that the firm borrows to fill its financial needs. By assuming away equity, we focus on the specific effect of the concentration of the financial sector on the performance of downstream industries. Characterizing the firm's choice of an optimal financial structure would require a more general framework than is presented in this essay. But we may note that the concentration of ownership of members of an industry may result in a more concentrated output market (see Reynolds & Snapp, 1986).

The model finds a natural interpretation in the theory of international trade. Suppose that we have an international duopoly output market with two countries and one firm in each country. We assume that output trade is liberalized between both countries but that financial markets are closed to international competition. This case would correspond to the case of both firms borrowing from different banks. Freeing financial markets from trade barriers would open the possibility for firms to borrow from the same lender. Our results show that if financial trade barriers are removed, both firms would borrow from the same bank and the international duopoly would become less competitive. The effects of banking
laws or financial trade barriers on the performance of output markets are often overlooked in discussions regarding possible changes in these laws which would affect the structure of the financial sector. We provide a motivation for considering the impact of financial markets on the performance of downstream industries. Although the model fits well in an international trade context, we abstract from this parallel interpretation in the presentation of the model and results. We discuss it further in the conclusion.

The essay is structured as follows. In the next section, we present the model and its assumptions. We define the firms’ and banks’ expected return function. We assume that the credit industry is characterized by banks competing for depositors. The supply of funds has positive slope. Banks compete for deposits and the debt contract maximizes the banks’ expected profits. In equilibrium, the rate paid on deposits adjusts such that banks earn zero profit. In Section 3, we derive the solution of the output competition for an arbitrary financial policy. The equilibrium outputs are characterized as a function of the parameter of the debt contracts. In Section 4, we solve the financial stage and compare the equilibrium when each firm borrows from a different bank to the equilibrium in which firms borrow from a common lender. In each case, firms choose a financial contract anticipating its effect on the output equilibrium computed in the second section. The conclusion follows in the last section.

2. The Model and Assumptions

Two identical firms operate in a one period duopoly output market.\textsuperscript{14} By assuming a one period game, we abstract from many problems related to the firm’s financial structure such as default, refinancing or debt restructuring. It allows us to focus on a different aspect of the financial policy, namely the choice of a lender. We assume that the firm is endowed with some assets and that it has no outstanding debts at the beginning of the period. For the current period, the firm has to finance a fixed cost $K$ before starting production. We assume that the firm cannot issue new stock and has to finance the fixed cost with debt.

The game unwinds in two distinct stages. In the first stage, the financial contract is determined and remains fixed for the rest of the game. In the second stage, each firm’s financial contract is revealed and production takes place. As we see below, the debt contracts influence the firms’ output decision. The output decision is made taking into account the financial choices made in the first stage. Conversely, in the first stage, financial decisions are made bearing in mind their impact on the equilibrium of the output stage. At each

\textsuperscript{14} The theory of financial contracts is not well developed for multi-period models in which the possibility of refinancing and debt restructuring are present. See Allen (1985) and Giammarino (1985) for recent treatments of two period models.
stage, we solve for the Nash equilibrium. As a consequence, the equilibrium for the game is sequential (see Kreps & Wilson, 1982b). Any subgame is characterized by Nash equilibrium play and the solution of the first stage takes into account the fact that Nash equilibrium play occurs in the second stage.

In the production stage, managers choose the firm's output to maximize the value of its equity. This assumption underlines the lack of control by the bank on the firm's output strategy. This absence of control may be due to the non-observability of the firm's output by financiers. The debt contract cannot enforce an output decision by the firm. The non-observability of the firm's output by the bank introduces moral hazard in the credit relationship. As seen in the previous chapter, under such conditions, the firm has incentives to choose a riskier strategy than the lender would like to impose on it. The presence of moral hazard in the debt contract creates a conflict between equityholders and debtholders in which the former possess more information and exploit this advantage. This conflict is at the base of our results. For more on this moral hazard problem, see Myers (1977) and Brander & Lewis (1986).

We are interested in comparing equilibria under two different structures of the financial sector. In the first case, each firm is forced to borrow from a different bank. This situation corresponds to the banking structure usually considered in the literature in which the choice of a lender is not explicitly taken into account and each firm borrows from a different lender. The alternative is that both firms borrow from the same bank. The comparison of these two equilibria allows us to study the incentive of the common lender to control the moral hazard effects of debt. We now turn to the formal presentation of the model.

**Firms:** Two identical risk neutral firms compete in a duopoly. Profits are stochastic. Firm $i$'s return in state $s_i$ is $R^i(q_i, q_j, s_i)$. We have a continuum of states of nature distributed over $[S_l, S_h]$ with the distribution function $F(s)$. We assume that $S_l > 0$. The parameter $s$ may be interpreted as a random shift parameter of the inverse demand function. We assume that $R^i(q_i, q_j, s_i) = p(q_i, q_j, s_i) q_i - c(q_i)$. The expected value of the firm is:

$$V^i(q_i, q_j) := \int_{S_l}^{S_h} R^i(q_i, q_j, s_i) \, dF(s_i)$$

(2.1)

The function $R^i(q_i, q_j, s_i)$ has the usual properties of a profit function. In particular, we assume that $R^i \geq 0$. We assume that $R^i_l > 0$ and that $R^i_u > 0$. This means that marginal returns to extra production are higher in better states of the world. An alternate assumption is to have $R^i_u < 0$. This would be the case if output itself is stochastic. These alternatives

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15 Superscripts denote players and subscripts, derivatives. Throughout the paper, when no confusion is possible, the arguments of the functions are omitted.
are discussed further in Brander & Lewis (1986). In this essay, we assume away the latter case. The reader has to be conscious that our results may be reversed if we adopt $R_i < 0$. However, we take our assumption to be the normal case.

Before starting production, firms have to finance a fixed expenditure \( K \) which is normalized to be one dollar. We assume that equity markets are inaccessible to both firms and that they have to finance the fixed cost with debt. This may be motivated by adverse selection problems in equity markets which preclude financiers from investing in the firm. Or it may be assumed that the firm is a family business and that initial stockholders have strong preferences for retaining complete ownership of the firm. If the firm is solvent, the interest rate is \( r_i \) and the face value of the debt at the end of the period, when profits are realized, is \((1 + r_i)\). Firms repay the loan only in those states in which profits are at least as large as the face value of the debt. The range of solvent states for the firm is \([s_i, S_h]\) where \( s_i \) is implicitly defined by

\[
R^i(q_i, q_j, s_i) - (1 + r_i) = 0
\]

Note that \( s_i \) is a function of \( q_i, q_j \) and \( r_i \) and may be written as \( s_i(q_i, q_j, r_i) \) by (2.2). In the remaining states, profits are too low to cover the debt payment and the bank becomes the residual claimant of the firm's returns.

**Banks:** The banks are risk neutral.\(^{16}\) Bank \( i \) has an expected return function:

\[
\rho_i(q_i, q_j, r_i) := \int_{s_i}^{q_i} R^i(q_i, q_j, s_i) \, dF(s_i) + (1 - F(s_i)) (1 + r_i) - (1 + r_0)
\]

where \((1 + r_0)\) represents the cost of funds.\(^{17}\) Outputs and lending rates are the only variables characterizing the bank's expected return. However, as we see below, the equilibrium outputs are functions of the interest rates. Hence, the bank's expected return is effectively a function of \( r_i \) and \( r_j \).

The lenders act as intermediaries between borrowers and depositors. The borrowers' activities generate profits which may be captured at either end of the financial chain. In a competitive banking industry, banks earn zero profit in equilibrium. The rents generated by the debt contract may be distributed to depositors through the rate paid on deposits or be kept by the firm through a lower lending rate. In general, the type of competition in the banking industry determines the debt contract and the distribution of rents.

We consider the case in which banks compete for depositors. There are many banks and many projects to be financed but a limited supply of funds is available. Only projects

\(^{16}\) We discuss later the possibility of having risk averse lenders.

\(^{17}\) It is implicitly assumed that bank \( i \) lends to firm \( i \). Note that we also abstract from potential agency costs existing between the bank and its depositors.
yielding the highest returns are financed. A bank chooses the face value of the debt that maximizes its expected return; in equilibrium, the excess rents generated by the debt contract are transferred to depositors through the rate paid on deposits, as it adjusts competitively until the bank earns zero profit. The bank perceives the rate paid on deposits as being fixed and maximizes its expected return. Competitive forces pull up the rate paid to depositors until all excess rents are dissipated. A bank failing to maximize its return would lose its deposits to a rival lender and would not have any funds to finance projects. Under this concept of competition, the supply of funds has positive slope and depositors keep the excess rents generated by the debt contract. Figure 2a represents this characterization of the loan market. When banks compete for depositors, the equilibrium rate maximizes the bank’s return at \( r^* \). This concept of competition is used in Section 4 to solve the financial stage. We discuss later the implications of this concept of competition on the nature of our results.

In the first stage, the financial stage, the debt contract is written and the face value of the debt is determined. Since the borrowed amount is fixed to one dollar by assumption, the face value of the debt is uniquely determined by the choice of the interest rate \( r_i \). The debt contract is completely characterized by the interest rate. In the second stage, the production decision takes place taking as given the face value of the debt. At each stage, it is assumed that the firm's objective function is the return to stockholders. Firms maximize the value of equity. Multistage games are usually solved by backward induction. Applying that method here, we solve for the production stage first, then examine the financial stage.

3. Equilibrium of the Production Stage

In the production stage, managers are assumed to maximize the expected value of equity. They are only concerned with those states in which the firm is solvent. Formally, we have for each firm:

\[
\max_{q_i} \Pi^s(q_i, q_j, r_i) := \int_{s_i}^{S_h} \left\{ R^d(q_i, q_j, s_i) - (1 + r_i) \right\} dF(s_i) 
\]

The First Order Condition (FOC) of (3.1) is:

\[
\Pi^s_i = \int_{s_i}^{S_h} R^d_i \, dF(s_i) = 0 
\]

Note that by (2.2), the derivative with respect to the lower bound of the integral vanishes. We require that the Second Order Condition (SOC) is satisfied, i.e., \( \Pi^s_i < 0 \). To ensure that a unique market equilibrium obtains, we also assume that

\[
\Pi^s_{ij} < 0 \quad \text{and} \quad \Pi^s_i \Pi^s_{ij} - \Pi^s_{ij} \Pi^s_{ji} > 0
\]
These assumptions imply that each FOC (3.2) characterizes a unique optimal output strategy by one firm in response to its interest rate and output decision by the rival firm. In turn, the FOC (3.2) for both firms are sufficient to characterize a unique market equilibrium. These assumptions facilitate the derivation of the results. Each firm's reaction function is obtained by inverting (3.2) and is denoted by \( q_i(r, q_j) \), for \( i = 1, 2 \). Solving for the equilibrium output of each firm as a function of the interest rates yields the mappings \( q_i(r, r_j) \) for \( i = 1, 2 \). These mappings characterize the equilibrium output of each firm as a function of each firm's debt contract. The assumptions (3.3) guarantee that these mappings exist and are unique. They are used in the computation of the equilibrium in the financial stage.

Brander & Lewis (1986) produce a similar two stage model. In the first stage, firms choose the face value of the debt, while the production decision is made in the second stage. They are interested by the strategic value of debt in the duopoly. They show that, if marginal returns are increasing with better states of nature \( (R_{it} > 0) \), debt precommits the firm to an aggressive output strategy by shifting its reaction function out. In the framework of our model, these results may be reinterpreted as having in equilibrium

\[
\frac{dq_i}{dr_i} > 0 \quad \text{and} \quad \frac{dq_j}{dr_i} < 0 \quad \text{for} \quad i, j = 1, 2, \quad i \neq j
\]  

(3.4)

These comparative statics results may be derived by first, totally differentiating (3.2) for both firms, then by solving for these effects using Cramer's rule. They can be signed using the assumptions (3.3). The intuition is that the firm's limited liability induces it to pursue a riskier strategy than would otherwise be the case. Because the firm is solvent only in relatively good states of the world (high marginal returns), larger output is more profitable. Debt precommits the firm to an aggressive stance in the output market. It shifts its reaction function out increasing its own output and decreasing its rival's output. In the financial stage, the firm anticipates the effect of debt on the output stage to follow. The firm borrows positive amounts to precommit itself to be aggressive in the output subgame. Debt gains an important strategic value with respect to the output stage. However as both firms borrow, the industry output becomes larger and both firms are worse off than if they had abstained from the strategic considerations of leverage.

It is important to note that the decision process is done in two stages. In the second stage, the financial policy is held fixed and output is chosen. As the face value of the debt is held fixed, the firm is precommitted to an aggressive stance in the output market. The solution is quite different from a simultaneous maximization of both variables. In a single stage maximization, firms possess no information on the chosen financial policies. In the two stage model, the first stage's choices become common knowledge at the beginning of the second stage. Outputs are picked conditional on the financial policies chosen in the first.
stage. In a two stage model, the information structure of each firm is different than in a single stage maximization. Consequently, the equilibrium outputs and financial policies are different under each assumption. Hence, assuming that the decision process is done in two distinct stages is equivalent to assuming that financial policies are fixed for the production stage and become common knowledge before production decisions are made. We now solve the financial stage of the game.

4. Equilibrium of the Financial Stage

We plan to compare the debt contract and output equilibrium under two different banking configurations. In the first case, both output firms are restricted to borrow from different banks. In the second case, both firms are allowed to borrow from the same bank. We compute the equilibrium under each banking regime and compare them. We are interested by the comparison of interest rates, levels of output and rates paid on deposits.

We assume that banks compete for funds. Banks face a positively sloped supply of funds. Because of the incentive effects of debt, banks typically have a non-monotonic return function (see Figure 2a). The equilibrium is at the maximum of their return function (Figure 2a). Debt contracts offered by banks maximize their return. This enables banks to secure deposits to finance projects. In this section, we show that a common lender facilitates a partial collusion of the output market.

The total amount of deposits available is limited with respect to the number of projects requiring financing. The banking industry is competitive. The debt contract maximizes the bank's expected return. In equilibrium, the rate paid on deposits adjusts such that banks earn zero profit. A share of the rents generated on the output market are transferred to depositors through the competitive adjustment of the risk-free interest rate, \((1 + r_0)\). In general, depositors do not extract all rents from the output market. To do so, the lender would have to raise the interest rate. Because of the incentive effects of the interest rate, the bank's expected return may not be monotonic in the interest rate. This implies that it may not be possible to extract all rents from the borrower. The loss due to the incentive effects may outweigh the increased interest payments. In the absence of incentive effects, the depositors would get all rents from the firm.

We make a final note before developing the model further. One has to keep in mind that we abstract from many determinants of financial policies such as taxes and bankruptcy costs. These abstractions serve the purpose of focusing on the effects of the choice of a lender on the competitiveness of downstream industries.
4.1 Dual Bank Configuration

Under this concept of competition, banks maximize their expected return. Doing this, they anticipate the resolution of the output stage. In the output stage, the financial policy of each firm is fixed and becomes publicly known. Firms make their output decision based on the observation of the financial choices made in the first stage. In choosing their lending rate, banks take into account its effect on the production decision since it affects the value of the debt. The offered financial contracts maximize the lender's return along the firm's FOC (3.2). By assumptions (3.3), we know that \( q_i(r_i, r_j) \) for \( i = 1, 2 \) completely characterize the output equilibrium as a function of each firm's debt contract. We can substitute in \( \rho' \) to obtain \( \rho'(q_i(r_i, r_j), q_j(r_j, r_i), r_i) \). This new objective function for the bank incorporates the firm's optimizing behaviour as it forces the bank to stay on the firms' reaction function. This also guarantees that we solve for a sequential equilibrium of the game. Banks perceive \((1 + r_0)\) to be fixed when they maximize their return. In equilibrium, competitive forces pushes \((1 + r_0)\) up until the bank's expected return reaches zero. Bank \( i \) solves the following problem:

\[
\max_{r_i} \rho'(q_i(r_i, r_j), q_j(r_j, r_i), r_i)
\]

The FOC is:

\[
\rho_i := \int_{\delta_i}^{k_i} \left\{ R_i \frac{dq_i}{dr_i} + R_j \frac{dq_j}{dr_i} \right\} dF(s_i) + (1 - F(\delta_i)) = 0
\]

Assume that \( \rho'_u < 0 \) and that an equilibrium exists. Call the resulting equilibrium \((r_i^a, r_j^a)\). This determines \( q_i^a = q_i(r_i^a, r_j^a) \) and \( q_j^a = q_j(r_j^a, r_i^a) \). In equilibrium,

\[
(1 + r_i^a) = \int_{\delta_i}^{k_i} R_i(q_i^a, q_j^a, s_i) dF(s_i) + (1 - F(\delta_i))(1 + r_i^a)
\]

This characterizes the dual bank equilibrium.

We note that the assumption that the SOC are satisfied is not a trivial one. The expression \( \rho'_u \) represents a complicated formula. It depends on the slope of the moral hazard effects derived in (3.4) with respect to the interest rate. It is a hard task to characterize conditions on the parameters of the model under which the SOC would hold. There are parameter values for which they do hold and obviously, other values for which they do not hold. We implicitly restrict our attention to the former case in assuming that \( \rho'_u < 0 \) over the relevant range of interest rates. In the next section, we compute the equilibrium for the single bank configuration.
4.2 Single Bank Configuration

Abstracting temporarily from the problem of the lender’s choice, we assume that both firms borrow from the same financial institution. The bank lends to both firms and its objective function is the sum of the debt value of each firm. The common bank offers debt contracts that maximize its return. If the bank fails to maximize its return, a rival bank can attract its depositors by offering a higher interest rate on deposits and pay this higher rate by maximizing the sum of the debt values. A single bank solves:

$$\max_{r_i, r_j} \rho^i(q_i(r_i, r_j), q_j(r_j, r_i), r_i) + \rho^j(q_j(r_j, r_i), q_i(r_i, r_j), r_j)$$

The FOCs of this problem are: for $i, j = 1, 2, i \neq j$

$$\rho^i + \rho^i = \int_{s_i} \left\{ R_i^i \frac{dq_i}{dr_i} + R_j^i \frac{dq_j}{dr_i} \right\} dF(s_i) + (1 - F(s_i)) + \int_{s_j} \left\{ R_i^j \frac{dq_i}{dr_j} + R_j^j \frac{dq_j}{dr_j} \right\} dF(s_j) = 0$$

Assuming that the SOCs are satisfied, we define the maximum by $(r^i_0, r^j_0)$. We compute the equilibrium outputs, $(q^*_i, q^*_j)$, and the bank’s return, $(1 + r^*_0)$, as in the previous case. The rate $r^*_0$ represents the real rate of return on the loans when the bank lends to both firms. We present the comparison between both banking configuration equilibria in Proposition 1. All proofs are relegated to Appendix 1.

**Proposition 1:** If both firms borrow from the same bank, the interest rates are lower and the equilibrium output of each firm is smaller than under the dual bank configuration.

As shown in Appendix 1, $\rho^i > 0$. This implies that the lender wishes to charge a lower interest rate under the single bank structure than under the dual bank configuration. Both loans’ value are correlated through the output market. As $r_i$ increases, firm $j$’s debt value, $\rho^j$, is affected. The single bank internalizes these externalities in choosing interest rates. Raising $r_i$ increases the output of firm $i$ and decreases the output of firm $j$ according to the effects computed in (3.4). The effect of $q_i$ dominates the effect of $q_j$ and firm $j$’s return in bankrupt states decreases. Hence, the debt value of firm $j$ decreases as $r_i$ increases. This means that raising $r_i$ has an adverse strategic effect on firm $j$’s debt value. The single bank does take this effect into account and does not increase $r_i$ as fast as under the dual bank system. The strategic incentives of the interest rate have adverse effects on the rival firm’s debt value through the return in bankrupt states. As a bank lends to both firms, this effect is internalized.

To maximize the aggregate value of the debts, a single lender prefers to keep interest rates down to limit their strategic incentives. Lower interest rates result in lower outputs. Hence, the industry becomes more collusive. As the single bank lowers the level of interest
rates in the industry, each firm's output reaction function is shifted in and the resulting output equilibrium is more collusive. However, full collusion is not achieved. Equilibrium outputs under the single bank structure are larger than monopoly outputs. The bank does not have perfect control over production decisions. For any positive level of interest rates, the firm always has an incentive to pursue a risky strategy by expanding output through the strategic effects computed in (3.4). Hence, outputs are larger than in a full equity equilibrium. The common bank reduces the incentives of debt but cannot eliminate them. To do so, the bank would need perfect information about the firms' production decision. This would give the bank complete control and it would allow the bank to impose a production plan through the debt contract. With asymmetric information about the firm's actions, a common lender attenuates the firms' incentives to expand output but cannot fully eliminate them. We now compare the players' return under each configuration of the financial sector.

**Corollary 1.1:** \( W_i(r_{1}^a, r_{1}^s) < W_i(r_{1}^f, r_{1}^f) \) and \( r_{0}^f > r_{0}^a \).

Firms prefer to be in an industry in which financial costs are lower. When debt has no strategic effects, firms prefer to have lower financial costs but are indifferent about their rival's financial costs. When debt has a strategic value, rival's financial costs become relevant. Firm \( j \)'s interest rate affects the output equilibrium in an adverse manner from firm \( i \)'s point of view. Corollary 1.1 shows that firms earn more in an industry with low financial costs. Low financial costs mean that the industry is more concentrated. This is preferred by both firms. Corollary 1.1 says that all players are no worse off borrowing from the same bank than borrowing from different banks. Both firms prefer to borrow from the same financial institution as it results in a more collusive output equilibrium. On the other side, depositors prefer to lend to a bank concentrated in the industry as the rate of interest paid on their deposits is not lower than when the bank lends to only one firm in the industry.

We now consider explicitly the choice of lender by both duopolists. We have characterized the equilibrium under each financial configuration and compared them. It is possible to extend the game to include a stage in which firms choose their lender. Suppose there exists a 'shopping' stage prior to the financial stage in which banks quote interest rates to firms seeking financing. Assume banks make these quotes contingent on the identity of their other potential borrowers. There are two possible contracts available to firm \( i \):

\[ a: \{ r_{i}^a, \text{if firm } j \text{ borrows from another lender.} \} \]

and

\[ f: \{ r_{i}^f, \text{if firm } j \text{ borrows from the same lender.} \} \]
With these two financial contracts, there are only two possible outcomes: if both firms choose different lenders, they get contract a and pay an interest rate of \( r^a \); if both firms choose the same lender, they get contract f and pay an interest rate of \( r^f \). From Corollary 1.1, we know that for each firm \( W^i(r^a, r^f) < W^i(r^f, r^f) \). Each firm prefers to borrow from the same lender. As a result, the single bank configuration dominates the dual banking structure and is therefore the only equilibrium of the shopping stage.

The concentration of financial contracts helps firms to partially collude by reducing the competitive effects of leverage. By choosing a common lender, firms precommit credibly to a more collusive output industry. This underlines the importance of the industry's banking configuration in characterizing its competitiveness. The identity of the lender becomes a relevant choice of the firm's financial policy. In this essay, the lender's identity may be value creating for firms in imperfect output markets when debt contracts have a strategic value. The concentration of debt contracts partially reduces the extent of the 'dilemma' in this financial version of the Prisoner's Dilemma. In equilibrium, neither firm has any incentive to cheat as the bank finances at \( r^f \) if and only if it finances both firms. This implicitly requires that both firms sign their debt contract simultaneously and that these contracts are binding and irreversible until the end of the game. Under these conditions, if one firm deviates from contract f, both firms' interest rate jumps from \( r^f \) to \( r^a \). Hence, deviation yields lower expected returns to each firm. It is not profitable to choose anything different from contract f. The equilibrium is characterized by both firms choosing the same lender. The interest rate is \( r_f \) and the produced output, \( q_i \), for \( i = 1, 2 \).

We conclude this section by making some remarks on these results. We show that a bank lending to all members of an oligopoly may facilitate a partial collusion of the industry. This is an unusual case in which a supplier exploits its power over downstream firms by lowering its price. Although the size of the loan is fixed by assumption and hence, the market analogy is not perfect, an interesting comparison may still be drawn. The level of price creates some adverse incentive effects for the bank. The interaction between both downstream firms in the output market amplifies these incentives on strategic grounds. A single lender wishes to restrain the firms' aggressiveness. This is achieved by lowering lending rates. The bank exercises better control of the industry by internalizing the moral hazard effects of debt and reducing each firm's incentives. As a result, it is lending to a safer industry.

It is the effect of the interest rate on the quality of the loans that forces the single lender to lower its price and hence improve the quality of borrowers. Banks in the dual system do not face the same incentives as the single bank. Borrowers are linked by the output market. As one bank alters its interest rate, it affects the quality of the rival bank's
loan. In a dual system, these effects represent externalities and are irrelevant to each bank's maximization problem. The single bank endogenizes these effects and as a result, lowers its lending rates. This reduces the firms' adverse incentives and increases the quality of both loans. By internalizing the effects of one interest rate on the other loan's quality, the single bank raises the quality of both loans. Downstream firms benefit from this increase in quality which corresponds to a reduction in the extent of competition in the industry. The dependence of quality on price produces the unusual result that the 'monopoly' price is lower than the 'duopoly' price.\textsuperscript{18}

The analysis may be applied to Bertrand competition in an industry with differentiated products and would yield similar results. A single bank restrains the interest rate and limits the firms' incentives to pursue an aggressive pricing strategy. This generates a partial collusion of the output market by maintaining higher prices. The derivation of the Bertrand case is formally similar to the Cournot case and is therefore omitted. However, one could note that price competition is slightly different from Cournot quantity rivalry. In a Cournot industry, as described by (3.4), a firm reacts as a 'beaten dog' to an increase in its rival's interest rate (and hence to its aggressive stance). As one interest rate goes up, the rival's output decreases. In a Bertrand industry, the rival responds aggressively to the same increase by lowering its price. This implies that debt has no strategic value in a pricing game (see Shapiro, 1986). This is the consequence of the fact that reaction functions are positively sloped in a pricing game. Hence, if one firm shifts its reaction function in by taking on debt, its rival responds aggressively by lowering its price. A firm does not make any strategic gain by borrowing. The bank's collusive incentives seem to be larger in a Bertrand industry. As an interest rate increases, both firms respond aggressively and the return to the bank in bankrupt states is doubly affected. In the Cournot case, the 'beaten dog' reaction weakens somewhat the adverse strategic effect. In a pricing rivalry, the strategic effect of debt is reinforced by the aggressive response of the rival firm.\textsuperscript{19} Presumably, this should increase the bank's willingness to keep interest rates down.

It seems that our result is not robust to alternative concepts of competition in the banking industry. To derive the results, we assume that banks compete for depositors. This implies that the supply of funds is positively sloped. Suppose that we assume that banks face a perfectly elastic supply of funds and that they compete for projects. This corresponds to our second concept of competition described in Chapter II and represented

\textsuperscript{18} The terms 'monopoly' and 'duopoly' are used to serve the purposes of the analogy of our framework with a market. They should not be interpreted in their most rigorous meaning.

\textsuperscript{19} It would be of some interest to compare the equilibrium under each type of rivalry. Intuitively, it seems that the interest rate may be lower in a Bertrand industry than in a Cournot market. This is the consequence of the rival's aggressive response to increases in the own lending rate. A single bank might want to restrain further the rate it is charging to avoid any aggressive reaction.
in Figure 2b. Banks offer debt contracts that maximize the value of the firm's equity. Under this assumption, in the dual bank configuration, competition for projects pushes the equilibrium interest rates at the intersection of the zero profit condition on each loan.

In the single bank configuration, the same equilibrium should prevail. Because the supply of funds is elastic, banks have no power to limit the firms' incentives and must offer debt contracts that maximize equity value. The rate paid on deposits is exogenous. Given that rate, there exists only one equilibrium contract that yields zero profit for each lender and for which firms maximize their equity value. This contract is the same as the contract offered in the dual bank configuration. Because the supply of funds is elastic, the rate paid on deposits exogenously determines the bank's zero profit curve. A common lender does not have any latitude to lower interest rates and raise the value of its loans. Competition between firms would push the interest rates up until the bank earns zero profit. Hence, the single bank equilibrium would be the same as the dual bank equilibrium. In our model, this does not occur since the supply of funds has positive slope. In that case, banks compete for depositors. A common lender can keep interest rates low and increase the value of its loans. These excess rents are given to depositors. Because the rate paid on deposits adjusts endogenously, the zero profit locus of the bank is shifted accordingly to the increase in the value of its loans. The competition in the output market cannot increase the interest rates as this would decrease the depositors' return. Hence, competition for funds pushes the equilibrium towards a more collusive industry in the single bank configuration. This cannot happen if the supply of funds is perfectly elastic and banks compete for projects.

It seems that the elasticity of the supply of funds plays a critical role in the ability of a common lender to control the firms' incentives of debt. If the financial sector is characterized by a perfectly elastic supply of funds, the interest rates are independent of the identity of the lender and the output equilibrium is determined by the lending rates, which are determined by the rate paid on deposits. If the supply of funds has positive slope, a common lender can facilitate a partial collusion of downstream firms. This suggests that the type of competition in the financial sector may have important effects on the competitiveness of output markets.

Throughout the analysis, we assume that banks are risk neutral. The expected returns on the loan of both firms are correlated through the output market. If the stochastic parameters of each firm are distributed independently, the risk neutrality assumption has no bearing on the results since the debt values would not be correlated in a stochastic sense. But suppose that $s_i$ is positively correlated with $s_j$. The debt values would be statistically correlated. If banks are risk averse, their willingness to concentrate in one industry may be mitigated. The probability of default on the bank's loans when returns are correlated would have to be taken into consideration. Our results may be weakened by a risk aversion
assumption. There may be a tradeoff between diversification and industry control on the part of the bank. However, if the bank is active in other markets as well, the risk of the industry may be diversified with other loans in uncorrelated markets. In this case, the risk neutrality assumption would be justified.

5. Conclusion

This essay shows that a single bank lending to two firms in a duopoly facilitates a collusive output equilibrium when marginal returns are increasing with better states of nature. This is the consequence of banks having better control over the firms’ incentives and limiting the strategic effects of leverage. A single bank is apt to exercise better control over the industry than if both firms borrow from different banks. A single bank partially eliminates the competition between both firms and this results in safer loans. What may appear as speculative investments by banks may only reflect the bank’s willingness to effectively control its borrowers’ incentives. This essay provides an explanation for the observed fact that some banks concentrate in few industries, seemingly relinquishing the advantage of diversification. By concentrating, banks can alleviate the incentive problems linked to debt and improve the quality of their loans. In some cases, this may be done at the expense of a lower degree of diversification than one would expect. However, we note that we would need a more complete model of portfolio selection by banks to draw definite conclusions about the tradeoff concentration-diversification.

Even with a competitive banking industry, it is possible that the choice of a lender becomes a relevant variable as shown by Proposition 1. This is the consequence of imperfect output markets and the moral hazard inherent to the credit relationship. A single bank achieves a partial collusion of the output industry. But the collusive effect is not strong enough to reverse Myers (1984)’s ‘pecking order’ of alternate financial means. Internal funding (which yields the same output equilibrium as the full equity Cournot solution) still yields higher returns than debt despite debt’s potential collusive properties. ²⁰

This model finds a natural interpretation in the theory of international trade. Suppose our industry is an international duopoly with each firm in a different country. Assume that output markets are open to trade but that financial markets are closed to international competition. The dual bank configuration corresponds to the case of closed financial markets. Each firm has to borrow from a lender in its own country. The single bank

²⁰This observation is made by comparing two equilibria. It does not account for the strategic incentives of debt derived in Brander & Lewis (1986). It is an ex-post comparison of two different financial regimes. Internal funding may not be an equilibrium as firms are caught in a financial version of the Prisoner’s Dilemma and want to use the strategic properties of debt (Brander & Lewis, 1986). If firms could precommit to not using debt, this would be preferred to the single bank equilibrium.
structure is only attainable under a regime of financial free trade. Our results indicate that if both countries agree to free financial markets from trade barriers, the output market becomes more concentrated. Removing financial trade barriers decreases the extent of competition in international oligopolies and facilitates a partial collusion of these industries. As a result, consumers are worse off since they face higher prices. However, it is difficult to make any policy recommendations from these results as many important determinants of financial structure are abstracted from the analysis for expository purposes. We can mention taxes, bankruptcy costs, equity markets, etc. However, this result seems to be interesting.

It is generally agreed upon that opening output markets increases the competitiveness of international industries. We show that opening financial markets to international trade may have the opposite effect. However, opening all markets is beneficial. Suppose output and financial markets are closed. Each firm is a monopolist in its own country. Opening output markets to international competition creates an international duopoly in which each firm finances locally. This increases the extent of competition of the industry in each country. Opening financial markets facilitates collusion of the duopoly as each firm finances with the same lender. This reduces the competitiveness of the industry. However, we show that the resulting equilibrium outputs are larger than monopoly outputs. Hence from an autarkical situation, opening both financial and output markets increases the competitiveness of the industry in each country.

The results of this essay may be compared to a paper by Bernheim & Whinston (1985). They derive an equilibrium in which a common marketing agent for competing firms can generate the fully collusive outcome. They assume risk neutrality of agents and complete information about the delegated marketing function. These assumptions differ from the assumptions of our model. With debt contracts, this would be equivalent to assume that banks can credibly enforce an output decision by the firm. It may be shown that with such an assumption, we obtain a similar result as Bernheim & Whinston (1985)'s. A common lender generates the monopoly output in the industry. A full collusion is achieved. However, in the context of debt contracts, it is more interesting to assume that banks cannot control completely production decisions. In this case, the bankruptcy constraint alters the risk incentives of players. This weakens the collusive powers of the common lender and the monopoly output fails to be generated. This suggests that bankruptcy constraints are an important determinant of equilibrium in agency relationships. Even with risk neutrality, these constraints change the risk attitudes of the players and alter the equilibrium allocations.

In the next chapter, we focus on different interactions between production and financial decisions. In this essay, the market structure is given and we study the incentive effects of debt and the problem of a lender's choice. In the next essay, we abstract from these incentive
effects and show that a firm's financial structure may be linked to market structure. In an entry game, we suggest that an incumbent's financial policy may be used as a signal of the profitability of entry sent to potential entrants. Financial signalling may have a strategic value in entry games.
CHAPTER IV

STRATEGIC FINANCIAL SIGNALLING

1. Introduction

Many entry games in the theory of Industrial Organization are characterized by the presence of asymmetric information. In many cases, it is to the advantage of the informed player to communicate in a credible fashion its private information to an uninformed player. To overcome the information problem, the informed player can elect to send a signal to the uninformed player. This signal is designed in such a way that it cannot be imitated by other players. In this case, the signal conveys credible information and is correctly interpreted by the uninformed player. The disclosure of private information to uninformed players affects their strategy and has an impact on the output equilibrium. Hence, the signal may become a determinant of competition in the output market.

As discussed in Chapter II, the presence of asymmetric information may also characterize financial markets. It has important implications for a firm's financial choices. The financial policy becomes a relevant parameter of the firm's market value. There are models in which a firm uses its financial structure to signal its quality to financiers. By signalling its quality to financiers, a firm may ensure that its securities are priced at actuarially fair prices. Financial structure plays an important role in overcoming informational asymmetries.

We present a model of an entry game in which both financial and output markets are characterized by the presence of asymmetric information. In some cases, the informed firm would like to signal to financiers its quality so as to be able to secure financing at actuarially fair prices. It would also like to signal its quality to other players in the entry game to try to influence the outcome of the game to its advantage. If a signal can be observed in both markets, it could serve the purposes of conveying information simultaneously to financial and output markets. We argue that a firm's financial policy may serve as a common signal in both markets. In this case, the financial policy conveys information to financiers about the firm's quality. This allows financiers to fairly price the firm's securities. The financial policy also conveys information to other players in the entry game. Uninformed players' strategy may depend on the disclosure of private information and the outcome of the game may be altered. The informed firm may influence the game's outcome to its advantage by revealing its private information. The financial signal may be value creating for the informed

21 See Ross (1977), Leland & Pyle (1977) and Heinkel (1982), among others.
player and may become a determinant of the output market competition. The informed firm's financial policy becomes a strategic tool affecting the outcome of the entry game as it is used strategically to signal about some parameter of the output market competition. In the presence of asymmetric information in financial and output markets, the financial policy may become a determinative factor of competition in the output market.

We provide a theoretical relationship between financial and output market structure. We show that the informed player's financial structure may reveal private information and in turn affect the output market structure. Financial signalling is a channel through which production and financial interactions occur. As a signal, financial structure may affect the outcome of the output game and hence, the value of the firm. In turn, the quality of the firm affects its security's prices and hence, its financial choices. The capacity to signal with financial variables in an entry game creates important strategic interactions between production and financial sides of the firm.

This essay also has implications for the theory of finance. Financial policy acts as a signal in an entry game. It can affect the outcome of the game and the market structure. The financial policy may become value creating for the signalling firm. In the presence of asymmetric information in output and financial markets, financial structure is no longer arbitrary as in a Modigliani-Miller type world. We show that high quality firms use debt to signal their value. We also demonstrate that high quality firms do not pay any dividend in the signalling equilibrium. It is shown that signalling is done at a lower cost when dividends are not used.

This essay is related to three avenues of the existing literature. The mainstream articles on these topics are surveyed extensively in Chapter II. We mention here the most relevant papers. Signalling or reputation building is now common in the Industrial Organization literature. This essay may be contrasted with the work of Milgrom & Roberts (1982a, 1982b), Kreps & Wilson (1982a) and Dixit (1980). In these papers, the incumbent tries to deter entry or induce exit by engaging in some costly activity: output signalling, predation, investment in reputation or in capacity. But the financial decisions of the firms (incumbent and entrant) are not explicitly modelled. In this essay, the costly activity undertaken to deter entry takes the form of a financial signal. The financial policy serves as a signal of a parameter of the post-entry competition and hence, may become an effective entry deterrent.

Financial decisions play an important role in models of predation. In many cases, it is assumed that the entrant is financially constrained. This opens the door for the incumbent to prey upon the entrant to cause its bankruptcy and induce its exit. The problem with these models is that no formal explanation of why the entrant is financially constrained is
offered. If financial markets are perfect, the entrant can secure financing as long as staying in the industry is a profitable strategy. Telser (1966) argues that if an entrant has limited financial resources, the incumbent may try to prey upon it to induce its exit or weaken it to merger on favorable terms. In Benoit (1984), the entrant is assumed not to be able to endure a price war for more than a given finite number of periods. In equilibrium, the incumbent threatens to prey and the entrant stays out. Fudenberg & Tirole (1985) are the first to provide a formal explanation of why the entrant may be financially constrained. They base their analysis on a recent paper by Gale & Hellwig (1985) in which it is shown that with asymmetric information in financial markets, a minimum equity investment is required from the firm by its creditors. Predation lowers the entrant's cash flow, hence reducing its chance to provide creditors with an equity investment and to secure a loan to stay in the market. Their analysis assumes that the incumbent does not have any financial needs. They also rule out the possibility of equity financing for the entrant. These are critical assumptions for the derivation of their results. In this essay, there is no financial constraint which encourages predatory behaviour. Financial decisions constitute a signal about the post-entry competition. We present a formal model of the 'deep pocket' argument in the third essay of this thesis.

There is a growing interest among economists in the study of strategic interactions between financial and production sides of the firm. In Brander & Lewis (1986), debt precommits firms to an aggressive output strategy, but the market structure is exogenously given. In Allen (1985), financial structure influences market structure in a two period model through the possibility of bankruptcy. Titman (1984) suggests that a durable good monopoly uses its financial structure to signal its long term commitment to service the good. We diverge from these papers as financial structure becomes a determinant of output market structure in its capacity to signal about some parameter of competition.

In the finance literature, Leland & Pyle (1977), Ross (1977) and Heinkel (1982), among others, look at the signalling properties of financial structure in the presence of asymmetric information in financial markets. There are two different types of firm. Financiers cannot directly observe the firm's quality. Without signalling, security pricing is done on the basis of the average quality of firms. This may cause adverse selection problems, as it may encourage low quality firms to flow in and get financing at average prices. This creates incentives for high value firms to signal their quality to secure financing at fair prices. Financial signalling contributes to overcome the adverse selection problems characterizing financial contracts. In these papers, the output market is introduced to generate random returns and there is no interaction between production and financial decisions. In our model, production returns are influenced by financial structure. As a signal, it may increase the signalling firm's value by altering its rival's strategy.
A monopoly is threatened by entry. The profitability of entry to the entrant critically depends on the cost level of the incumbent. We suppose that the entrant wishes to enter the market if and only if the incumbent has high cost. But the entrant cannot observe the incumbent's cost level directly, and is therefore uncertain of whether the incumbent is a low or high cost type. All firms have to finance a fixed cost of production at the beginning of the period. Financial markets are characterized by the presence of asymmetric information about the incumbent's cost level. Without additional information, financiers cannot distinguish among incumbent's types. As a result, all security's prices are based on the average quality of the incumbent firms. A low cost incumbent would like to credibly reveal its private information to financiers to obtain financial prices that reflect its quality. Simultaneously, it would like to signal its cost to the entrant to deter its entry. We suggest that financial structure acts as a common signal in financial and output markets. Asymmetric information in financial markets allows the low cost incumbent to use its financial structure to signal its type and deter entry. We rely on financial markets' imperfect information to generate our results.

We are interested in equilibria in which the low cost incumbent distinguishes itself from the high cost firm. In these equilibria, the low cost firm's financial choices are such that misrepresentation by the high cost type is unprofitable. Since all players know the parameters of the game, they can compute the low cost firm's distinctive financial policy. The entrant bases its entry decision on the observation of the incumbent's financial policy and enters the market if and only if it observes a financial policy which is consistent with the high cost firm's optimal actions. In equilibrium, the low cost firm borrows an amount such that the high cost incumbent does not find it profitable to get a similar loan and deter entry. As the interest rate increases, the borrower transfers part of the rents generated on the output market to the lender. This transfer renders mimicking by the high cost type unprofitable. The equilibrium considered here is called 'separating' as each firm's type is fully revealed through its choice of financial structure. In a separating equilibrium, entry occurs in the same circumstances as if complete information prevails.

We disregard equilibria in which both types of incumbent choose the same financial policy. In this case, financial choices would convey no information to financiers and entrants. This type of equilibria is called 'pooling'. We do not consider these equilibria as interesting as separating equilibria in the context of our model.

Signalling is costly in our model. The low cost firm spends resources to signal itself to the entrant. The signalling costs take the form of a transfer of profits from stockholders to debtholders. This transfer means that debtholders earn abnormal returns on the low cost incumbent's loan. This is not inconsistent with competition in financial markets. These
rents persist over time as they are the direct consequence of the signalling function of the debt contract. For the low cost type, the signalling costs do not exceed the gains from separating from the high type: these gains consist of actuarially fair financial prices and a more concentrated output market. Hence, it is in the interest of the low cost incumbent to incur signalling costs by transferring rents to debtholders. These abnormal returns cannot be dissipated in the context of the game.

We now give an outline of the essay. In the next section, we present the basic structure of the model and assumptions. In Section 3, we abstract temporarily from the problem of existence of a separating equilibrium to derive its properties. We characterize the equilibrium financial policy of each player. In Section 4, we make a simplifying assumption to reduce the model. This allows us to derive a necessary and sufficient condition for the existence of a separating equilibrium. In Section 5, we present an example that shows that the existence condition derived in Section 4 is not vacuous and can be satisfied for reasonable values of the parameters. The conclusion follows in the last section.

2. The Model and Assumptions

An incumbent sees its market threatened by a single entrant. The incumbent may be one of two types completely characterized by its cost level which may be low, \( c_1 \), or high, \( c_2 \). This information is private to the incumbent as the entrant and financiers cannot directly observe the incumbent’s cost level. This represents the source of the asymmetry in the distribution of information among players in the model. The uninformed agents have common priors over the possible values of \( c_i \), the incumbent’s cost:

\[
\text{Prob}\{c_i = c_1\} = q \quad \text{and} \quad \text{Prob}\{c_i = c_2\} = 1 - q
\]  

(2.1)

The entrant’s marginal cost is \( c_e \) and common knowledge. Before starting production, the incumbent and the entrant must finance a fixed production cost, \( K \). We assume throughout that the riskless factor of interest and all discount factors are equal to 1. This eases the notation and is not necessary for the derivation of the results.

The inverse market demand function is denoted by \( P(Q) \) where \( Q \) is the aggregate output of the industry. We assume that \( P(Q) \) satisfies the usual properties that ensure that the Second Order Condition (SOC) for profit maximization is satisfied. We assume that profits are stochastic. We denote by \( a \) the stochastic component of the profits distributed over \( A = [a_l, a_h] \) according to the distribution function \( F(a) \). We adopt the convention that

---

22 A similar result is obtained in Giammarino & Lewis (1985); see also Stiglitz & Weiss (1984).
23 It is not necessary for both players to face the same fixed cost for the results to obtain.
higher realizations of \( a \) result in higher profits. We assume that firm \( i \)'s return in state \( a \) is \( P(Q)q_i - c_iq_i + a \). We discuss below the motivations behind this assumption and its implications for our results. Firms do not know the realized value of \( a \) when making their production decisions.

The assumption of stochastic profits makes the problem more interesting as firms may face a positive probability of bankruptcy. This plays an important role in equilibrium. This assumption underlines the role of debt contracts in signalling situations. We show that debt may be a cheaper signal than equity. The use of debt contracts allows high quality firms to signal at a lower cost than with other types of financial contract. Furthermore, the level of dividends in the financial policy is directly affected by the assumption of random returns. We show that, with stochastic profits, paying dividends is a more costly signal than debt. Dividends will therefore be zero. It can be shown that this result is reversed with non-stochastic profits. We feel that our assumption makes the problem of separation of both types less trivial and yields more interesting results.

If the entrant stays out, the monopoly expected operating profits are: for \( i = 1,2 \)

\[
\bar{\pi}(c_i) := \max_{q_i} \int_a^dh \{ P(q_i)q_i - c_iq_i + a \} dF(a)
\]

and \( q^m_i \) is the monopoly output. If the entrant comes in, we define incumbent \( i \)'s Nash duopoly profits as \( \pi(c_i, c_e) \) for \( i = 1,2 \); the entrant's profits are \( \pi(c_e, c_i) \) when facing incumbent \( i \). For example, duopoly profits may be computed by setting up a Cournot industry. We assume that \( q^d_i \) is incumbent \( i \)'s duopoly output and \( q^d_e \), the entrant's.

The ex-post operating return is contingent on the realized level of demand. We define

\[
\bar{R}(a, c_i) := P(q^m_i)q^m_i - c_iq^m_i + a
\]

for \( a \in A \) and \( i = 1,2 \) as the monopolist's operating return if state \( a \) has occurred. Similarly,

\[
R(a, c_i, c_e) := P(q^d_i + q^d_e)q^d_i - c_iq^d_i + a
\]

represents the duopolist's operating return for incumbent \( i \) in state \( a \).

A financial policy is defined by a five component vector \( s := (D, r, E, N, d) \in \mathbb{R}^5_+ \) where \( D \) is the borrowed amount; \( r \), the interest rate;\(^{24} \) \( E \), the outsiders' equity raised by the firm; \( N \), the number of new shares issued and \( d \), the dividends paid out to stockholders. Firms may raise more cash than needed to finance the fixed cost. They are allowed to pay

\(^{24} \) Note that \( r \) is not the interest factor, i.e., the magnitude of \( r \) is a number like .07, while the interest factor would be 1.07.

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the difference as dividends to shareholders before starting production. We show later that dividends play an important role in equilibrium.

There is a critical level of demand, $\hat{a}_i$, for which incumbent $i$ just meets its debt obligations. This level is implicitly defined by the following cash flow constraint: for $i = 1, 2$

$$\tilde{R}(\hat{a}_i, c_i) + D + E - K - d = D(1 + r)$$  (2.5)

The state $\hat{a}_i$ is called the breakeven state. For a given financial policy, one can show that $\hat{a}_2 > \hat{a}_1$. If the entrant comes in, $R(\hat{a}_i, c_i, c_e)$ may be defined similarly.

We now define the return function of each group of interest to the firm. We assume that all players behave as risk neutral agents. $N_0$ is the number of outstanding shares held by the firm's initial stockholders. If incumbent $i$ adopts the financial policy $s = (D, r, E, N, d)$ and the entrant stays out, the expected value of equity of its initial shareholders is: for $i = 1, 2$

$$\Pi(s, c_i) := \frac{N_0}{N + N_0} \left\{ d + \int_{\hat{a}_i}^{\hat{a}_h} \left[ \tilde{R}(a, c_i) + D + E - K - d - D(1 + r) \right] dF(a) \right\}$$  (2.6)

as they are residual claimants only in those states in which the firm is solvent. Note that the dividends $d$ are outside the integral sign as they are paid out to stockholders before the realization of the state of nature. The expected profits of incumbent $i$'s new shareholders are: for $i = 1, 2$

$$\Phi(s, c_i) := \frac{N}{N + N_0} \left\{ d + \int_{\hat{a}_i}^{\hat{a}_h} \left[ \tilde{R}(a, c_i) + D + E - K - d - D(1 + r) \right] dF(a) \right\} - E$$  (2.7)

The creditors' expected returns from a loan to incumbent $i$ are: for $i = 1, 2$

$$\rho(s, c_i) := \int_{\hat{a}_i}^{\hat{a}_h} \left[ \tilde{R}(a, c_i) + D + E - K - d \right] dF(a) + (1 - F(\hat{a}_i))D(1 + r) - D$$  (2.8)

Creditors are residual claimants in default states. When the entrant enters the market, $\Pi(s, c_i, c_e)$, $\Phi(s, c_i, c_e)$ and $\rho(s, c_i, c_e)$ may be defined similarly where $R(a, c_i, c_e)$ replaces $\tilde{R}(a, c_i)$ in the above expressions. The same definitions apply to the entrant with $c_i$ and $c_e$ being inverted.

We have discussed the basic assumptions of the model. We make additional assumptions about financial markets, objective functions and profitability of entry. The following assumption characterizes financial markets:

A.1 Financial markets are competitive.

Financial decisions cannot be reversed costlessly.
We assume that financiers compete for projects. This type of competition corresponds to the second concept of competition in Chapter II. The last assumption precludes the possibility that the manager of a high cost firm would report a false signal, thus conferring a capital gain to initial shareholders who would sell their shares at a high price following the signal, and then reverse the firm’s financial policy. Potential investors would be suspicious of stockholders trying to liquidate their shares after the signal is sent. This is why we assume away such moral hazard. Furthermore, it is always possible for the signalling firm to include provisions in its financial contract that would render financial restructuration costly. These costs would be sufficient to prevent the high cost firm from mimicking and then reverse its financial structure. The existence of these costs makes financial structure a credible commitment that may permit the separation of both types of incumbent. For example, the low cost firm could include a clause in its debt contract which would specify costs for paying back the debt before term. The enforcement of this clause by legal institutions would make debt contracts a credible commitment. We now make some behavioural assumptions:

A.2 The financial policy is chosen to maximize $\Pi(s, \cdot)$, the expected end of period value of the initial owners’ equity.

The financial policy is observable by all players.

Output maximizes the expected end of period value of the initial owners’ equity.

The first assumption is made for convenience. The determination of the firm’s objective function is still an unresolved issue in microeconomics and in the theory of finance. We conjecture that maximizing a weighted sum of all stockholders’ returns would not change most of our qualitative results. Since our assumption is a standard assumption of models of financial choices and it facilitates the derivation of the results, it is adopted in this essay. The second assumption is necessary for the financial policy to constitute a valid signal. The third assumption, is linked to the type of uncertainty assumed earlier. Define $\overline{R}(a, q_i, q_e, c_i) := P(Q)q_i - c_iq_i + a$. This functional form allows us to rule out any incentive effects of debt such as those described in Brander & Lewis (1986). As seen in Chapter III, debt precommits a firm to an aggressive stance in the output market. These considerations are important but we assume them away to focus on a different strategic role for financial structure. As shown in Brander & Lewis (1986), if $\overline{R}_{a_i} = 0$, debt has no effect on output and the output that maximizes the value of equity also maximizes the value of the firm. It can be shown that the assumption $\overline{R}_{a_i} = 0$ is basically equivalent to the treatment of uncertainty considered in this essay. Alternatively, we could simply assume that firms earn some returns from production and that these returns are unaffected by the level of debt. We would not have to model the explicit output decision. However, we feel that our assumptions have some expository advantages. We now characterize formally the profitability of entry:
A.3 $\pi(c_e, c_1) - K < 0 \quad \text{and} \quad \pi(c_e, c_2) - K > 0.$
\[ q\pi(c_e, c_1) + (1 - q)\pi(c_e, c_2) - K > 0. \]

The entrant wishes to enter if and only if the incumbent has high cost; but without information about the incumbent's cost, it would enter the market on the basis of its priors. If this is not the case, the low cost firm has no incentive to signal itself to deter entry.

The set-up is a multistage non-repeated game. At each stage, the information structure is altered.

S.0 Nature chooses the incumbent's type in accordance with the commonly known priors (2.1).

The incumbent learns his own type.

The stage S.0 establishes the source of the asymmetric information in the model.

S.1 Each type of incumbent chooses its financial policy to finance $K$.

S.2 The entrant observes the incumbent's financial policy.

The entry decision is made.

The entrant chooses its financial policy.

At stage S.2, the market structure is determined after observation of the incumbent's financial policy.

S.3 Production takes place.

S.4 The uncertainty is resolved.

Profits are realized.

Financial claims are paid out of operating profits.

S.5 End of the game.

We restrict our attention to a pure strategy equilibrium. Incumbent $i$ chooses a financial policy denoted by the vector $s(c_i)$. The entrant bases its entry decision upon the observation of the incumbent's financial policy. Conditional on the observation of $s(c_i)$, the entrant may enter or not. Its entry decision is represented by the variable $t(s(c_i))$ which takes the values 0 or 1, where 0 means 'no entry' and 1 that it 'enters the market'. In the case of entry, the entrant chooses its financial policy. It is represented by a vector $z(c_e)$. Since financial markets are competitive, financiers agree to finance any non-negative expected net present value projects whose value is computed in accordance with their beliefs. Upon observation of a firm's projected financial choices, financiers form beliefs about the firm's type. These beliefs are Bayesian updates of the priors (2.1). They are defined by $m(s(c_i)) \in [0, 1]$ where
\( m = \text{Prob}\{c = c_1 / s\} \) and \((1 - m) = \text{Prob}\{c = c_2 / s\} \). In the next section, we present the general characterization of an equilibrium of the game.

3. Equilibrium of the Model

We express each player's maximization problem and define an equilibrium of the game. Then, we assume that a separating equilibrium exists and characterize the separating strategy of each player. In the next section, we consider the existence problem. We derive a necessary and sufficient condition for the existence of a separating equilibrium. Some of the properties of the equilibrium derived in this section are used to show its existence. It is therefore better to delay the existence question until the next section.

We are interested in the characterization of an equilibrium in which the low cost incumbent can successfully deter entry by signalling its type to the entrant. To do so, the low cost firm must choose its financial structure such that it is unprofitable for the high cost incumbent to imitate it and deter entry. The high cost incumbent prefers to finance differently and allow entry on its market. The low cost firm's financial structure distinguishes the low cost from the high cost incumbent. All private information is revealed through financial choices. This type of equilibrium is called 'separating' as each type is identified following its financial choices. In 'pooling' equilibria, both types choose the same financial structure and this does not reveal any private information. In this case, entry would occur in all circumstances, by assumption A.3. Financial policies would have no strategic role to play. In our model, these equilibria are not as interesting as separating equilibria and are therefore not discussed.

For the low cost type, the choice of an appropriate financial structure constitutes a signal of its type. For the high cost incumbent to forego imitation and allow entry in its market, the signal has to be costly if imitated. The low cost incumbent uses its financial contracts to transfer rents from the firm's profits to securityholders. This transfer is such that imitation by the high cost firm is not profitable. Hence, the type 2 incumbent chooses a different financial policy than the type 1's financial policy. Financiers and the entrant correctly interpret the incumbent's choice of a financial policy and entry occurs in the same circumstances as in the presence of perfect information. Asymmetric information imposes signalling costs on the low cost incumbent but does not alter the outcome of the output stage from the full information solution.\(^{25}\) This is a common feature of many signalling separating equilibria.

\(^{25}\) Output may be altered if debt has a strategic role as in Brander & Lewis (1986). But we rule out this possibility with our treatment of the market uncertainty.
At each stage, each player chooses its strategy anticipating the response by other players in subsequent stages. In stage S.2, the entrant makes its entry decision and chooses its financial policy anticipating the output choices made in S.3. In stage S.1, the incumbent chooses its financial policy, knowing that it is observed by the entrant in S.2 and that the entrant bases its entry decision upon it. The incumbent takes into account the entrant’s reaction in choosing its financial policy. The correct method to solve these multistage games is to proceed by backward induction. Since production in stage S.3 is the last decision made by players, it has no strategic value and firms choose their output as described in Section 2. This is implicitly incorporated in all players’ return function.

We now express the incumbent’s maximization problem at the financial stage. Incumbent $i$ solves the following maximization problem:\textsuperscript{26} for $i = 1, 2$

$$\max_s \left[ 1 - t(s) \right] \Pi(s, c_i) + t(s)\Pi(s, c_i, c_e)$$

subject to:

\begin{enumerate}
  \item $D \geq 0$,  
  \item $r \geq 0$,  
  \item $E \geq 0$,  
  \item $N \geq 0$,  
  \item $d \geq 0$
\end{enumerate}

\textsuperscript{vi)} $E + D - K - d \geq 0$

\textsuperscript{vii)} $m(s) \left\{ \left[ 1 - t(s) \right] \bar{\rho}(s, c_1) + t(s)\rho(s, c_1, c_e) \right\} + \left[ 1 - m(s) \right] \left\{ \left[ 1 - t(s) \right] \bar{\rho}(s, c_2) + t(s)\rho(s, c_2, c_e) \right\} \geq 0$

\textsuperscript{viii)} $m(s) \left\{ \left[ 1 - t(s) \right] \bar{\Phi}(s, c_1) + t(s)\Phi(s, c_1, c_e) \right\} + \left[ 1 - m(s) \right] \left\{ \left[ 1 - t(s) \right] \bar{\Phi}(s, c_2) + t(s)\Phi(s, c_2, c_e) \right\} \geq 0$

The first six constraints are feasibility constraints on the financial policy. The first five constraints are non-negativity constraints on financial variables. Constraint vi) represents the cash flow constraint: the fixed cost and dividends cannot be larger than the money raised in financial markets. This implicitly means that the firm starts off with no liquidity. This is not necessary for the derivation of the results. As long as the firm cannot entirely finance the fixed cost with internal funds, it has to use financial markets. For example, $K$ may be reinterpreted as the difference between the fixed cost and the internal funding of the project. $K$ would then represent the outside financial needs of the firm. And even if the firm can finance its investment entirely with internal funds, financial structure may still be used as a signal. The low cost incumbent may use financial markets just to distinguish itself from a high cost firm. In vii), we require non-negative expected profits for all debtholders according to their beliefs, where $\rho(\cdot)$ is the debtholders’ return function. In viii), we impose

\textsuperscript{26} Note that all variables may be interpreted as end of period or beginning of period dollars as the discount factor equals 1.
the same condition on all issues of new shares. All new stockholders must earn non-negative profits according to their beliefs. Financiers agree to finance any non-negative net present value project. They price securities to ensure that they earn non-negative expected profits. We do not impose a priori a zero profit condition. We show that some financiers may earn positive rents in equilibrium. These rents are part of the signalling strategy of the low cost incumbent.

Note that the entrant’s strategy and financiers’ beliefs are made dependent on the incumbent’s financial policy. This notation reflects the fact that the incumbent anticipates the effect of its financial choices on other players’ strategy when choosing its financial policy. We also note that the optimal output strategies developed in the preceding section are embodied in the definition of the different return functions. This underlines the fact that we are solving the problem by backward induction.

Problem (3.1) is more complex than many signalling problems. In our model, the signal is sent in different markets than the output market. Other economic agents, financiers, are involved in the signalling. The signal has to satisfy a participation constraint for these new actors. This is incorporated in our problem through the constraints vii) and viii). It adds a new complexity to the incumbent’s maximization problem.

The entrant solves the following program: for \( t = 1, 2 \)

\[
\max_{z, c_t} \left\{ \mathbb{E} \left\{ \Pi(z, c_t, c_t) t(s(c_t)) \right\} \right. \\
\text{subject to:}
\]

i) \( D \geq 0 \), ii) \( r \geq 0 \), iii) \( E \geq 0 \), iv) \( N \geq 0 \), v) \( d \geq 0 \)

vi) \( E + D - K - d \geq 0 \)

vii) \( m(s(c_t)) \rho(z, c_t, c_1) + \left( 1 - m(s(c_t)) \right) \rho(z, c_t, c_2) \geq 0 \)

viii) \( m(s(c_t)) \Phi(z, c_t, c_1) + \left( 1 - m(s(c_t)) \right) \Phi(z, c_t, c_2) \geq 0 \)

where \( E_{c_t} \) is the expectation operator contingent on the entrant’s beliefs after the observation of the incumbent’s financial policy. These beliefs are Bayesian updates of the common priors (2.1). The constraints in (3.2) are similar to the constraints in (3.1) and their interpretation follows from the interpretation of the constraints in (3.1).

Financiers agree to finance any project or contract yielding non-negative expected returns. This is incorporated in the players’ optimization problems. By definition, they accept any financial policy that solves (3.1) or (3.2). Financiers evolve in a competitive environment and have no explicit strategy. They finance any project at any price under the
unique condition that this contract earns them non-negative profits computed in accordance with their beliefs.

Beliefs are formed from the priors being updated according to the equilibrium policy of each incumbent. For non-equilibrium policies, we assume that the entrant and financiers adopt a conservative stance and impute a high cost type to the deviating firm. It is always hard to motivate why rational players would ever deviate from their equilibrium strategy. However, we must define beliefs for these non-equilibrium choices to support the equilibrium. When making its financial choices, each player considers what would be its payoff if it deviates and chooses an out-of-equilibrium strategy. To prevent any deviation, we assume that financiers and entrant adopt conservative beliefs. These beliefs support the equilibrium. They are not costly for the entrant and financiers since deviations from the equilibrium strategies occur with probability zero.

An equilibrium is described by the solution to Problems (3.1) and (3.2) and the corresponding financiers' beliefs.

(E) Definition of an Equilibrium:

1) \( s^*(c_i) \) is the solution to (3.1) for \( i = 1, 2 \) given \( \bar{t}, m^*, \bar{z}; \)
2) \((t^*(\bar{s}), z^*)\) is the solution to (3.2) given \( \bar{s}, m^*; \)
3) \( \bar{s} = s^*, \bar{t} = t^*, \bar{z} = z^*; \)
4) \( m^* \) is the financiers' Bayesian update of the priors conditional on the observation of \( s^*(c_i) \) for \( i = 1, 2. \)

This definition is general enough to describe separating and pooling equilibria. As explained above, we are interested in the characterization of separating equilibria as pooling equilibria have a trivial interpretation in our model. We proceed with the derivation of the properties of separating equilibria implicitly assuming that one exists. In the next section, we use these properties to derive a necessary and sufficient condition for the existence of a separating equilibrium.

Definition (E) is satisfied when both types of incumbent solve (3.1) for given strategies of other players. The entrant maximizes its return after observing the incumbent’s financial policy. In equilibrium, no player has incentives to deviate from its chosen strategy, given the other players’ optimal strategy. This corresponds to a Nash equilibrium. The backward induction method for solving the equilibrium ensures that the equilibrium is sequential (see Kreps & Wilson, 1982b). This means that starting from any stage of the game, subsequent play constitutes a Nash equilibrium of the remaining subgame so defined. We
now characterize a separating sequential Nash equilibrium of the game.

In a separating equilibrium, each player can precisely infer the incumbent's type upon observation of its financial policy. In equilibrium, financiers' beliefs are $m^*(s^*(c_1)) = 1$ and $m^*(s^*(c_2)) = 0$. Given the assumption on non-equilibrium financial policies, we know that $m(s) = 0 \ \forall \ s \neq s^*(c_1)$. These probabilities completely characterize the financiers' equilibrium beliefs. In accordance with these beliefs, financiers decide whether they provide financing or not to an incumbent. Financing is provided if financiers earn non-negative profits on the financial contract proposed by the incumbent. We note that the entrant forms the same beliefs about the incumbent's type upon observation of its financial policy.

In a separating equilibrium, the entrant enters if and only if the incumbent has high cost. If the entrant decides to enter, all parameters relevant to the output competition are known. The entrant's cost is public knowledge. Hence, financiers can assess with certainty the value of the entrant. The entrant's financial policy has no strategic value. Its sole purpose is to finance the fixed cost of production. Given that financiers know with certainty the entrant's expected value, it is able to finance at actuarially fair prices in competitive financial markets. There is no residual private information and the entrant's financial policy is irrelevant to the output stage as financing occurs in a Modigliani-Miller type environment. This is shown in the following proposition.

**Proposition 1:** a) $z^* = (D', r', E', N', d')$ is any financial policy that satisfies:

i) $z^* \geq 0$

ii) $E' + D' - K' - d' \geq 0$

iii) $\rho(z^*, c_e, c_2) = 0$

iv) $\Phi(z^*, c_e, c_2) = 0$

b) $t^*(s) = \begin{cases} 0 \text{ if } s = s^*(c_1) \\ 1 \text{ if } s \neq s^*(c_1) \end{cases}$

c) the entrant's expected return from entry is $\pi(c_e, c_2) - K$.

**Proof:** b) If $s^*(c_1)$ is observed, the entrant knows that it is facing a low cost incumbent and by assumption A.3 does not enter. Any other observed financial policy induces entry as the entrant infers that the market is occupied by a high cost incumbent. Clearly, by A.3, the strategy in b) is optimal given that all private information is revealed in equilibrium.

a) If the entrant enters the market, it is because it observes a financial policy consistent with the financial choices of a high cost incumbent. The entrant's financial policy, $z^*$, satisfies the four conditions in the statement of the proposition. i) and ii) are feasibility constraints
for $z^*$. The last two constraints are the financiers' participation constraints. Since entry occurs if and only if the incumbent has high cost, all relevant parameters of the entrant's value are known in equilibrium. In competitive financial markets, financiers earn zero profit.

c) Inserting iii) and iv) in $\Pi(z^*, c_e, c_2)$ yields $\pi(c_e, c_2) - K$. Q.E.D.

Before the entrant makes its entry decision, the incumbent's type is known, revealed by its financial policy. The entrant comes in the market if and only if the incumbent has high cost. If the entrant comes in the market, all parameters of competition are known. Both firms' cost becomes common knowledge. Financiers know with certainty the entrant's expected value. Furthermore, the entrant's financial policy has no strategic value. The economic environment is similar to a Modigliani-Miller type world. The entrant's financial policy is irrelevant to its output decisions. Hence, any feasible financial policy is optimal for the entrant. Since financial markets are competitive, the entrant's financiers earn zero profit in equilibrium. This implies that the entrant keeps all rents generated on the output market and earn $\pi(c_e, c_2) - K$. We now characterize the high cost incumbent's equilibrium financial policy.

In a separating equilibrium, players can infer exactly the type of the incumbent. The high cost incumbent chooses $s^*(c_2)$ that solves (3.1). The high cost incumbent does not choose $s^*(c_1)$, the low cost's separating strategy, as it is selected such that misrepresentation by the high type is not profitable. Therefore, imitation is not a profitable strategy. By choosing a different financial policy than $s^*(c_1)$, the high cost incumbent fully reveals its type. Hence, its financial policy has no strategic role and is then irrelevant to the output stage. We prove this result in the next proposition.

**Proposition 2**: a) $s^*(c_2)$ is any feasible financial policy that satisfies $\rho(s^*(c_2), c_2, c_e) = 0$ and $\Phi(s^*(c_2), c_2, c_e) = 0$.

b) The high cost incumbent's expected returns are $\pi(c_2, c_e) - K$.

**Proof**: a) We transform problem (3.1) by incorporating the results obtained so far. Incorporating the entrant's optimal strategy and the financiers' beliefs and substituting constraints vii) and viii) in the objective function, we obtain the following transformed problem:

$$\max_s \pi(c_2, c_e) - K - \rho(s, c_2, c_e) - \Phi(s, c_2, c_e)$$

subject to:

i) $D \geq 0$,  ii) $r \geq 0$,  iii) $E \geq 0$,  iv) $N \geq 0$,  v) $d \geq 0$

vi) $E + D - K - d \geq 0$

vii) $\rho(s, c_2, c_e) \geq 0$
viii) \( \Phi(s, c_2, c_e) \geq 0 \)

It is clear that the objective function is maximized when vii) and viii) are satisfied with equality. Within these bounds, any policy that satisfies i) to vi) is feasible and optimal since the objective function becomes independent of the financial policy.

b) It follows from a) and the objective function in (3.3) that the high cost incumbent's expected returns are \( \pi(c_2, c_e) - K \). Q.E.D.

The intuition behind Proposition 2 is that the type 2 incumbent reveals its type by choosing a financial policy different from \( s'(c_1) \). Since the high cost incumbent cannot profitably misrepresent its type, its financial policy has no strategic value. The entrant comes in the market and market structure is determined. Financiers anticipate the entry and assess with certainty the incumbent's value. Since financial markets are competitive, the economic environment is similar to Modigliani-Miller's world. The Modigliani-Miller theorem applies and we obtain an irrelevance result. The financial policy has no effect on the firm's productive activities. As in Proposition 1, the chosen financial policy must be feasible and financiers must earn zero profit. Under these conditions, any financial policy is optimal. We remind the reader that we abstract here from important determinants of financial structure such as taxes and bankruptcy costs. The introduction of these factors would affect the results but not change their nature. The high cost incumbent's financial policy would still have no strategic value. We provide an example of an optimal policy for the type 2 incumbent:

\[
s'(c_2) = (0, 0, K, \frac{N_0 K}{\pi(c_2, c_e) - K}, 0)
\]

is an optimal financial policy. In this case, firm 2 finances in equity markets only. The optimal number of issued shares is obtained from the solution of \( \Phi(0, 0, K, N_0, 0, c_2, c_e) = 0 \) where \( \Phi(\cdot) \) is the new stockholders' expected return. Clearly \( s'(c_2) \) is feasible and also optimal as new stockholders earn zero profit.

We now compute \( s'(c_1) \), the separating financial policy for the type 1 incumbent. We incorporate in (3.1) the financiers' beliefs and the entrant's optimal strategy. These are based on the condition that the high cost incumbent cannot imitate the low cost firm's financial policy profitably. As an alternative representation of the equilibrium, we introduce in problem (3.1) a constraint to ensure that the chosen financial policy cannot be imitated profitably by the high cost firm. This constraint is called a self-selection constraint for the type 2 firm. To find \( s'(c_1) \), the separating strategy for firm 1, the type 1 incumbent can solve the following maximization problem:

\[
\max_s \Pi(s, c_1)
\] (3.4)
subject to:

i) $D \geq 0$,  ii) $r \geq 0$, iii) $E \geq 0$, iv) $N \geq 0$, v) $d \geq 0$

vi) $E + D - K - d \geq 0$

vii) $\tilde{\Pi}(s, c_2) \leq \pi(c_2, c_e) - K$

viii) $\tilde{\rho}(s, c_1) \geq 0$

ix) $\tilde{\Phi}(s, c_1) \geq 0$

This is similar to problem (3.1) in which we incorporate the entrant's optimal strategy and the financiers' beliefs. The first six constraints are feasibility restrictions. In viii), we impose that debtholders earn non-negative expected profits. The same constraint applies to new stockholders in ix). Constraint vii) represents the self-selection constraint for the type 2 firm. By misrepresenting as a low cost firm, the high cost incumbent deters entry. The returns from doing so are on the l.h.s. of the constraint. By Proposition 2, we know that the r.h.s. represents the returns from choosing $s^*(c_2)$ and allowing entry. The constraint says that the returns from misrepresentation, on the l.h.s., cannot be greater than the returns from choosing $s^*(c_1)$ and allowing entry. If $s^*(c_1)$ satisfies this constraint, it means that it credibly separates both types of incumbent. Hence, uninformed players' beliefs are rational given that the self-selection constraint holds in equilibrium.

We now characterize $s^*(c_1)$. The First Order Conditions (FOC) to problem (3.4) are:

$$
D : \frac{N_0}{N + N_0}(-r(1 - F(\hat{a}_1))) + \lambda_1 + \lambda_6 - \lambda_7 \frac{N_0}{N + N_0}(-r(1 - F(\hat{a}_2))) + \\
\lambda_8 r(1 - F(\hat{a}_1)) + \lambda_9 \frac{N}{N + N_0}(-r(1 - F(\hat{a}_1))) = 0 \quad (3.5)
$$

$$
r : \frac{N_0}{N + N_0}(-D(1 - F(\hat{a}_1))) + \lambda_2 - \lambda_7 \frac{N_0}{N + N_0}(-D(1 - F(\hat{a}_2))) + \\
\lambda_8 D(1 - F(\hat{a}_1)) + \lambda_9 \frac{N}{N + N_0}(-D(1 - F(\hat{a}_1))) = 0 \quad (3.6)
$$

$$
E : \frac{N_0}{N + N_0}(1 - F(\hat{a}_1)) + \lambda_3 + \lambda_6 - \lambda_7 \frac{N_0}{N + N_0}(1 - F(\hat{a}_2)) + \\
\lambda_8 F(\hat{a}_1) + \lambda_9 \frac{N}{N + N_0}(1 - F(\hat{a}_1)) - \lambda_9 = 0 \quad (3.7)
$$

We assume interior solutions for the probabilities of bankruptcy.
\[
N : \frac{-N_0}{(N + N_0)^2} A_1 + \lambda_4 + \lambda_7 \frac{N_0}{(N + N_0)^2} A_2 + \lambda_9 \frac{N_0}{(N + N_0)^2} A_1 = 0
\]

\[
d : \frac{N_0}{N + N_0} F(\hat{a}_1) + \lambda_5 - \lambda_6 - \lambda_7 \frac{N_0}{N + N_0} F(\hat{a}_2) - \lambda_8 F(\hat{a}_1) + \lambda_0 \frac{N}{N + N_0} F(\hat{a}_1) = 0
\]

where \( \lambda_i \) is the Lagrange multiplier for the \( i \)th constraint, and

\[
A_i := d + \int_{\hat{a}_i}^{a_k} \left[ \tilde{R}(a, c_i) + E + D - K - d - D(1 + r) \right] dF(a) \quad \text{for} \quad i = 1, 2
\]

We first show that the low cost incumbent finances at least partially with debt.

**Lemma 1**: \( s^*(c_1) \) is characterized by \( D^* > 0, r^* > 0 \).

**Proof**: Suppose the opposite. Then \( F(\hat{a}_i) = 0 \) for \( i = 1, 2 \).

(3.5) reduces to \( \lambda_1 + \lambda_6 = 0 \Rightarrow \lambda_1, \lambda_6 = 0 \);

(3.6) reduces to \( \lambda_2 = 0 \).

The firm finances with equity: \( E^* > 0, N^* > 0 \Rightarrow \lambda_3, \lambda_4 = 0 \);

(3.7) reduces to \( 1 - \lambda_7 - \lambda_9 = 0 \);

(3.8) reduces to \( 1 - (A_2/A_1)\lambda_7 - \lambda_9 = 0 \).

There are two possible cases:

a) if \( \lambda_7 > 0 \): the last two equations are inconsistent since \( A_2 \neq A_1 \). We reach a contradiction and hence, firm 1 must use debt.

b) if \( \lambda_7 = 0 \): by (3.7), we have that \( \lambda_9 > 0 \). This implies that \( \Phi(s, c_1) = 0 \) by the Kuhn-Tucker complementary slackness conditions (omitted here). But this means that equity financing is done at actuarially fair prices for firm 1 and that no rents are transferred to new stockholders. It can easily be shown that the self-selection constraint cannot hold under these conditions. Hence, firm 1 must use debt. \( Q.E.D. \)

This lemma states that separation of both types of incumbent cannot occur unless the low cost type uses debt. The intuition behind this result is clear. If the low cost firm finances only through equity, misrepresentation is attractive to the high cost type as stock prices are high. For such prices, the type 2 incumbent would sell a small fraction of its firm to finance the fixed cost of production. It would issue less new shares than if financiers know with certainty its firm’s value. Hence, the high cost incumbent would gain in financial markets since it would finance on more favorable terms. It would also gain in the output market since, by misrepresenting, it would deter entry. Equity financing cannot be a separating
strategy for the low cost type. Hence, if a separating financial policy exists, it must involve debt.

If the low cost firm tries to signal in equity markets, it must make the terms of the issue unattractive to the high cost incumbent. This can be done by issuing more shares than fair pricing requires for the given cash payment. For low debt levels, the marginal cost of signalling with equity consists of giving away an extra share on the firm's assets to new stockholders. This cost is proportional to the value of the firm. Since firm 1 has higher firm's value, equity signalling is too costly to use for firm 1. Using debt shrinks the interval of states for which the firm is solvent. This domain decreases faster for the high cost firm than the low cost type. This is used to reduce the incentives of misrepresentation of the high cost incumbent. As a result, low cost firms finance at least partially through debt.

**Lemma 2:** Necessary conditions for a separating equilibrium are that
\[ \lambda_1 = \lambda_2 = \lambda_6 = \lambda_8 = 0, \lambda_7 > 0. \]

*Proof:* a) Since \( D^* > 0, r^* > 0 \Rightarrow \lambda_1 = \lambda_2 = 0. \)

b) Using a) in (3.5) and (3.6), we obtain that \( \lambda_6 = 0. \)

c) From (3.6), we know that:
\[
\frac{N_0}{N + N_0} (1 - F(\hat{a}_1)) - \lambda_7 \frac{N_0}{N + N_0} (1 - F(\hat{a}_2)) - \lambda_8 (1 - F(\hat{a}_1)) + \lambda_9 \frac{N}{N + N_0} (1 - F(\hat{a}_1)) = 0 \quad (3.11)
\]

Using in (3.7) yields:
\[
\lambda_3 + \lambda_8 - \lambda_9 = 0 \quad (3.12)
\]

There are two possible cases:

i) if \( \lambda_9 = 0, \lambda_3 = \lambda_8 = 0 \Rightarrow \lambda_7 > 0 \) by (3.11).

ii) if \( \lambda_9 > 0, \bar{\Phi}(s, c_1) = 0. \) Hence, signalling costs are constituted of a transfer of rents to debtholders.\(^{26}\) This implies that \( \bar{\rho}(s, c_1) > 0, \) which in turn means that \( \lambda_8 = 0 \) and \( \lambda_7 > 0 \) by (3.11). Q.E.D.

The two main points of this lemma are:

i) The self-selection constraint for the type 2 firm is binding. In solving (3.4), the type 1 incumbent minimizes its signalling costs. It reduces type 2's expected profits from misrepresentation just enough to ensure that the high cost firm does not mimic and chooses \( s^*(c_2). \) Further reductions in type 2's profits would be unnecessarily costly for the type 1 firm in terms of signalling costs given the entrant's and financiers' beliefs. The low cost incumbent is solving for the least cost separating equilibrium. Other more costly equilibria

\(^{26}\) We assume that separation cannot occur without the type 1 incurring positive signalling costs. Otherwise the problem becomes almost trivial.
may be supported by appropriate beliefs, but finding the least cost equilibrium seems to be a rational action to be undertaken by the low cost incumbent.

ii) Even if the cash flow equation vi) in (3.4) holds with equality, it is not binding at the optimum. This is the consequence of all expressions in (3.4) depending only on the product $Dr$. Equations (2.5) to (2.8) can all be rewritten to depend only on the interest payments $Dr$. As long as $D \geq K + d - E$, the value of $D$ is arbitrary since $r$ can adjust to keep $Dr$ constant. This means that there is some arbitrariness in the choice of $D$. Hence $D$ can always be chosen such that vi) does not bind in equilibrium.

Our model allows us to derive intuitive results about the use of dividends in a signalling equilibrium. We show that dividends are more costly to use than debt for firm 1 to signal its quality to uninformed players. Hence, the low cost incumbent does not pay out any dividends in equilibrium.

**Proposition 3:** At the optimum, $s^*(c_1)$ is characterized by $d^* = 0$.

**Proof:** From Lemma 2 and (3.12), we know that $\lambda_3 - \lambda_9 = 0$.

a) If $\lambda_9 > 0$, $\lambda_3 = \lambda_9 > 0$. Hence, $N^* = E^* = 0$.

(3.9) becomes: $F(\hat{a}_1) + \lambda_5 - \lambda_7 F(\hat{a}_2) = 0$ and (3.6) yields:

$1 - F(\hat{a}_1) - \lambda_7(1 - F(\hat{a}_2)) = 0$. Suppose $\lambda_5 = 0$. Then, (3.9) implies that $\lambda_7 < 1$. But this means that both (3.6) and (3.9) cannot be satisfied. Hence, these two equations are consistent if and only if $\lambda_5 > 0$.

b) If $\lambda_9 = \lambda_3 = 0$, a similar comparison as above of (3.6) and (3.9) also yields that $\lambda_5 > 0$. This implies that $d^* = 0$. Q.E.D.

The low cost incumbent minimizes its signalling costs by not paying out any dividends. The cost to firm $i$ of not paying to stockholders a dividend of one dollar is $F(\hat{a}_i)$: if the dividend is not paid out, stockholders keep the dollar only in solvent states. If the firm goes bankrupt, creditors are residual claimants and get the foregone dividend. Since $F(\hat{a}_2) > F(\hat{a}_1)$, a one dollar dividend is more valuable to the high cost incumbent than to the low cost firm. If the low cost incumbent pays out the dividend, it increases type 2’s return from misrepresentation. This has to be offset by a larger loan to keep firm 2 on its self-selection constraint. To keep firm 2 on its self-selection constraint and increase dividends by one dollar, the loan must be increased by

$$\frac{F(\hat{a}_2)}{r(1 - F(\hat{a}_2))}$$

as an extra dollar of debt costs $r(1 - F(\hat{a}_i))$ to firm $i$. Since

$$\frac{F(\hat{a}_2)}{r(1 - F(\hat{a}_2))} > \frac{F(\hat{a}_1)}{r(1 - F(\hat{a}_1))}$$
firm 1 decreases its expected profits when paying a dividend of one dollar, offsetting it by a loan increase to remain on firm 2’s self-selection constraint. The type 1 firm must increase the loan by more than it would like to keep firm 2 on its self-selection constraint. Doing so puts firm 1 on a lower isoprofit line than if the dividend is not paid out. Separation costs are minimized when no dividend is paid out.

FIGURE 4
Dividend Signalling

This is illustrated in Figure 4. If dividends are positive, firm 1 incurs losses to keep firm 2 on the line $\pi^2 = \pi(c_2, c_e) - K$, firm 2’s self-selection constraint. Suppose $d_a > 0$ is paid out by both firms with a loan of $D_a$. If firm 1 increases its dividend payment by one dollar and offsets it with an appropriate loan increase to stay on $\pi^2$, it moves from $\pi_1^a$ to $\pi_1^b$. This corresponds to a decrease in firm 1’s expected profits. In equilibrium, firm 1 maximizes its expected return along firm 2’s self-selection constraint $\pi^2$ when $d^* = 0$. Then, firm 1 earns $\pi_1^a$, where $\pi_1^a > \pi_1^b > \pi_1^c$. Dividends are too costly in terms of signalling costs for firm 1 to pay out any. In the least cost separating equilibrium, dividends are absent.

Bhattacharya (1979, 1980) considers a possible signalling role for dividends. The signal is an actual promise by the firm to pay dividends at the end of the production period. The high value firm announces a dividend payment that it knows it can pay out at the end of
the period. This promise is such that the low value firm has little chance to be able to pay out the promised level of dividends. If the firm cannot keep its promise, it must finance the promised dividends and this is assumed to be costly. In expected terms, these costs are different for both types of firm and this difference allows separation to occur. In our model, dividends have a different interpretation than in many models of dividend signalling. We only consider dividends paid out prior to the production period. Hence, announced dividends are paid out with certainty by the firm since they are financed with cash raised in equity and debt markets instead of being generated from random production returns. This complicates comparisons between our model and alternative models of dividend signalling such as Bhattacharya (1979, 1980).

Ambarish, John & Williams (1987) consider a signalling model in which dividends play an active role. They assume that investors pay personal taxes on dividends and that they have a demand for liquidity. This demand is assumed to be decreasing in the paid dividend. They have a multidimensional signal. Dividends contribute to decrease signalling costs. They show that a mix of dividends and new stock issue constitutes an efficient signal of firm's quality. In our model, investors do not face a demand for liquidity. As they note, if the demand for liquidity is independent of dividends, dividends are not used in the signalling equilibrium. Finally, debt is assumed away from their model. Hence the effects on the bankruptcy probabilities described above cannot occur in their equilibrium.

If more cash than needed is raised in equilibrium, the extra liquidities are kept within the firm instead of being paid out as dividends. It is well known that, with perfect information, the dividend policy is irrelevant to the firm's value. In the presence of imperfect information, dividends may have a strategic role to play (even if they are null in our model). Positive dividends may render signalling costly enough that they may prevent the separating solution from occurring. Hence, the level of dividends is not arbitrary as it may affect the firm's value.

In Proposition 4, we provide a necessary and sufficient condition for the low cost firm to use equity. First, we need some additional notation. As we argue in the next section, all expressions in (3.4) depend only on the product $Dr$, the interest payments. This allows us to define for $i = 1,2$

$$\Pi(Dr, c_i) := \tilde{\Pi}(D, r, 0, 0, 0, c_i)$$

This represents the original stockholders' return when only debt is used. We know from Lemma 2 that the self-selection constraint for firm 2 is binding. We now define implicitly $Dr_1$ as the smallest root solving the equation $\Pi(Dr_1, c_2) := \pi(c_2, c_2) - K$. Hence $Dr_1$ represents the lowest interest payments such that firm 2's self-selection constraint is binding. Define
the condition (EC1) as:

\[
\frac{\Pi(D_{r1}, e_1)}{(1 - F(\hat{a}_1(D_{r1})))} \geq \frac{\pi(e_2, e_2) - K}{(1 - F(\hat{a}_2(D_{r1})))}
\]

where \(\hat{a}_i(D_{r1})\) represents firm \(i\)'s breakeven state when the interest payments are \(D_{r1}\). We now state the proposition.

**Proposition 4:** The low cost incumbent uses equity if and only if (EC1) does not hold.

**Proof:** Suppose \(E^* > 0, N^* > 0\), then \(\lambda_3 = \lambda_4 = 0\). By Lemma 2 and (3.12), \(\lambda_0 = 0\). (3.8) reduces to:

\[
\frac{N_0}{(N + N_0)^2} A_1 - \lambda_7 \frac{N_0}{(N + N_0)^2} A_2 = 0
\]

where the first term (the second term multiplying \(\lambda_7\)) represents the marginal cost to firm 1 (firm 2) of signalling with equity. The type 1 incumbent signals with equity by issuing more shares. In the above expression, each term represents the change in the old stockholders' return when an additional share is issued.

Equation (3.6) reduces to:

\[
\frac{N_0}{N + N_0} (1 - F(\hat{a}_1)) - \lambda_7 \frac{N_0}{N + N_0} (1 - F(\hat{a}_2)) = 0
\]

where the first term (the second term multiplying \(\lambda_7\)) represents the marginal cost to firm 1 (firm 2) of signalling with debt. The debt signal consists of a marginal increase in the interest rate. Combining these two equations, we obtain:

\[
\frac{A_1}{(1 - F(\hat{a}_1))} = \frac{A_2}{(1 - F(\hat{a}_2))}
\]

This condition says that in equilibrium, if equity is used, the financial policy is such that the ratio of the marginal cost of signalling with equity over the marginal cost of signalling with debt must be equal for each firm.

Condition (EC1) says that the relative marginal cost of equity in terms of debt is at least as big for firm 1 as for firm 2 when only debt is used to reduce firm 2's to its self-selection level. Hence if condition (EC1) is not satisfied, the marginal cost of equity in terms of debt is smaller for firm 1 than for firm 2. The statement of the proposition says that equity is used if and only if the marginal cost of equity in terms of debt is smaller for firm 1 than for firm 2 when firm 1 borrows \(D_{r1}\). If (EC1) does not hold, incumbent 1 can increase its return by decreasing the interest rate marginally and increasing the number of issued shares to keep firm 2 on its self-selection constraint. Conversely, if firm 1 can increase its return by making such a transfer, it must be the case that (EC1) does not hold. \(Q.E.D.\)
The marginal cost of using equity consists of a larger share of the firm sold to outsiders: it is the expression
\[ \frac{N_0}{(N + N_0)^2} A_i \]
The marginal cost of debt consists of an increase in the lending rate, \((1 - F(a_i))\). We consider a situation in which the low cost incumbent uses only debt to reduce the high cost firm's return from misrepresentation to its self-selection level. Proposition 4 tells us that equity is used if and only if the relative marginal signalling cost of equity with respect to debt is smaller for the low cost incumbent than for the high cost firm. If this is true, increasing the number of issued shares and decreasing marginally the interest rate reduces firm 2's return more than firm 1's. Hence, if firm 1 makes such a substitution and keeps firm 2 at its same level of profit, it increases its own return. Consequently, if (EC1) does not hold, the marginal cost of equity in terms of debt is smaller for firm 1 than for firm 2. In this case, the use of equity reduces firm 1's signalling costs. Firm 1 makes the substitution from debt to equity and chooses the most efficient financial mix to minimize signalling costs. If (EC1) holds, the type 1 firm prefers not to use any equity and finances only with debt. In this case, the substitution from debt to equity along firm 2's self-selection constraint is not profitable for firm 1 as it decreases its own return.

Propositions 3 and 4 underline the advantage of using debt contracts in signalling. Suppose a firm does not use its financial structure to signal its value. A high value firm may signal its quality by signing a contract with a third party, promising to give this party a share of its rents at the end of the period. Assume that this contract is binding and that defaulting is costly. The transfer of rents may be such that misrepresentation by a low quality firm is non-profitable. This contract may be seen as equivalent to equity financing in our model. Proposition 4 and Lemma 1 tell us that a financial contract using debt, at least partially, is more efficient to signal the firm's value than a contract using only equity. The use of debt in financial contracts minimize the high value firm's signalling costs. The marginal cost of debt is the loss of a dollar in solvent states. The marginal cost of equity is an additional fraction of the firm given to outsiders. For low debt levels, the marginal cost of equity in terms of debt is proportional to the firm's value as is shown in (3.13). At these debt levels, this relative marginal cost is higher for firm 1 than for firm 2, as firm 1 has a higher firm's value. Thus, it is always efficient to use debt in the separating financial contract. We show in Proposition 3 that debt is a cheaper signal than are dividends. Hence, debt is preferred to equity financing, dividend payments, the contract described above or even to a binding promise of a public burning of resources at the end of the period. Equity may be used at some point, if the relative marginal cost of debt in terms of equity becomes lower for firm 1 than for firm 2. This may occur if signalling costs reduce firm 1's value so much that issuing more shares is not too costly for original stockholders.
It is easily shown that $s^*(c_1)$, $s^*(c_2)$, $t^*$, $z^*$ and $m^*$ satisfy the definition (E) of an equilibrium.

**Theorem 1:** If a separating equilibrium exists, the following strategies and beliefs satisfy (E), the definition of an equilibrium:

i) $s^*(c_1)$ as characterized by Lemma 1, Propositions 3 and 4;

ii) $s^*(c_2)$ as characterized by Proposition 2;

iii) $z^*$, $t^*$ as characterized by Proposition 1;

iv) $m^*(s) = \begin{cases} 1 & \text{if } s = s^*(c_1) \\
0 & \text{if } s \neq s^*(c_1) \end{cases}$

**Proof:**

i) If a separating equilibrium exists, the gains from signalling for firm 1 exceed the signalling costs. Under this condition, $s^*(c_1)$ maximizes (3.1) for $i = 1$, given the entrant's optimal strategies and financiers' beliefs.

ii) From Proposition 2, it follows that $s^*(c_2)$ maximizes (3.1) for $i = 2$, given other players' optimal strategies.

iii) From Proposition 1, it follows that $z^*$ and $t^*$ solve (3.2).

iv) Given the players' strategies, financiers' beliefs are computed from the priors (2.1) and support the equilibrium. Q.E.D.

In the next section, we look at the problem of existence of the separating equilibrium. We derive conditions under which the equilibrium described in Theorem 1 exists. In Section 5, we provide an example that shows that these conditions are not vacuous and may be satisfied for reasonable values of the parameters of the model.

4. Existence of a Separating Equilibrium

In this section, we consider the problem of existence of the equilibrium presented in Theorem 1. We know from Proposition 4 that equity is used if and only if (EC1) does not hold. For now, we assume that the relative costs of both incumbents and the distribution function of the stochastic parameter, $a$, are such that (EC1) holds. As a result, the low cost incumbent uses only debt to separate itself from the high cost firm. We relax this assumption later. An equilibrium exists if a participation constraint for firm 1 is satisfied. In other words, we make sure that signalling costs do not exceed the gains to firm 1 from signalling. In a first step, we characterize the low cost type's separating strategy, $s^*(c_1)$, when (EC1) holds. Then, we derive a necessary and sufficient condition for the existence of a separating equilibrium.

---

29 In the next section, we consider the existence problem.
Assuming that (EC1) holds and using the results of Propositions 3 and 4, we can rewrite problem (3.4) in the following form:

$$\max_{D,r} \Pi(D, r, 0, 0, 0, c_1)$$ (4.1)

subject to:

i) \( D \geq 0 \)

ii) \( r \geq 0 \)

vii) \( \Pi(D, r, 0, 0, 0, c_2) \leq \pi(c_2, c_2) - K \)

viii) \( \rho(D, r, 0, 0, 0, c_1) \geq 0 \)

We know from Lemma 2 that constraint vi) in (3.4) is not binding in equilibrium, hence it is suppressed from (4.1). If we examine all expressions in (4.1), we notice that only the product of the debt \( D \) and the interest rate \( r \) is relevant: the solution depends only on the value of the interest payments. Suppose the firm borrows more than the fixed cost \( K \). The face value of the debt, \( D(1 + r) \), can be divided in three: \( D(1 + r) = K + (D - K) + Dr \). The extra liquidities \( D - K \) are kept within the firm since dividends are zero (Proposition 3). If the firm goes bankrupt, creditors recover this portion of the loan. Hence, the only risky portion of the loan is \( K \) and the interest payments \( Dr \). Of these two terms, only \( Dr \) is endogenous to the problem and, hence is of relevance. This means that there is some arbitrariness in the choice of \( D \).

Since \( d' = 0 \) and only \( Dr \) is relevant, the firm may borrow the exact amount \( K \) and transfer rents to debtholders by paying a high interest rate. This high interest payment would represent the signalling costs. Alternatively, the firm may borrow more than \( K \) and pay the same interest rate on \( D - K \) as on the first \( K \) dollars. Since \( D - K \) is always reimbursed to the bank, paying \( r' > 0 \) on this portion of the loan would constitute a transfer of rents from the firm to creditors. These two debt contracts achieve the same goal in signalling firm 1's value and keeping firm 2 on its self-selection constraint. Note that these remarks could be included in the preceding section. But they are most useful in the discussion of the existence problem. This is why we introduce this new notation in this section. This allows us to write problem (4.1) in the following form:

$$\max_{Dr} \Pi(Dr, c_1) := \int_{a_1} a_h \left[ \tilde{R}(a, c_1) - K - Dr \right] dF(a)$$ (4.2)

subject to:

---

30 Remember that the riskless rate of interest is 0.
i) $Dr \geq 0$

vii) $\Pi(Dr, c_2) := \int_{q_2}^{a_1} \left[ \tilde{R}(a, c_2) - K - Dr \right] dF(a) \geq \pi(c_2, c_e) - K$

viii) $\tilde{\pi}(Dr, c_1) := \int_{q_1}^{a_1} \left[ \tilde{R}(a, c_1) - K - Dr \right] dF(a) + Dr \geq 0$

These three constraints define the feasible set or the domain of maximization of (4.2). This set is closed. If it is not empty, by continuity of the objective function, we know that there exists a solution to (4.2). We now characterize the feasible set.

**Lemma 3:** Over the relevant range (interior default probabilities),

i) $\tilde{\pi}(Dr, c_i)$ is concave and increasing in $Dr$;

ii) $\Pi(Dr, c_i)$ is convex and decreasing in $Dr$ for $i = 1, 2$.

**Proof:**

i) \[
\frac{\partial \tilde{\pi}(Dr, c_1)}{\partial Dr} = 1 - F(\hat{a}_1) > 0 \quad \text{and} \quad \frac{\partial^2 \tilde{\pi}(Dr, c_1)}{\partial Dr^2} = -f(\hat{a}_1) \frac{d\hat{a}_1}{dDr} < 0
\]

ii) for $i = 1, 2$:

\[
\frac{\partial \Pi(Dr, c_i)}{\partial Dr} = 1 - F(\hat{a}_i) < 0 \quad \text{and} \quad \frac{\partial^2 \Pi(Dr, c_i)}{\partial Dr^2} = -f(\hat{a}_i) \frac{d\hat{a}_i}{dDr} > 0 \quad \text{Q.E.D.}
\]

By assumption, the low cost incumbent must incur positive signalling costs. Otherwise, the problem is trivial: firm 1 borrows $K$ at an interest rate such that creditors earn zero profit, and firm 2 has no incentive to imitate this contract to deter entry. This is why we assume that this contract is not enough to stop firm 2 from misrepresentation and rents have to be transferred to debtholders. This means that constraint viii) is not binding in equilibrium. In the preceeding section, we define $Dr_1$ as the smallest root solving vii) with equality. By the curvature of the different functions derived in Lemma 3, we know that $[Dr_1, G]$ is the domain of maximization, for some $G$ such that $0 < Dr_1 < G$. Because the objective function is decreasing in $Dr$, the optimum is at $Dr_1$ where vii) is binding. This confirms one of the results of Lemma 2 that says that the self-selection constraint of firm 2 is binding in equilibrium. This is the consequence of firm 1 minimizing its signalling costs. This is shown in Lemma 4.

**Lemma 4:** Define implicitly $Dr_1$ by $\Pi(Dr_1, c_2) := \pi(c_2, c_e) - K$. Then $Dr_1$ is the solution to (4.2).

**Proof:** We know that constraint viii) is not binding. Since $\Pi(Dr, c_2)$ is decreasing in $Dr$ (Lemma 3), the constraint vii) in (4.2) specifies feasible values of $Dr \geq Dr_1$. Since $\Pi(Dr, c_1)$ is also decreasing in $Dr$, the optimal solution is at $Dr = Dr_1$. Q.E.D.
The low cost firm raises its interest payments until firm 2's expected profits from misrepresentation drop enough to eliminate its incentives to mimic. Problem (4.2) is represented in Figure 5. By assumption, we know that, in equilibrium, $\pi(Dr, c_i) > 0$. Positive rents are transferred to debtholders. They represent signalling costs incurred by the low cost incumbent to separate itself from the high cost firm and hence deter entry.

**FIGURE 5**
Separating Equilibrium

The existence of these rents is consistent with the assumption that the credit industry is competitive. The reason is that these rents are paid out voluntarily to debtholders as part of a signalling equilibrium. These supranormal profits constitute a tool in the hands of the low cost incumbent to separate itself from high cost firms. Firm 1 chooses a financial policy that minimizes its signalling costs. In equilibrium, signalling costs are lower than the gains from signalling. Hence it is rational for a low cost incumbent to transfer these rents to debtholders. Competition in the credit industry does not eliminate these abnormal returns. However, these rents may be dissipated with some competition prior to the beginning of
the game. This type of competition would have no effect on the outcome of the game
and banks would earn zero expected profit in equilibrium. For example, creditors could
give a cash payment to an incumbent prior to the start of the game just to earn the right
to be its creditor. This cash payment would be made before incumbents learn their own
type and would be equal to the expected value of the rents transfer, i.e., \( q \bar{p}(D_r, c_1) \). This
would guarantee that creditors earn zero expected profit computed prior to the start of
the game. Of course, this payment would be irrelevant to the entry game itself and would
not have any impact on subsequent play. Alternatively, creditors could pay a third party
a cash payment just to earn the right to play the game. This entry fee would dissipate
any excess rents in an expected sense. Creditors entering the game would expect to earn
zero profit. Of course, these alternatives must be such that they do not confer market
power to financiers after their purchase of the right to play the game. Otherwise, firms
would not face competitive financial markets and this could alter the nature of the results.
See Giammarino \& Lewis (1985) and Stiglitz \& Weiss (1984) for a discussion of abnormal
returns in competitive industries in signalling models.

The preceding analysis provides some insight into the existence of a separating equilib­
rium. We know that \( D_r_1 \) is the solution to (4.2). It is the best separating action that firm 1
can undertake. It is an equilibrium if it satisfies a participation constraint for firm 1. The
low cost incumbent must prefer \( D_r_1 \) to any pooling solution, i.e., when both firms choose
the same financial policy. In other words, signalling must be worth it. Its gains must exceed
its costs. By assumption A.3, we know that if the entrant cannot distinguish between both
types of incumbent, it enters the market on the basis that entry has a positive expected
value. In Appendix 2, we derive the expected profits of firm 1 under the pooling solution.
We denote these profits by \( \pi \). Hence, \( \bar{\pi}(c_1) - K - \pi \) represents firm 1’s gains in profits
from separation. The type 1 incumbent’s participation constraint is

\[ \bar{p}(D_r, c_1) \leq \bar{\pi}(c_1) - K - \pi \]

It says that signalling costs cannot exceed signalling benefits. Define \( D_r_2 \) as the smallest
root solving:

\[ \bar{p}(D_r, c_1) := \bar{\pi}(c_1) - K - \pi \]

\( D_r_2 \) is the largest interest payment that firm 1 is willing to make to separate itself from
firm 2. Define \( \Pi^{-1}(\cdot, c_2) \) and \( \bar{p}^{-1}(\cdot, c_1) \) as the inverse functions of \( \Pi(D_r, c_2) \) and \( \bar{p}(D_r, c_1) \)
respectively, defined over the monotonic range of these functions, i.e., \( 1 - F(\hat{a}_i) > 0 \). Hence,

\[ D_r_1 = \Pi^{-1}(\pi(c_2, c_e) - K, c_2) \quad \text{and} \quad D_r_2 = \bar{p}^{-1}(\bar{\pi}(c_1) - K - \pi, c_1) \]

We define condition (EC2) as:

\[ (EC2) \quad \Pi^{-1}(\pi(c_2, c_e) - K, c_2) \leq \bar{p}^{-1}(\bar{\pi}(c_1) - K - \pi, c_1) \]
We may now state the following theorem:

**Theorem 2:** If (EC1) holds, a separating equilibrium exists if and only if (EC2) is satisfied. This equilibrium is characterized by

i) \( E^* = 0, \ N^* = 0, \ d^* = 0, \ D^* r^* = D r_1 = \Pi^{-1}(\pi(c_2, c_e) - K, c_2) \) for \( s^*(c_1) \);

ii) \( z^* \) and \( t^*(s) \) as described in Proposition 1;

iii) \( s^*(c_2) \) as described in Proposition 2;

iv) \( m^*(s^*(c_1)) = 1 \) and \( m^*(s) = 0, \ \forall \ s \neq s^*(c_1) \).

**Proof:**
a) If (EC2) does not hold, signalling is too costly and no separating equilibrium exists. Firm 1 opts for the pooling solution.

b) If (EC2) holds, signalling costs are less than the gains from signalling. Firm 1 chooses a separating strategy and a separating equilibrium exists.

c) By Theorem 1, we know that the strategies and beliefs described in the statement of this theorem satisfy (E), the definition of an equilibrium. \( Q.E.D. \)

If condition (EC1) holds, (EC2) is both necessary and sufficient for the existence of a separating equilibrium. It is hard to see how each parameter affects (EC2). Suppose that there is no uncertainty in the model and that profits are non-stochastic, i.e., \( A = \{ \bar{a} \} \). This little exercise of removing uncertainty off the model can yield useful insights in the existence problem by characterizing the parameter space where (EC2) tends to hold. We have: for \( i = 1, 2 \)

\[
\Pi(Dr, c_i) = \max \{ 0, \bar{\pi}(c_i) + D - K - D(1 + r) \} \tag{4.3}
\]

\[
\bar{\rho}(Dr, c_i) = \min \{ \bar{\pi}(c_i) + D - K, D(1 + r) \} - D \tag{4.4}
\]

The self-selection constraint for firm 1 is:\[^{31}\]

\[
\bar{\pi}(c_1) - K - Dr \geq \pi(c_1, c_e) - K
\]

and for firm 2:

\[
\pi(c_2, c_e) - K \geq \bar{\pi}(c_2) - K - Dr
\]

Firm 1 chooses \( Dr \) such that this last inequality is just binding:

\[
Dr_1 = \bar{\pi}(c_2) - \pi(c_2, c_e)
\]

If \( Dr_1 \leq \bar{\pi}(c_1) - \pi(c_1, c_e) \), both incentive-compatibility constraints are satisfied and a separating equilibrium exists when returns are non-stochastic. We can show that, if demand

[^{31}]: \( \pi(c_1, c_e) - K \) is an upper bound on firm 1's return in a pooling solution.
is linear, this condition tends to hold if $c_2$ is not too large in comparison with $c_1$ and $c_2$. The functions in (4.3) and (4.4) are linear. As seen in Lemma 3, adding a small amount of uncertainty adds curvature to $\Pi(\cdot, \cdot)$ and $\bar{\rho}(\cdot, \cdot)$. If the curvature is not too pronounced, the existence of the equilibrium is not compromised. If $\bar{\pi}(c_2) - \pi(c_2, c_e) \leq \bar{\pi}(c_1) - \pi(c_1, c_e)$ holds and if $A$ is a narrow enough support, $^{32}$ (EC2) is satisfied and a separating equilibrium exists.

Our model can handle some uncertainty if the width of the support is not too large. In the limit pricing model of Milgrom & Roberts (1982a), the introduction of a stochastic demand might destroy the equilibrium if the state of the world cannot be observed by the entrant: he may not be able to infer the incumbent's cost from the observation of the price. Matthews & Mirman (1983) consider a limit pricing model with stochastic demand. They show that entry does not occur in the same circumstances as with perfect information since the signal conveys only statistical information. It seems that financial structure signalling may handle better situations in which there is some degree of uncertainty. With financial signalling, entry occurs in the same circumstances as in the presence of perfect information. The advantage of a financial signal comes from the fact that it is observed before the resolution of the uncertainty. The information is not contingent on the realization of the state of nature. In a separating equilibrium, financial structure conveys perfect information to uninformed players. If price acts as a signal, it is observed after the resolution of uncertainty. Hence, it conveys only statistical information.

In this section, we assume that (EC1) holds and that no equity is used in the separating equilibrium. For cases in which (EC1) does not hold, the low cost incumbent uses equity in conjunction with debt to signal its type to the entrant. The use of equity reduces signalling costs from a situation in which firm 1 would use only debt. Equity allows the type 1 firm to choose a more efficient financial policy than if only debt is used. We argue that (EC2) is a sufficient condition for the existence of a separating equilibrium when (EC1) does not hold.

**Theorem 3:** If (EC1) does not hold, (EC2) is a sufficient condition for the existence of a separating equilibrium.

**Proof:** Suppose (EC1) does not hold. In the separating equilibrium, firm 1's financial policy is characterized by positive amounts of equity. If it uses only debt, it increases its signalling costs. Hence, if (EC2) holds, an equilibrium exists with firm 1 using only debt. Then it must be the case that one also exists with firm 1 using equity and debt, since it is a more efficient mix of signals than only debt. Q.E.D.

$^{32}$ The required width of the support is determined in part by the difference between $c_1$ and $c_2$. 

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In summary, if (EC1) holds, condition (EC2) is necessary and sufficient for the existence of a separating equilibrium. If (EC1) does not hold, (EC2) is sufficient, but not necessary for existence of the equilibrium. There are cases in which (EC2) does not hold, but equity reduces signalling costs enough to satisfy firm 1's participation constraint. In these cases, a separating equilibrium would exist even if (EC2) does not hold. In the next section, we present an example that shows that condition (EC2) is not vacuous.

5. Example

In this section, we present an example that shows that the condition (EC2) is not vacuous for reasonable parameter values. Assume that $c_1 = 0.5$, $c_2 = 2.0$ and $c_e = 2.0$. The linear inverse demand is given by $P(Q) = 10 - Q$. To facilitate computations, we assume that $F(a)$ is the uniform distribution with support $A = [-7.7, 7.7]$ and $f(a) = 1/15.4$. In Table I, we report each firm's expected profits for each possible market structure.

<table>
<thead>
<tr>
<th>Firms</th>
<th>Output</th>
<th>Profits*</th>
</tr>
</thead>
<tbody>
<tr>
<td>$c_1$</td>
<td>4.75</td>
<td>22.56</td>
</tr>
<tr>
<td>$c_2$</td>
<td>4.00</td>
<td>16.00</td>
</tr>
<tr>
<td>$c_1, c_e$</td>
<td>3.67</td>
<td>13.44</td>
</tr>
<tr>
<td>$c_2, c_e$</td>
<td>2.67</td>
<td>7.11</td>
</tr>
<tr>
<td>$c_e, c_1$</td>
<td>2.17</td>
<td>4.69</td>
</tr>
<tr>
<td>$c_e, c_2$</td>
<td>2.67</td>
<td>7.11</td>
</tr>
</tbody>
</table>

*Profits are for the first listed firm.

With these data, one can show that the condition $\bar{\pi}(c_1) - \pi(c_1, c_e) \geq \bar{\pi}(c_2) - \pi(c_2, c_e)$ holds. This means that a separating equilibrium exists when profits are non-stochastic. We illustrate now that if the support of $F(a)$ is not too large, a separating equilibrium also exists for random returns. If $K = 5$, the assumption A.3 is satisfied for $q < .87$. We assume that the low cost incumbent uses only debt for its financial policy and compute the solution to problem (4.2). We know that, at the solution, the self-selection constraint for firm 2 is binding. Hence, we calculate $Dr_1$ defined in the preceding section. We can write

$$\overline{\Pi}(Dr, c_2) = \int_{\delta_2}^{7.7} \left[ \bar{R}(a, c_2) - 5 - Dr \right] \frac{1}{15.4} da$$
This expression represents firm 2’s return if it mimics and deter entry. Using Table I, we obtain:

\[ \bar{\Pi}(Dr, c_2) = \int_{-7.7}^{7.7} (16 - 5 - Dr + a) \frac{1}{15.4} da \]

This expression reduces to \( \bar{\Pi}(Dr, c_2) = 0.032(Dr)^2 - 1.21Dr + 11.35 \). From Table I, we know that \( \pi(c_2, c_e) - 5 = 2.11 \). This is firm 2’s return if it does not misrepresent and allow entry. We can compute the level of interest payments that remove firm 2’s incentives to mimic. \( \bar{\Pi}^{-1}(2.11, c_2) = D r_1 = 10.64 \). \( D r_1 \) is the solution to (4.2). With interest payments equal to 10.64, the high cost incumbent has no incentive to mimic firm 1 and deter entry. It earns the same return for misrepresentation as for allowing entry. Now, we have to verify that firm 1’s participation constraint is satisfied for this value of the interest payments. We can verify that condition (EC2) is satisfied. First, we express the bank’s return.

\[ \bar{\rho}(Dr, c_1) = \int_{-7.7}^{7.7} [\bar{R}(a, c_1) - 5 - Dr] \frac{1}{15.4} da + Dr \]

Using Table I, we obtain:

\[ \bar{\rho}(Dr, c_1) = \int_{-7.7}^{7.7} (22.56 - 5 - Dr + a) \frac{1}{15.4} da + Dr \]

Hence, \( \bar{\rho}(Dr, c_1) = -0.032(Dr)^2 + 1.55Dr - 2.37 \). Now, we have to calculate firm 1’s gain from separation. If we assume that \( q = 1/2 \) and that only equity is used in the pooling solution,\(^{33} \) the return in the pooling solution is

\[ \Pi_0 = \pi(c_1, c_e) - \frac{K \pi(c_1, c_e)}{\hat{\pi}} \]

where \( \hat{\pi} = (1/2) \pi(c_1, c_e) + (1/2) \pi(c_2, c_e) \). Using Table I, \( \Pi_0 = 6.9 \). The gain from separation is:

\[ \hat{\pi}(c_1) - K - \Pi_0 = 22.56 - 5 - 6.9 = 10.66 \]

Hence \( D r_2 = \bar{\rho}^{-1}(10.66, c_1) = 10.65 \). This represents the maximum level of interest payments for which firm 1’s participation constraint is satisfied. We have \( D r_1 < D r_2 \) and condition (EC2) is satisfied. A separating equilibrium exists with \( D^* r^* = D r_1 = 10.64 \).

We can compute the expected profits for each firm in each situation.

Firm 1: If it chooses the separating strategy: \( \bar{\Pi}(10.64, c_1) = 6.94 \).

In the full equity pooling solution, \( \Pi_0 = 6.9 \)

Firm 2: Its return is the same if it misrepresents or not: \( \bar{\Pi}(10.64, c_2) = \pi(c_2, c_e) - K = 2.11 \).

\(^{33} \) These assumptions facilitate the derivation of the results.
Bank 1: \( \bar{\rho}(10.64, c_1) = 10.62 \).

The bank lending to firm 1 earns 10.62. These constitute the signalling costs of the low cost incumbent. These costs are smaller than the gains from separation. This implies that a separating equilibrium exists. All other financiers earn zero profit.

In this example, the separating equilibrium involves a positive probability of bankruptcy for each firm, i.e., \( \hat{a}_1 = -6.92 \), \( \hat{a}_2 = -0.36 \). Furthermore, in order to separate itself, firm 1’s financial choices do not have to induce bankruptcy with certainty for firm 2 if it misrepresents. This example underlines the importance of the width of the support of the random parameter of the demand function. Using the same data as above, one may show that if \( A = [-8, 8] \), no separating equilibrium exists.

We assume above that firm 1 uses only debt to separate itself from firm 2. We can show that condition (EC1) is satisfied in this example and hence, the exclusive use of debt minimizes firm 1’s signalling costs. Condition (EC1) can be expressed as:

\[
\frac{\Pi(Dr_1, c_1)}{(1 - F(\hat{a}_1))} \geq \frac{\pi(c_2, c_e) - K}{(1 - F(\hat{a}_2))}
\]

This yields:

\[
\frac{6.94}{(7.7 - (-6.92)) / 15.4} \geq \frac{2.11}{(7.7 - (-.036)) / 15.4}
\]

This inequality is satisfied. Hence, condition (EC1) holds and signalling costs are minimized with the low cost incumbent using only debt.

6. Conclusion

This essay focuses on the presence of asymmetric information in financial and output markets to show that simultaneous signalling in both markets is possible. This adds a new strategic dimension to financial policies. We demonstrate that an incumbent’s financial policy may be used successfully to signal to potential entrants about the profitability of entry. The same signal is observed by financiers. They are aware of the output game being played and can draw inferences from the observation of the incumbent’s financial policy on its value. These inferences allow financiers to correctly price the incumbent’s securities.

This essay has some implications for the theory of market structure. We suggest that financial structure and market structure are intimately linked. An incumbent may use its financial choices to signal about the profitability of entry to potential entrants. The financial signal may be interpreted as a deterrent to entry. The incumbent’s financial policy is observed by the entrant. It enters if and only if the financial policy is consistent with
the incumbent being in a profitable market for the entrant. Our argument is different from Telser (1966)'s long purse argument. In Telser (1966), the entrant is financially constrained and the incumbent engages in a price war to financially exhaust the entrant. In our model, the low cost incumbent uses its financial structure to transfer rents to financiers. This transfer is such that if the high cost incumbent mimics and deters entry, it does not earn more than if it allows entry in its market. Entrants are not financially constrained. They may be deterred from entry by observing the incumbent's financial policy. We provide a formal representation of the long purse argument in the next chapter.

Price or output have no strategic role to play in our model. The only signal considered here is the firm's financial structure. On technical grounds, this allows entry deterrence in only one production period. In Milgrom & Roberts (1982a), two production periods are required, as the price in the pre-entry period is used as a signal to the entrant of the profitability of entry. We also note that financial signalling handles stochastic market data better than does price signalling if the entrant cannot observe the state of the world. In this case, the observation of the price would only give statistical information on the incumbent's costs. As shown by Matthews & Mirman (1983), this distorts the entry decision with respect to the full information situation. A financial signal is sent and observed before the resolution of the uncertainty. Hence, in a separating equilibrium, the introduction of random returns does not affect the entry decision. Entry occurs in the same circumstances as with perfect information.

We show that financial contracts involving an issue of debt are relatively cheaper in terms of signalling costs than are contracts restricted to the sale of equity. This provides a rationalization for simultaneous signalling in credit and equity markets. We show that a low cost firm prefers to issue debt to signal its quality rather than to issue only equity. Doing so minimizes its signalling costs. This may be contrasted with Giammarino & Lewis (1985) who assume away debt in a financial signalling model.

In our model, signalling is dissipative. The signal is costly to send for the low cost firm. It must expend resources to signal its true value. In a separating equilibrium, these resources are recuperated through the gains from revealing its quality. In our model, these gains arise from stopping entry and from actuarially fair financial prices. The signalling costs consist of a transfer of rents generated on the output market from the firm to financiers. Even if financial markets are competitive, some financiers may receive positive rents from some projects. These abnormal profits for some creditors are consistent with competitive financial markets. They are offered voluntarily by the low cost firm to deter entry. Hence, they are value creating and persist in equilibrium. A more complete characterization of the credit market is needed to determine how these rents may be dissipated in equilibrium.
This essay has implications for the theory of financial structure. In the presence of asymmetric information in financial and output markets, financial structure becomes an important parameter of the output game. It is value creating as it constitutes a signal to potential entrants of the profitability of entry. The financial policy is not irrelevant to production decisions. With the introduction of asymmetric information, we diverge from a Modigliani-Miller type world.

In a Modigliani-Miller world, the firm's dividend policy is irrelevant to any output or investment decision. In our signalling model, the dividend policy becomes a relevant choice. In the absence of taxes, the optimal level of dividends is zero. Ironically, in this model, positive dividends may be a signal that the firm is of low value! This result is different from what is usually observed empirically. But we note that we abstract from important determinants of dividend policy such as taxes, shareholders' demand for liquidity, etc.

In this essay, we focus on asymmetric information about the incumbent's costs to show that its financial structure may serve as an entry deterring signal. In the next essay, we provide a formal representation of Telser (1966)'s deep pocket argument. We base our explanation on the presence of asymmetric information in financial markets. We assume that there are two types of entrant. The incumbent and financiers cannot directly observe the entrant's cost level. We show that an efficient entrant uses its financial choices to signal its quality to uninformed players. This forces the entrant to issue debt. This encourages the incumbent to prey upon the entering firm. It engages in a price war to try to financially exhaust the entrant.
CHAPTER V
PREDATION AND FINANCIAL SIGNALLING

1. Introduction

This essay presents a formal description and analysis of the so-called 'deep pocket' argument described by Telser (1966) and McGee (1958) among others. They argue that an entrant typically comes into a market having a more vulnerable financial structure than does a typical incumbent. Following entry, the incumbent engages in costly predatory activities, such as price wars, to try to financially exhaust the entrant. Because it has greater resources, the incumbent forces the entrant to exit, at least temporarily.

Two major problems have been noted in conjunction with this argument. First, it does not explain why the entrant is financially weak. With perfect financial markets, if it is profitable to enter the market, an entrant should always be able to secure funds to finance its entry. Predation is equally costly for the entrant and the incumbent. For example, if the incumbent engages in a price war, its own cash flow decreases. Hence, the incumbent cannot continue this strategy for a long period of time. Therefore, predatory activities should not alter significantly the long run profitability of entry. The entrant should be able to raise sufficient financing to enter and stay in the industry. This brings us to a second criticism of Telser's argument made by McGee (1980). If the entrant knows with certainty that the incumbent is predating, surely it wants to stay in the market as it knows that the incumbent cannot prey forever. In this case, predation cannot be successful in inducing exit and thus, cannot be a rational strategy for the incumbent to undertake. Consequently, even if predation was empirically observed (see McGee, 1958), until recently, no theoretical justification for it could be provided.

The development of the theory of models with imperfect information allows a formal representation of an incumbentrationally preying upon an entrant. Kreps & Wilson (1982a) and Milgrom & Roberts (1982b) justify predation on informational grounds. They assume that there are two types of incumbent. Efficient incumbents' cost is so low that the entrant cannot survive in their market. For these incumbents, responding to entry by lowering their price is rational. It is justified by their cost level. In high cost incumbents' market, entry is profitable. They show that if entrants are uncertain whether the incumbent is a high or low cost type, high cost incumbents have incentives to disguise themselves as efficient firms by predating. This is interpreted by the entrant as the incumbent having low cost and induces its exit. Predation becomes an investment in a reputation for being efficient (or tough). Such a reputation is sufficient to induce exit and discourage future entry. High
cost incumbents prey upon entrants for as long as the long run benefits of the reputation predation establishes outweigh its costs.

The above motive for predation is not based on the assumption that entrants are financially weak or vulnerable. Predation represents an investment in reputation. It is not linked to the deep pocket argument. It does not explain why entrants do not have the same financial structure as incumbents do. The 'long purse' argument is studied formally in Benoît (1984). The entrant is assumed to be able to sustain a price war for a finite number of periods. In equilibrium, the incumbent threatens to prey if the financially weak entrant enters the market. The entrant believes the incumbent's threat and chooses to stay out. The entrant's financial weakness renders the incumbent's threat credible. In this paper, no formal argument justifies the entrant's financial vulnerability.

In a recent paper, Fudenberg & Tirole (1985) build a predation model based on the deep pocket argument, justifying the entrant's financial weakness using recent developments in the theory of finance by Gale & Hellwig (1985): in the presence of imperfect information in financial markets, an optimal debt contract requires a minimum equity investment by the borrowing firm. Upon entry, predation reduces the entrant's cash flow, mortgaging its ability to fill future debt contract requirements. This increases the entrant's probability of exit. In this paper, there is an asymmetry in the treatment of the entrant and the incumbent that facilitates the derivation of the result. Only the entrant has financial needs. Suppose the incumbent also has to borrow. Then its own predatory activities may reduce its chance of securing a loan in the future. Also, predatory behaviour may be initiated by the entrant. Fudenberg & Tirole (1985) base their version of the long purse argument on the idea that entrants have larger financing requirements. Furthermore, they assume away equity financing. In their model, if we allow entrants to have access to these markets, the predation argument is destroyed.

In this essay, we argue that it is a 'lemons' problem characterizing entrants that induces them to choose a leveraged financial structure. We focus on asymmetric information in financial markets to generate incentives for low cost entrants to signal their true quality. In an entry game, financiers are uncertain of the quality of potential entrants. Efficient entrants can profitably enter the market, while bad entrants cannot make a profitable entry. We show that bad entrants still have incentives to misrepresent themselves as good entrants on financial markets, secure funds, and enter the industry. This 'lemons' problem implies that financiers cannot fairly price each firm's securities. Financial markets may become so thin that they disappear (see Akerlof, 1970). Consequently, if they cannot reveal credibly their quality to financiers, efficient entrants may be cut off from financial markets. This provides efficient entrants with an incentive to signal their value to financiers. As in Chapter IV, we
propose that financial structure acts as a signal of quality.

In equilibrium, efficient entrants use debt to signal their value to financial markets. These financial choices are such that bad entrants have no incentives to mimic good entrants by picking the same financial structure and enter the market. Because of the need to reveal their quality to financiers, good entrants enter the market heavily leveraged. This financial structure renders them vulnerable to predation. This is exploited by the incumbent predator. We assume that the incumbent benefits from its rival's bankruptcy. Therefore, the incumbent engages in a price war, thus decreasing the entrant's cash flow and increasing its probability of bankruptcy. Predation is a rational strategy to follow by the incumbent. This predatory response is anticipated by the entrant in its choice of financial structure. It lowers the expected value of entry by increasing the entrant's probability of bankruptcy. However, in many cases, predation is not sufficient to deter all entrants from entering the industry. Good entrants still find entry profitable despite the anticipation of predation.

Predation increases the cost of using debt to signal quality. But it also increases the cost from misrepresentation by low quality firms. Hence, despite the incumbent's predatory behaviour, it is worthwhile for the type 1 entrant to use debt to distinguish itself from high cost entrants. Debt is still the cheapest signal for the low cost entrant to reveal its quality and finance its entry. The entrant's financial structure becomes a determinant of its entry and also of the output market equilibrium as it leads to predatory activities by the incumbent. In our model, entrants and incumbents have equal financial requirements. The only asymmetry between entrants and incumbents is that the entrants' type cannot be observed directly by financiers. We show that imperfect information about the entrant's quality in financial markets is a sufficient condition for a formal justification of the deep pocket argument.

We are interested in the characterization of separating equilibria in which the low cost entrant distinguishes itself from the high cost firm. In such equilibria, misrepresentation by the high cost type is unprofitable. Financiers know the parameters of the game and they can compute the low cost firm's distinctive financial policy. They correctly interpret their observation of the entrant's financial policy, and provide funds only to firms making financial choices consistent with the low cost entrants' financial policy. As seen in previous chapters, this type of equilibrium is called separating. In a separating equilibrium, all private information is revealed through each type's financial choices.

The separating equilibrium is characterized by dissipative signalling as the low cost entrant devotes resources to the signalling of its quality. Signalling costs are constituted of expected bankruptcy costs, a possible transfer of rents from stockholders to debtholders, and a decrease in profits due to predation. As the size of the loan increases, expected
bankruptcy costs increase. The borrower may also transfer rents available from the output market to the lender in the same manner as in the preceding chapter. Because of the presence of debt, the separating financial structure entails predation by the incumbent following entry. These costs and transfers represent signalling costs and render mimicking by the high cost type unprofitable. In the previous essay, signalling is done with a transfer of rents from the incumbent to financiers. There is a transfer in value from equityholders to debtholders. Financiers are better off following the signal. In this essay, the low cost entrant faces expected bankruptcy costs as a result of its signalling. These costs decrease the firm's value. If private information could be transmitted freely from the entrant to financiers, these costs could be avoided and all parties would be better off. However, information cannot be revealed freely and credibly as high cost entrants would always have incentives to misrepresent themselves as low cost firms. Despite the presence of signalling costs, the low cost entrant may still earn positive rents in the output market and entry may remain profitable. In some cases, predation is sufficient to deter entry even by the low cost entrant. In this case, no entry occurs as the low cost entrant cannot credibly signal its type. In other cases, predation is not strong enough to deter entry of the low cost entrant. Entry has a positive expected value. In this case, entry occurs in the same circumstances as with perfect information. However, we show below that the output equilibrium is affected by the incumbent's predation. Note that predation is a rational strategy for the incumbent even if it does not deter entry. It reduces the entrant's cash flow and increases its probability of bankruptcy.

This essay has implications for the theory of finance. In the presence of asymmetric information in financial and output markets, financial decisions become relevant to production decisions. We also show that a firm's production decision may be affected by its rival's financial structure in imperfect output markets. If a firm is highly leveraged, we show that its rival may have incentives to engage in a price war to cause its bankruptcy. Finally, we show that in the presence of bankruptcy costs, regardless of tax considerations, a firm may still issue debt to finance its fixed cost of production. Debt has signalling advantages over equity. As shown in the second essay, debt is part of the efficient financial mix to signal quality to financiers. Hence, even with bankruptcy costs, debt may be preferred to equity. We note that we abstract from many important determinants of financial structure to focus on signalling incentives.

Contrary to the results of the preceding chapter, we show here that dividends may be used in a signalling equilibrium. The presence of bankruptcy costs may give a signalling value to dividends. The payment of dividends increases the probability of bankruptcy by decreasing the firm's cash flow. It is possible that, with bankruptcy costs, the increased probability of default contributes to decrease signalling costs. In this case, dividends would
be used as part of the least cost financial signal. We show in this essay that bankruptcy costs may have an impact on the optimal level of dividends. It has been shown that taxes are an important determinant of the optimal level of dividends. Since there is no tax in our model, we should interpret this result carefully. In other models, dividends may have a different role to play. For example, dividends may be used to fulfil the stockholders' demand for liquidity (see Ambarish, John & Williams, 1987).

The models of Chapters IV and V are closely related. In each essay, financial and output markets are characterized by asymmetric information. In the previous essay, there are two types of incumbent. In this essay, we have two types of entrant. Since incumbents and entrants must finance the same fixed cost, one may think that both models are conceptually similar. However, there are significant differences. In Chapter IV, the incumbent's financial structure is observed by the entrant and determines its entry decision. The low cost incumbent's financial structure becomes a strategic tool to deter entry. In the present essay, the entrant's financial decision does not determine any market structure decision by the incumbent. It is a determinant of market structure through the indirect effect of signalling in financial markets. By convincing financiers of its quality, a good entrant can finance its entry. Its financial structure has no direct strategic effect on market structure, but it has an indirect effect on the output game to be played following entry. By issuing debt, the entrant provides the incumbent with incentives to engage in a price war to induce its own exit. Hence, the entrant's financial structure has no strategic role to play in the determination of market structure but influences indirectly the output equilibrium. The informed player's financial structure plays a different role in each essay. In one case, it directly determines market structure. In the other case, it influences the output equilibrium through the predation incentives it confers to the incumbent.

In the next section, we present the formal structure of the model and the basic assumptions. We describe the different stages of the game. In particular, we assume that the financial stage in which players select their financial policy is played before the output stage in which output equilibrium strategies are derived. As in the previous essay, we prefer to delay until Section 5 the problem of existence of the equilibrium. It is easier to present the existence proof once the properties of the equilibrium are known. So, we first solve for the equilibrium and characterize it. Then, we show that such an equilibrium exists. In Section 3, we find the solution to the output stage for any given financial policy. We show that a firm's predatory incentives are a function of its rival's financial structure. In Section 4, we characterize the equilibrium of the financial stage, taking into account its effects on the solution of the output stage. When they make their financial decisions, players anticipate how these decisions affect the resolution of the output stage. This allows us to solve for a sequential equilibrium of the game. In Section 5, we use the results of the two preceding
sections to present the proof of the existence of a separating equilibrium. We show that such an equilibrium always exists. In Section 6, we present a reduced form of the model similar to the reduced model of the previous chapter. The conclusion follows.

2. The Model and Assumptions

A monopoly is threatened by entry. There are two types of entrant which are completely characterized by their cost level which may be low, \( c_1 \), or high, \( c_2 \) (> \( c_1 \)). Entry is profitable if and only if the entrant has low cost. The information about the entrant’s cost is private. The incumbent and financiers are uncertain of the entrant’s cost level and cannot observe it directly. This represents the source of the asymmetry in the distribution of information in the model. Uninformed agents have common priors over the possible values of \( c_e \), the entrant’s cost:

\[
\text{Prob}\{c_e = c_1\} = q \quad \text{and} \quad \text{Prob}\{c_e = c_2\} = 1 - q
\]  

(2.1)

The incumbent’s marginal cost is \( c_i \) and common knowledge. The entrant and incumbent must finance a fixed production cost, \( K \), before starting production.\(^{34}\)

Entrants and incumbents are only distinguished by their respective information set. Entrants know their rival’s and own cost. Incumbents only know their own cost with certainty. Incumbents have no advantage with regard to financial requirements as they have in Fudenberg & Tirole (1985) and Benoit (1984). Incumbents and entrants must finance the same amount \( K \). Neither type of player is financially constrained a priori.

We assume that the entrant’s alternative project earns a competitive return equal to zero. This assumption facilitates the derivation of the results. By assuming this, we ensure that the low cost firm always wants to distinguish itself from the high cost entrant. With a higher alternative return, separation may become too expensive in terms of signalling costs and the low cost firm may prefer to undertake the alternative project. In this case, no separating equilibrium would exist. The riskless factor of interest and all discount factors are equal to 1.

The inverse market demand is denoted by \( P(Q) \) where \( Q \) is the aggregate output of the industry. We assume that \( P'(Q) < 0 \) and \( P''(Q) \leq 0 \). Profit returns are stochastic and \( a \) denotes a random parameter with support \( A = [a_l, a_h] \) and distribution \( F(a) \). We assume that

\[
\bar{a} = \int_{a_l}^{a_h} a \, dF(a) = 0 \quad \text{and} \quad \int_{a_l}^{a_h} a^2 \, dF(a) > 0
\]

\(^{34}\) It is not necessary for both players to face the same fixed cost for the results to obtain.
To simplify the mathematical treatment of the problem, we assume that $F(a)$ is the uniform distribution. This assumption is not necessary for the results to obtain. In one occasion, we need to sign the derivative of the density function. Because we want to abstract from the effects of moving between states of different likelihood, we assume that $F(a)$ is uniform. Assuming a uniform distribution helps to focus on the main point of the essay. The main results hold for arbitrary distribution functions.

The fact that profits are stochastic makes the problem more interesting. We can have default probabilities different from zero or one. This means that predation can have a marginal effect on the probability of bankruptcy. If profits were non-stochastic, predation would have no effect until the prey’s profits are equal to its debt obligations. At this point, more predation would result in the prey going bankrupt with probability one. With interior default probabilities, a marginal analysis of predatory incentives is possible.

The entrant’s expected operating profits in state $a$ are: for $e = 1, 2$

$$ \int_{q_e}^{a} [P(Q)q_e - c_eq_e + a] dF(a) $$

where $q_e$ is the output of firm $e$. In general, it is believed that debt has important effects on output. This is formally modelled in Brander & Lewis (1986). We abstract from these well known effects to focus on entry, financial signalling and its possible predatory implications. We believe that introducing the strategic effects of debt would not change the qualitative nature of the results. There are different ways of ruling out these effects. First, we can assume that managers must follow a strict plan which forces them to choose production to maximize the value of the firm, independently of its financial structure. In this case, debt would have no effect on the firm’s output strategy. Alternatively, it can be assumed that uncertainty has no effect on the firm’s marginal revenue. Under this assumption, choosing output to maximize the value of equity or the firm’s value would be equivalent. This is the approach adopted in this essay. Our treatment of uncertainty precludes strategic interactions between output strategy and financial policy of the sort modelled in Brander & Lewis (1986). A sufficient condition for these strategic interactions to be ruled out is that

$$ \frac{\partial^2 [P(Q)q_e - c_eq_e + a]}{\partial a \partial q} = 0 $$

This condition is satisfied with our treatment of uncertainty.

A financial policy is defined by a 5-component vector $t = (D, r, E, N, d) \in \mathbb{R}^5_+$ where $D$ is the borrowed amount; $r$ is the interest rate; $E$ is the outsiders’ equity raised; $N$ is

---

35 Note that $r$ is different from the interest factor $(1 + r)$. It is also different form the riskless rate of interest as firms usually command a risk premium.
the number of new shares issued and \( d \) is the dividend paid out to stockholders. Dividends have the same interpretation as in the preceeding chapter. Firms may raise more cash than needed to finance the fixed cost. They are allowed to pay the difference as dividends to shareholders before starting production. We show later that dividends play an important role in equilibrium.

We assume that a firm obtains a benefit of \( B > 0 \) if its rival goes bankrupt at the end of the period. This may represent a strategic advantage gained over the rival in future periods. Bankruptcy may cause a firm to leave the market temporarily or permanently. This yields a strategic benefit to its rival. For a formal model of this, the reader is referred to Allen (1985). Conversely, we assume that a leveraged firm incurs bankruptcy costs \( BC \geq 0 \) if it defaults on its loan. These may represent direct or indirect bankruptcy costs. For simplicity, we consider \( B \) and \( BC \) as exogenous: they do not depend on the players' debt or cost levels. Endogenizing these parameters in the model would complicate the computation of the results. Refinancing or debt restructuring would have to be incorporated in the analysis to endogenize \( B \) and \( BC \). The theory of two period financial contracts is still at an early stage and these issues are still unresolved for their most part.\(^{36}\) Worrying about them would take us away from the topic of this essay.

The ex post operating return depends on the realization of \( a \), the state of nature. We define for \( e = 1, 2 \):

\[
S(a, q_e, q_i) := P(Q)q_e - c_e q_e + a \quad \forall \ a \in A
\]

as the entrant's operating return if state \( a \) has occurred. There is a critical state of nature, \( \hat{a}_e \), for which entrant \( e \)'s production return just meets its debt obligations. This level is implicitly defined by: for \( e = 1, 2 \)

\[
S(\hat{a}_e, q_e, q_i) + D_e + E - K - d = D_e(1 + r) \quad (2.2)
\]

\( \hat{a}_e \) is called the breakeven state. The firm is solvent \( \forall \ a \in [\hat{a}_e, a_h] \). For a given financial policy, we can show that \( \hat{a}_1 < \hat{a}_2 \). The efficient entrant is always solvent in more states than is the high cost entrant. We report the following derivatives:

\[
\frac{d\hat{a}_e}{dq_e} = -\frac{\partial S(\hat{a}_e, q_e, q_i)}{\partial q_e}, \quad \frac{d\hat{a}_e}{dq_i} = -\frac{\partial S(\hat{a}_e, q_e, q_i)}{\partial q_i},
\]

\[
\frac{d\hat{a}_e}{dD_e} = r, \quad \frac{d\hat{a}_e}{dr} = D_e, \quad \frac{d\hat{a}_e}{dd} = 1, \quad \frac{d\hat{a}_e}{dE} = -1 \quad (2.3)
\]

obtained from total differentiation of (2.2).

\(^{36}\) Giammarino (1985) is one exception. He studies the impact of asymmetric information on the process of debt restructuring.
We now define the profit function of each group of investors in the entrant's firm. \( N_0 \) shares are held by the entrant's initial stockholders. If an entrant \( e \) adopts the financial policy \( t = (D_e, r, E, N, d) \), its initial stockholders earn at the end of the period:\(^{37}\) for \( e = 1, 2 \)

\[
\Pi(t, c_e, c_i, D_i) := \frac{N_0}{N + N_0} \left\{ d + F(\hat{a}_i)B - F(\hat{a}_e)BC \right. \\
\int_{\hat{a}_e}^{\hat{a}_i} \left( R(a, c_e, c_i, D_e, D_i) + D_e + E - K - d - D_e(1 + r) \right) dF(a) \right\}
\]

(2.4)

where \( R(a, c_e, c_i, D_e, D_i) \) represents the operating return when each firm chooses its output optimally taking into account its rival's and own financial policy. This is derived in Section 3 when we solve the output stage of the game. Original stockholders are residual claimants in those states in which the firm is solvent. The expected profits of the entrant \( e \)'s new shareholders are: for \( e = 1, 2 \)

\[
\Phi(t, c_e, c_i, D_i) := \frac{N}{N + N_0} \left\{ d + F(\hat{a}_i)B - F(\hat{a}_e)BC \right. \\
\int_{\hat{a}_e}^{\hat{a}_i} \left( R(a, c_e, c_i, D_e, D_i) + D_e + E - K - d - D_e(1 + r) \right) dF(a) \right\} - E
\]

(2.5)

as they own the firm's complementary fraction of initial stockholders' share. Creditors' expected return for a loan \( D_e \) to entrant \( e \) is: for \( e = 1, 2 \)

\[
\rho(t, c_e, c_i, D_i) := \int_{\hat{a}_i}^{\hat{a}_e} \left( R(a, c_e, c_i, D_e, D_i) + D_e + E - K - d \right) dF(a) + (1 - F(\hat{a}_e))D_e(1 + r) - D_e
\]

(2.6)

Creditors are residual claimants in default states. Similar definitions apply to the incumbent's financiers.

We have discussed the basic assumptions of the model. We make additional assumptions about financial markets, objective functions and profitablility of entry. The following assumption characterizes financial markets:

A.1 Financial markets are competitive.

Financial decisions cannot be reversed costlessly.

This characterization of financial markets is the same as in the preceeding essay and bears the same interpretations and implications. Financiers compete for projects. With the last assumption, the manager of a high cost firm cannot report a false signal to confer

\(^{37}\) We assume that \( F(\hat{a}_i)B \) belongs to stockholders independently of bankruptcy. The benefit \( B \) may become available only in future periods. In the event of bankruptcy, creditors are residual claimants in the current period. In the latter periods (not explicitly modelled here), financial restructuration or refinancing may occur and \( B \) could belong to all shareholders. This simplifies the mathematical exposition of the results. We also assume that bankruptcy costs are borne by all stockholders.
a capital gain to initial stockholders who could sell their shares at a high price following
the signal, and then reverse the financial policy of the firm. Potential financiers would be
suspicious of stockholders trying to liquidate their shares after the signal has been sent.
We preclude by assumption such moral hazard actions from occurring. Furthermore, as
mentioned in the previous chapter, the signalling firm can include in its financial contract
costly penalties for such reversal. These penalties would be sufficient to prevent the high
cost firm from mimicking and then reverse its financial structure. We make the following
behavioural assumptions:

A.2 The financial policy is chosen to maximize $\Pi(t, c_k, c_j, D_j)$, $j \neq k$, the end of period
expected value of the firm accruing to initial owners.
Output maximizes the expected value of the original stockholders' equity.
The financial policy is observable by all players.

These assumptions have the same interpretation and justifications as in Chapter IV and
we refer the reader to it for more details. Assume that $\pi(c_e, c_i, 0, 0)$ represents entrant e’s
value when both firms in the industry finance with equity. In this case, neither firm has
incentives to prey upon its rival. We now characterize formally the profitability of entry in
the absence of predation:

A.3 $\pi(c_2, c_i, 0, 0) - K < 0$ and $\pi(c_1, c_i, 0, 0) - K > 0$
$q \pi(c_1, c_i, 0, 0) + (1 - q) \pi(c_2, c_i, 0, 0) - K < 0$

When all firms finance with equity, no predation takes place. In a full equity output
equilibrium, only the low cost entrant can profitably enter the market. With perfect
information, only the low cost entrant would be able to secure financing to enter the market.
We also assume that the average value of an entrant is negative. This is computed according
to the priors (2.1). This means that with incomplete information about the entrant’s cost,
no financing is available for any entry project. This reinforces the low cost firm’s incentives
to signal its value to financiers to secure financing and enter the market. This assumption
has important implications for the problem of existence of the separating equilibrium. If
the low cost firm cannot distinguish itself from a high cost firm and enter the market, the
best that it can do is to stay out and earn a competitive return of zero. Hence, the low cost
entrant can afford large signalling costs in order to be able to secure funds and enter the
market. This assumption ensures that a separating equilibrium always exists.

The assumption A.3 can be justified explicitly. It is derived from a ‘lemons’ problem.
In the absence of any strategic considerations, because of positive bankruptcy costs, firms
prefer to finance with equity. Suppose that only the low cost entrant seeks financing and

---

38 $\pi(\cdot)$ is defined more formally in the next section.
chooses to finance in equity markets. Define \( t_0 \) as its financial policy in which it uses only equity to finance \( K \) and in which stock prices are such that new stockholders earn zero profit. We show that if stock prices are actuarially fair, the high cost entrant has incentives to misrepresent itself as a low cost firm and enter the market. The low cost firm’s initial stockholders earn

\[
\Pi(t_0, c_1, c_i, 0) = \frac{N_0}{N + N_0} \pi(c_1, c_i, 0, 0)
\]

and the new stockholders’ zero profit condition is

\[
\frac{N}{N + N_0} \pi(c_1, c_i, 0, 0) = K
\]

The new stockholders’ expected return is equal to their equity contribution. This implies that \( \Pi(t_0, c_1, c_i, 0) = \pi(c_1, c_i, 0, 0) - K \). Suppose that a high cost firm misrepresents itself as a low cost firm and gets the same financial contract. After substitutions, we find that this high cost firm’s initial stockholders earn

\[
\Pi(t_0, c_2, c_i, 0) = \pi(c_2, c_i, 0, 0) - \frac{\pi(c_2, c_i, 0, 0)}{\pi(c_1, c_i, 0, 0)} K
\]

Hence, given A.3, we can sign this expression. It reduces to:

\[
\Pi(t_0, c_2, c_i, 0) = \pi(c_2, c_i, 0, 0) \left( 1 - \frac{K}{\pi(c_1, c_i, 0, 0)} \right) > 0 \quad (2.7)
\]

This shows the incentives of firm 2 to misrepresent itself as a type 1 firm and enter the market even if it is an inefficient entrant. By mimicking, a high cost firm’s initial stockholders can shift the expected loss from its entry to new stockholders by selling equity at relatively high stock prices. Misrepresentation confers an immediate capital gain on the high cost firm. This result is independent of the relative size of the costs of each type. If stock prices remain high, inefficient firms always have an incentive to issue equity. This shows that for any level of stock prices, inefficient firms want to issue equity to realize a capital gain at the expense of new stockholders. This underlines the ‘lemons’ problem characterizing equity markets and justifies the assumption that the average quality of entrants is negative. At actuarially fair equity prices for the low cost entrant, initial stockholders of all types of entrant may earn positive returns from misrepresentation. This may increase drastically the supply of bad entrants. Equity markets may become so thin that they disappear. In turn, this provides strong incentives for firm 1 to signal its value to financiers in order to be able to secure funds and enter the market.

The set-up is a multistage non-repeated game. At each stage, the information structure is altered.
S.0 Nature chooses the entrant’s type according to the commonly known priors (2.1).
   The entrant learns his own type.

The stage S.0 establishes the source of the asymmetric information in the model.

S.1 Each type of entrant chooses its financial policy to finance $K$.
   The entry decision is made.

The output market structure is determined in stage S.1.

S.2 The incumbent chooses its financial policy to finance $K$.

S.3 Production takes place.

In stage S.3, each firm observes the financial policy of its rival. This determines the
   predatory incentives and production decision.

S.4 The market uncertainty is resolved.
   Profits are realized.
   Financial claims are paid out of operating profits.

S.5 End of the game.

There is an important difference between this essay and the previous one that emerges
from the description of the stages of the game. In this essay, the informed player's financial
policy has no strategic value. It has an indirect effect on the output market equilibrium by
influencing the uninformed player’s preying incentives through the benefits conferred by its
rival’s bankruptcy. In the previous essay, the informed player’s financial policy is observed
by uninformed players. From this observation, they make inferences about the incumbent’s
type. These inferences, in turn, determine an entry decision. Hence, the informed player’s
financial policy becomes a determinant of market structure. We may also note that, in both
essays, the informed player chooses its financial structure first. Then, it is followed by the
uninformed player’s financial choices. This allows information to be transmitted before the
uninformed player moves.

We now define each player’s financial strategy. We restrict our attention to a pure
strategy equilibrium. An entrant $e$ chooses a financial policy denoted by $t(c_e)$. The entrant
also makes the decision whether to enter or not. This is parametrized by $u(c_e) \in \{0, 1\}$,
where $u = 0$ means ‘no entry’ and $u = 1$ means ‘entry’. The incumbent's financial
policy is denoted by $s(c_i)$. Financial markets are competitive and financiers agree to
finance any non-negative expected net present value projects computed in accordance with
their beliefs. These beliefs are Bayesian updates from the observation of the entrant’s
financial policy and are defined by: $m(t) \in [0, 1]$ where $m(t) = \text{Prob} \{ c_e = c_1 / t \}$ and
$1 - m(t) = \text{Prob} \{ c_e = c_2 / t \}$. In a separating equilibrium, financiers are able to assign a value of 0 or 1 to $m(t)$ as the entrant’s financial choices fully reveal its private information.

To solve this multistage problem, we use the method of backward induction which consists in solving the second stage first, and then solving the first stage, incorporating the solution of the second stage in the resolution of the first stage. At each stage, we solve for a Nash equilibrium. This allows us to solve for a sequential equilibrium of the game (see Kreps & Wilson, 1982b). Starting from any stage, subsequent play represents Nash equilibrium play of the subgame constituted of the remaining stages. For example, in the output stage S.3, firms take the financial policies as given and make their production decision to maximize the equity value of initial stockholders. Hence, financial decisions in stages S.1 and S.2 are made anticipating the resolution of the output stage S.3.

In the next section, we solve for the output equilibrium strategies for arbitrary financial policies. This corresponds to finding a Nash equilibrium of the stage S.3 which is the last stage in which players have to make a decision. In Section 4, we use these output strategies to derive each player’s optimal financial policy. The incumbent makes its financial choices in stage S.2 and the entrant, in stage S.1. These choices determine the predatory incentives in stage S.3. This is taken into account by each player in its financial choices. We delay until Section 5 the problem of proving the existence of the equilibrium. It turns out that the existence proof is based on some of the results derived in Sections 3 and 4.

3. Equilibrium of the Output Stage

In the output stage, each firm makes its production decision to maximize the value of equity. Financial policies are known and influence the output decisions. Because of the presence of bankruptcy costs and benefits (resulting from their rival’s bankruptcy), firms have incentives to take into account each player’s financial policies in making their production decision. For example, if a firm benefits from a rival’s bankruptcy, it may want to engage in a price war to cause its rival to default on its loan.

A firm $k$ facing a rival $j$ chooses its output to maximize its equity value:\textsuperscript{39}

$$
\max_{q_k} \frac{N_0}{N + N_0} \left\{ d + F(\hat{a}_j)B - F(\hat{a}_k)BC + \int_{\hat{a}_k}^{q_k} \left( P(Q)q_k - c_kq_k + a + D_k + E - K - d - D_k(1 + r) \right) dF(a) \right\}
$$

\textsuperscript{39} The output decision actually maximizes the value of equity accruing to old stockholders. But since this represents a fraction of the total value of equity, maximizing equity value is basically equivalent to maximizing a fraction of the equity.
where $\hat{a}_k$ and $\hat{a}_j$ are defined by (2.2) for each firm respectively. The First Order Condition (FOC) is:

$$
(P'(Q)q_k + P(Q) - c_k)(1 - F(\hat{a}_k)) - f(\hat{a}_k)BC\frac{d\hat{a}_k}{dq_k} + f(\hat{a}_j)B\frac{d\hat{a}_j}{dq_k} = 0
$$

(3.2)

Of particular interest is a special case in which only firm $k$ finances with debt. As we show in the next section, firm $k$ may be called an entrant and firm $j$, an incumbent. Under this assumption,

$$
\hat{a}_j = a_j \quad \text{and} \quad \frac{d\hat{a}_j}{dq_k} = 0
$$

Firm $k$’s FOC (3.2) reduces to:

$$
(P'(Q)q_k + P(Q) - c_k)(1 - F(\hat{a}_k)) - f(\hat{a}_k)BC\frac{d\hat{a}_k}{dq_k} = 0
$$

with

$$
\frac{d\hat{a}_k}{dq_k} = -\left[ P'(Q)q_k + P(Q) - c_k \right]
$$

obtained from (2.3). Hence, we have:

$$
\left[ P'(Q)q_k + P(Q) - c_k \right] [(1 - F(\hat{a}_k)) + f(\hat{a}_k)BC] = 0
$$

The solution is at $P'(Q)q_k + P(Q) - c_k = 0$. The output that maximizes the value of equity also maximizes the value of the firm. This means that bankruptcy costs have no effect on output choice. This is not surprising given the assumption on the form of uncertainty, i.e., $S_{aq} = 0$. At the margin, output has no effect on the default state: since marginal returns are zero, a marginal change in the output decision does not change the firm’s return. This means that the breakeven state remains unaffected by a marginal increase in output. Consequently, the bankruptcy costs, $BC$, are irrelevant to the production decision. Bankruptcy costs shift down the profit function without changing the optimal output decision. This is proven in Brander & Lewis (1988).

By assumption, firm $j$ uses only equity. It is solvent in all states of the world. A similar problem to (3.1) implies that firm $j$’s FOC is:

$$
P'(Q)q_j + P(Q) - c_j + f(\hat{a}_k)B\frac{d\hat{a}_k}{dq_j} = 0
$$

(3.3)

with, from (2.3),

$$
\frac{d\hat{a}_k}{dq_j} = -P'(Q)q_j > 0
$$

This means that

$$
f(\hat{a}_k)B\frac{d\hat{a}_k}{dq_j} > 0
$$
Hence, in (3.3), \( P'(Q)q_j + P(Q) - c_j < 0 \) in equilibrium. For any level of its rival’s output, firm \( j \) produces more in comparison with the full equity solution. This may be interpreted as predatory behaviour by firm \( j \). By assumption, firm \( j \) benefits from firm \( k \)’s bankruptcy. By increasing its output, firm \( j \) lowers its rival’s cash flow and hence, makes default on its loan more likely. This increases firm \( j \)’s expected return. Upon observation of firm \( k \)’s financial structure, firm \( j \) engages in a predatory price war. Formally, one can show that firm \( j \)’s benefits from firm \( k \)’s bankruptcy shift out firm \( j \)’s reaction function. As a result, firm \( j \)’s output increases while firm \( k \)’s output decreases. Firm \( j \) engages in a price war to influence the output market to its advantage. This is made possible by the fact that its rival finances at least partially with debt.

Further, by assumption

\[
\frac{d}{dD_k} \left( f(\hat{a}_k)B \frac{\partial \hat{a}_k}{\partial q_j} \right) = f'(\hat{a}_k) B \frac{\partial \hat{a}_k}{\partial q_j} = 0 \quad (3.4)
\]

The outward shift in firm \( j \)’s reaction function is independent of firm \( k \)’s debt level. If a firm issues debt, there is a once and for all discrete shift in its rival’s reaction function. The assumption of a uniform distribution plays a critical role in this result. It means that \( f'(\cdot) = 0 \). Suppose that the distribution is an arbitrary function. The sign of the expression (3.4) would depend on the derivative of the density function. If \( f' > 0 \), the equilibrium would be moving toward a more likely state. In this case, as debt increases, predatory incentives increase also. The return from predation increases as the marginal bankrupt state becomes a more likely state. Hence, firm \( j \)’s output becomes an increasing function of firm \( k \)’s debt level. Under the opposite assumption, \( f' < 0 \), the return from predation decreases. There is a discrete shift in firm \( j \)’s output as firm \( k \)’s debt goes from zero to \( \epsilon \). For higher levels of debt, firm \( j \)’s output would be a decreasing function of firm \( k \)’s debt.

We conjecture that the assumption of a uniform distribution does not affect our results. As the low cost entrant borrows to signal its quality, it takes into account the predatory response of the incumbent. With a uniform distribution, this response is constant for any positive debt levels. For arbitrary distributions, the response would vary with the level of debt. It could be more or less severe depending on the sign of \( f' \). A more severe response \( (f' > 0) \) could increase the extent of predation and render entry unprofitable for the low cost entrant. To avoid the fact that results would depend on the likelihood of the marginal state of bankruptcy, we assume that the distribution is uniform. This has no bearing on the qualitative nature of the results.

We represent in Figure 6 firm \( j \)’s predatory response and its effect on the output equilibrium. At point A, we have the full equity duopoly equilibrium. At this point, both
firms finance with equity. Point A' represents the duopoly equilibrium if firm k is leveraged.
Taking on debt allows its competitor to be aggressive in the output market. Firm j's reaction function is shifted out, raising its own output and decreasing its rival's output. This decreases the leveraged firm's profits and increases the predator's returns. The fact that this effect is independent of the debt level depends critically on the assumption about the distribution function of the stochastic parameter. In a more general model, these effects would depend on debt levels. This is worked out in Brander & Lewis (1988).

This section characterizes the output equilibrium when one firm finances with equity and the other firm issues positive amounts of debt. We show in the next section that the incumbent finances only with equity, while a successful entrant must use debt. These financial policies are consistent with the output equilibrium derived above. We define

$$\pi(c_k, c_j, D_k, D_j) := \int_{q_j}^{q^*_j} S(a, q^*_k, q^*_j) \, dF(a)$$

where $q^*_k$ and $q^*_j$ represent the solution to (3.1) for each firm. These outputs constitute a Nash equilibrium of the output stage S.3. The expression represents the maximized value of firm $k$ when it borrows $D_k$ and its rival, $D_j$. Similarly, we may define $R(a, c_k, c_j, D_k, D_j)$
as the ex post optimal per-state return. These definitions are used in the derivation of the results of the financial stage.

4. Equilibrium of the Financial Stage

We are interested in the characterization of an equilibrium in which the low cost entrant can successfully signal its value to financiers and enter the market. In doing so, the low cost firm chooses a financial structure such that it is unprofitable for the high cost entrant to imitate it and enter the market. If it cannot misrepresent as a low cost entrant, the high cost firm must choose a different financial policy from the low cost firm. These financial choices reveal its type. Hence, financiers refuse to provide financing to this firm identified as a high cost entrant. Consequently, it stays out. This corresponds to a separating equilibrium as defined in the previous essay. For separation to be credible, the low cost firm's financial choices must be such that it becomes costly for the high cost entrant to misrepresent itself as a low cost firm and enter the market.

In this model, separation is costly for the low cost entrant. The cost of the signal borne by the low cost type consists of expected bankruptcy costs, a possible transfer of rents from stockholders to debtholders and a predatory response by the incumbent. These signalling costs render misrepresentation by the high cost entrant unprofitable. These costs are high enough to ensure that the type 2 firm's stockholders forego imitation and stay out of the market. Financiers observe the entrant's financial policy and correctly interpret it. They are able to infer exactly the entrant's true type. This allows financiers to fairly price the entrant's securities.

As in the second essay of this thesis, the efficient firm elects to use debt to signal its quality to financiers. We show that debt is a cheaper signal than equity. This is true despite the anticipated predatory response by the incumbent if the entrant uses debt. Debt is cheaper for two reasons. First, misrepresentation is always attractive for the high cost entrant when the low cost entrant uses equity and stock prices are high. Second, signalling with equity means that the low cost entrant must issue equity shares on high value assets. In contrast, these same shares for the high cost firm are on low value assets. We show that the relative cost of signalling with debt with respect to equity is lower for the low cost firm than for the high cost entrant.

Contrary to many signalling models, entry does not occur in the same circumstances as with perfect information. This comes from the fact that the incumbent's predatory behaviour has real effects on the entrant's profits. In some circumstances (to be described later), predation may render entry unprofitable. With perfect information, the low cost
entrant would finance in equity markets, thus avoiding predation, and enter the market (Point A in Figure 6). We show that this is impossible with asymmetric information as the low cost entrant must use debt to signal its value; hence the output equilibrium is located at Point A'. If the entrant's cost is such that entry has negative value at A', the low cost entrant cannot signal its type and enter the market profitably. Predation is successful in deterring entry.

We express each player's optimization problem and define an equilibrium of the game. We start by assuming that a separating equilibrium exists and we characterize each player's separating strategy. Anticipating on our results, we show in Section 5 that a separating equilibrium always exists.

At financial stage S.1, the entrant makes its financial choices. If it is a low cost entrant, we show that it can distinguish itself from high cost firms and secure financing to enter the market. The high cost entrant cannot separate itself and it stays out. Financial choices are made anticipating the optimal strategies played in subsequent stages. For example, if a low cost entrant uses debt, it anticipates the incumbent's predatory response in the output stage.

The entrant $e$ solves the following maximization problem: \(^\text{40}\) for $e = 1, 2$

$$
\max_{t\in U} u \cdot \Pi(t, c_{e}, c_1, D_i)
$$

subject to:

i) $D \geq 0$

ii) $r \geq 0$

iii) $E \geq 0$

iv) $N \geq 0$

v) $d \geq 0$

vi) $E + D - K - d \geq 0$

vii) $m(t) \rho(t, c_1, c_i, D_i) + (1 - m(t)) \rho(t, c_2, c_i, D_i) \geq 0$

viii) $m(t) \Phi(t, c_1, c_i, D_i) + (1 - m(t)) \Phi(t, c_2, c_i, D_i) \geq 0$

The first six constraints represent feasibility requirements for the financial policy. The first five constraints are non-negativity constraints on the financial variables. Constraint vi) represents the cash flow constraint: the fixed cost and dividends cannot be larger than the money raised in financial markets. This implicitly means that the firm starts off without any liquidity. This is not necessary however for the derivation of the results. As long as the firm cannot entirely finance the fixed cost with internal funds, it has to use financial markets. For example, $K$ may be interpreted as the difference between the fixed cost and the internal funding of the project. $K$ would represent the external financial needs of the firm. Even if

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\(^{40}\) Note that all variables maybe interpreted as end of period or beginning of period dollars as the discount factor equals 1.
the firm can finance its investment entirely with internal funds, financial structure may still be used as a signal. The low cost entrant would use financial markets just to distinguish itself from a high cost firm. In vii), we require that creditors earn non-negative expected profits based on their beliefs, where $\rho(\cdot)$ is the debtholders' return function. In viii), we impose the same constraint on all issues of new shares. New stockholders must earn non-negative profits according to their beliefs. We do not impose a priori a zero profit condition on financiers. As part of a signalling equilibrium, the low cost firm may elect to transfer rents to financiers to separate itself from the high cost type.

Note that financiers' beliefs are dependent on the entrant's financial policy. The entrant chooses a financial policy, anticipating the effects of its choice on financiers' beliefs. Optimal output decisions are embodied in the definition of the different return functions. It underlines the fact that we are solving the game by backward induction. We also note that, as in the preceding essay, problem (4.1) is different from many signalling problems. In this model, the signal is sent in a different market than the output market. This means that new players, financiers, are involved in the signalling and that the signal has to satisfy a participation constraint for these new agents. This is incorporated in constraints vii) and viii).

In stage S.2, the incumbent chooses its financial policy. The incumbent can observe the entry decision. It knows before making its financial choices the market structure. It also knows its rival's cost if there is entry. The incumbent observes the entrant's financial policy. From this observation, it infers what the entrant's cost is. This allows the incumbent to assess correctly its own firm's value and seek actuarially fair prices for its financial securities. If there is entry, the incumbent solves:

$$\max_{s} E_{ee} \{ \Pi(s, c_{i}, c_{e}, D_{e}) \}$$

subject to:

i) $D \geq 0$,  ii) $r \geq 0$,  iii) $E \geq 0$,  iv) $N \geq 0$,  v) $d \geq 0$

vi) $E + D - K - d \geq 0$

vii) $m(t) \rho(s, c_{i}, c_{1}, D_{1}) + (1 - m(t)) \rho(s, c_{i}, c_{2}, D_{2}) \geq 0$

viii) $m(t) \Phi(s, c_{i}, c_{1}, D_{1}) + (1 - m(t)) \Phi(s, c_{i}, c_{2}, D_{2}) \geq 0$

where $E_{ee}$ is the expectation operator over the entrant's cost contingent on the incumbent's beliefs after the observation of the entrant's financial policy. These beliefs are Bayesian updates of the common priors (2.1). The constraints in (4.2) have the same interpretation as the constraints in (4.1). If the entrant stays out, the incumbent is a monopolist in the
market. Its market value would be known to all players and financing would be done at actuarially fair prices. It is easy to show that, because of the presence of bankruptcy costs, the incumbent would finance entirely in equity markets. We put aside this situation to consider the more interesting situation in which there is entry.

Financial markets are characterized by the same economic environment as in Chapter IV. Financiers agree to finance any project or contract yielding non-negative expected returns computed in accordance with their beliefs. These beliefs are updated after the observation of each firm's financial choices. Because the financiers' participation constraint is incorporated in the firms' optimization problem, financiers agree to finance any equilibrium financial policy that solves (4.1) and (4.2). To support the equilibrium, we must make some assumptions about the beliefs that financiers hold for out of equilibrium financial policies. We have the same motivation as in the preceeding chapter and assume that financiers adopt conservative beliefs. This means that they attribute a high cost type to any firm deviating from the low cost entrant's equilibrium strategy.

An equilibrium is described by the solution to problems (4.1) and (4.2), and the corresponding financiers' beliefs.

(E) Definition of an Equilibrium:

i) \((t^*(c_e), u^*(c_e))\) is the solution to (4.1), \(e = 1, 2\), given \(m^*, \bar{s}\);

ii) \(s^*(c_i)\) is the solution to (4.2), given \(t, m^*, \bar{u}\);

iii) \(s^* = \bar{s}, t^* = \bar{t}, u^* = \bar{u}\);

iv) \(m^*\) is the Bayesian update of the priors (2.1) conditional on the observation of \(t^*\).

This definition is general enough to describe pooling and separating equilibria. We are interested in the characterization of strategies for which separation of each type of entrant occurs. These strategies must satisfy (E) and each entrant must choose a different financial policy. As mentioned earlier, we assume that a separating equilibrium exists. First, we characterize such an equilibrium and then show that it exists. The existence proof is provided in Section 5.

In a separating equilibrium, each player can precisely infer the entrant’s type upon observation of its financial policy. In equilibrium, the financiers' beliefs are \(m^*(t^*(c_1)) = 1\) and \(m^*(t) = 0 \ \forall \ t \neq t^*(c_1)\). If financiers observe the optimal financial policy consistent with a low cost type, they attribute to this firm a probability of one that it has low cost. They agree to finance the entry of this firm. But if financiers observe any other financial policy, they infer that the firm has high cost and refuse to finance its entry. In equilibrium,
the low cost entrant gets financing and enters the market. The high cost entrant has a negative entry value and hence cannot secure financing. Consequently, it stays out.

At stage S.2, the market structure is determined and all relevant parameters of the output competition are known. The incumbent can finance at actuarially fair prices in financial markets. Because of the presence of bankruptcy costs, the incumbent finances entirely in equity markets.

**Proposition 1**: \( s^*(c_i) = (D', r', E', N', d') \) is any financial policy that satisfies:

i) \( D' = 0, r' = 0, E', N', d' \geq 0 \);

ii) \( E' - K - d' \geq 0 \);

iii) \( \rho(s^*, c_i, c_1, D_1) = 0 \);

iv) \( \Phi(s^*, c_i, c_1, D_1) = 0 \).

**Proof**: In a separating equilibrium, if entry occurs, only the type 1 firm enters the market. If we incorporate in (4.2) the financiers’ equilibrium beliefs and substitute for constraints vii) and viii) in the incumbent’s objective function, we obtain:

\[
\Pi(s, c_i, c_1, D_1) = \pi(c_i, c_1, D_1, D_1) - K - \rho(s, c_i, c_1, D_1) - \Phi(s, c_i, c_1, D_1) + F(\hat{a}_e)B - F(\hat{a}_f)BC
\]

This function is maximized when \( \Phi(\cdot) = 0, \rho(\cdot) = 0, D' = 0 \) and \( r' = 0 \). In this case, the objective function reduces to:

\[
\Pi(s^*, c_i, c_1, D_1) = \pi(c_i, c_1, 0, D_1) - K + F(\hat{a}_e)B
\]

This expression is independent of the precise value of \( E, N \) and \( d \). Hence, the incumbent is indifferent between any financial policy satisfying i) to iv) of the proposition statement. Q.E.D.

This proposition has the following interpretation. In a separating equilibrium, the entrant’s type is fully revealed. Hence, the incumbent’s financial policy has no strategic value. When the incumbent makes its financial choices, all parameters relevant to its value are publicly known. The incumbent may incur bankruptcy costs if it issues debt. These costs are minimized when the incumbent finances in equity markets. Hence, no debt is issued in equilibrium. In the absence of taxes and with perfect information about the incumbent’s value, dividends have no effect on the value of the firm. The incumbent may choose \( E' > K \) and set \( d' = E' - K \). As long as i) to iv) hold, the incumbent’s financial policy is irrelevant to its firm’s value. Independently of market structure, the incumbent

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41 Note that we have abstracted from important strategic effects of debt as derived in Brander & Lewis (1986).
finances in equity markets. This allows it to avoid unnecessary bankruptcy costs. However, we note that the output strategy is affected by the entry decision. If there is no entry, the incumbent produces at the monopoly level. If the low cost entrant comes in the market and is leveraged, the incumbent engages in a price war.

We can compare this proposition with Proposition 1 of the previous chapter. In Chapter IV, Proposition 1 describes the entrant’s financial policy. As in this chapter, the uninformed player’s financial choices are made after all private information becomes public knowledge. In both cases, financial structure has no strategic value. In the previous chapter, any feasible financial policy is optimal. This is the consequence of the absence of bankruptcy costs. In the present model, bankruptcy costs are positive. The incumbent chooses the financial policy that minimizes these costs. This explains why the incumbent finances in equity markets while the entrant could finance in credit markets in Chapter IV.

Because all types are revealed in equilibrium, the high cost entrant is not able to convince financiers that it has low cost. Since it has negative expected entry value, the high cost entrant cannot secure financing. Hence $t^*(c_2) = 0^5$ and $u^*(c_2) = 0$. The high cost entrant cannot enter the market and stays out of the game.

In a separating equilibrium, the low cost entrant distinguishes itself from the high cost type. Financiers can infer its cost level from its financial choices. Since it has a positive entry value, the low cost firm is able to get financing and enter the market. Hence $t_1 = 1$. To find $t^*(c_1)$, the separating financial strategy for firm 1, we solve the following maximization problem:

$$\max_{t} \Pi(t, c_1, c_i, 0)$$

subject to:

i) $D \geq 0$, ii) $r \geq 0$, iii) $E \geq 0$, iv) $N \geq 0$, v) $d \geq 0$

vi) $E + D - K - d \geq 0$

vii) $\Pi(t, c_2, c_i, 0) \leq 0$

viii) $\Phi(t, c_1, c_i, 0) \geq 0$

ix) $\rho(t, c_1, c_i, 0) \geq 0$

Problem (4.3) is similar to problem (4.1) in which we incorporate the incumbent’s strategy and financiers’ beliefs. The type 1 entrant makes its financial decision at stage S.1. It can anticipate that the incumbent finances in equity markets in stage S.2. These anticipations are incorporated in the entrant’s new optimization problem. For the financiers’ beliefs to be rational, the low cost entrant’s selected strategy must separate credibly both
types of entrant. It must be the case that the type 1 firm’s optimal strategy cannot be imitated profitably by the high cost entrant. By inserting a self-selection constraint for firm 2 in the maximization problem, we ensure that the low cost entrant chooses a financial policy that does not yield the high cost type incentives to misrepresent. If the type 2 firm stays out, it earns zero profit, hence constraint vii) requires that type 2’s return from mimicking, \( \Pi(t, c_2, c_1, 0) \), is not positive. Problem (4.3) constitutes an alternative representation of the equilibrium. We can interpret it as a conceptual device allowing us to solve for the separating equilibrium. We show later that the strategy solving (4.3) can be part of a separating equilibrium.

We now characterize \( f(c_1) \). The FOC to problem (4.3) are:

\[
D: \quad \frac{N_0}{N + N_0} \left\{ -r(1 - F(\hat{a}_1)) - f(\hat{a}_1)BC \frac{d \hat{a}_1}{dD} \right\} + \lambda_1 + \lambda_6 = 0
\]

\[
\lambda_7 \frac{N_0}{N + N_0} \left\{ -r(1 - F(\hat{a}_2)) - f(\hat{a}_2)BC \frac{d \hat{a}_2}{dD} \right\} + \lambda_9 r(1 - F(\hat{a}_1)) +
\]

\[
\lambda_8 \frac{N}{N + N_0} \left\{ -r(1 - F(\hat{a}_1)) - f(\hat{a}_1)BC \frac{d \hat{a}_1}{dD} \right\} = 0 \tag{4.4}
\]

\[
r: \quad \frac{N_0}{N + N_0} \left\{ -D(1 - F(\hat{a}_1)) - f(\hat{a}_1)BC \frac{d \hat{a}_1}{dr} \right\} + \lambda_2 = 0
\]

\[
\lambda_7 \frac{N_0}{N + N_0} \left\{ -D(1 - F(\hat{a}_2)) - f(\hat{a}_2)BC \frac{d \hat{a}_2}{dr} \right\} + \lambda_9 D(1 - F(\hat{a}_1)) +
\]

\[
\lambda_8 \frac{N}{N + N_0} \left\{ -D(1 - F(\hat{a}_1)) - f(\hat{a}_1)BC \frac{d \hat{a}_1}{dr} \right\} = 0 \tag{4.5}
\]

\[
E: \quad \frac{N_0}{N + N_0} \left\{ 1 - F(\hat{a}_1) - f(\hat{a}_1)BC \frac{d \hat{a}_1}{dE} \right\} + \lambda_3 + \lambda_6 = 0
\]

\[
\lambda_7 \frac{N_0}{N + N_0} \left\{ 1 - F(\hat{a}_2) - f(\hat{a}_2)BC \frac{d \hat{a}_2}{dE} \right\} + \lambda_9 F(\hat{a}_1) +
\]

\[
\lambda_8 \frac{N}{N + N_0} \left\{ 1 - F(\hat{a}_1) - f(\hat{a}_1)BC \frac{d \hat{a}_1}{dE} \right\} - \lambda_8 = 0 \tag{4.6}
\]

\[
N: \quad \frac{-N_0}{(N + N_0)^2} A_1 + \lambda_4 + \lambda_7 \frac{N_0}{(N + N_0)^2} A_2 + \lambda_8 \frac{N_0}{(N + N_0)^2} A_1 = 0 \tag{4.7}
\]

\[
d: \quad \frac{N_0}{N + N_0} \left\{ F(\hat{a}_1) - f(\hat{a}_1)BC \frac{d \hat{a}_1}{dd} \right\} + \lambda_5 - \lambda_6 - \lambda_7 \frac{N_0}{N + N_0} \left\{ F(\hat{a}_2) - f(\hat{a}_2)BC \frac{d \hat{a}_2}{dd} \right\} -
\]

\[
\lambda_9 F(\hat{a}_1) + \lambda_8 \frac{N}{N + N_0} \left\{ F(\hat{a}_1) - f(\hat{a}_1)BC \frac{d \hat{a}_1}{dd} \right\} = 0 \tag{4.8}
\]

\[\text{We assume interior solutions for the default probabilities.}\]
where $\lambda_i$ is the Lagrange multiplier for the $i^{th}$ constraint, and for $e = 1, 2$

$$A_e := d - F(\hat{a_e})BC + \int_{\hat{a_e}}^{a_e} [R(a, c_e, c_i, D_e, 0) + E + D_e - K - d - D_e(1 + r)] dF(a) \quad (4.9)$$

We know that there is a discrete jump in the functions of problem (4.3) as the entrant’s debt becomes positive. As seen in Section 3, as a firm’s debt level goes from 0 to $\epsilon$, its rival’s reaction function is shifted out. We move from point A to point A’ in Figure 6. For any positive debt level, this jump is constant. The shift in the rival firm’s reaction function reflects a predatory response to the firm issuing debt. We want to show that the low cost entrant has to use debt at least partially despite the incumbent’s predation.

**Lemma 1:** $t'(c_1)$ is characterized by $D' > 0$, $r' > 0$.

**Proof:** We provide two methods of proof.

a) Suppose the contrary. Then, firm 1 finances only with equity. Firm 2’s return from misrepresentation is

$$\Pi(t, c_2, c_i, 0) = \pi(c_2, c_i, 0, 0) - \left( \frac{\Phi(t, c_1, c_i, 0) + K}{\pi(c_1, c_i, 0, 0)} \right)$$

This is obtained from (4.3) by inserting $\Phi(t, c_1, c_i, 0)$ in $\Pi(t, c_2, c_i, 0)$. Hence

$$\Pi(t, c_2, c_i, 0) \leq 0 \iff \Phi(t, c_1, c_i, 0) \geq \pi(c_1, c_i, 0, 0) - K$$

This means that the low cost firm would have to transfer all rents generated on the output market to new stockholders in order to satisfy the high cost firm’s self selection constraint and distinguish itself from the high cost entrant. This corresponds to old shareholders giving away to new stockholders all existing shares. In this case, entry would not benefit initial owners and they may be assumed staying out. Furthermore, the high cost entrant would also earn zero profit if it enters. Since both firms would have the same incentives, they could not be separated in equilibrium. Entry would not be profitable to either entrant and they would stay out. We show below that there exist separating leveraged financial structures that confer positive expected rents to the low cost firm despite the incumbent’s predatory behaviour. They are preferred to the full equity separating solution.

b) This can also be shown using the FOCs. If $D' = r' = 0$, $F(\hat{a_e}) = 0$ for $e = 1, 2$. (4.4) reduces to:

$$\lambda_1 + \lambda_6 = 0 \Rightarrow \lambda_1 = \lambda_6 = 0$$

(4.5) reduces to $\lambda_2 = 0$, using (2.3). Since $E^* > 0$, $N^* > 0$, $\lambda_3 = \lambda_4 = 0$. Because signalling costs must be incurred for separation to occur, $\Phi(t, c_1, c_i, 0) > 0$, and consequently $\lambda_8 = 0$. By the Kuhn-Tucker slackness conditions, $\lambda_7 A_2 = 0$. Hence (4.7) reduces to:

$$-\frac{N_0}{(N + N_0)^2} A_1 = 0$$

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This is possible if and only if $A_1 = 0$. We show below that there exist separating debt levels that yield $A_1 > 0$. Hence $D^* = r^* = 0$ is not a maximum of (4.3). Q.E.D.

The intuition behind this lemma is clear. Equity is always attractive to firm 2, unless stock prices are so low that firm 1 loses all rents from the market opportunity. Hence, the low cost entrant prefers to finance at least partially through debt. By issuing debt, the low cost entrant increases expected bankruptcy costs. Debt also shrinks the set of solvent states for the borrowing firm. We know that for any financial policy, $\hat{a}_1 < \hat{a}_2$. Hence, the interval of solvent states decreases faster for the high cost entrant than for the low cost firm. These factors mean that firm 2's expected return from misrepresentation decreases faster than firm 1's expected return. These factors allow firm 1 to separate at a lower cost by issuing debt than by issuing equity only. Debt is preferred to equity despite the predatory incentives it confers to the incumbent.

There exist circumstances in which the low cost entrant cannot use debt. If predation renders entry unprofitable, neither type of entrant can enter the market. This is the case when $\pi(c_1, c_i, D_1, 0) - K < 0$ for all $D_1 > 0$. If the above inequality is satisfied, entry has a negative value when the low cost entrant finances with debt. This means that the low cost entrant has negative value at point $A'$ in Figure 6. Financiers know the entrant's value if it uses debt, and, in this case, they refuse to finance its entry. Equity markets are unavailable for entrants since mimicking is always profitable and the average value of all entrants is negative. In this case, predation is successful and no entry occurs. This is the case in which, in a separating equilibrium, entry does not occur in the same circumstances as with perfect information. The choice of the separating financial strategy has some effects on the incumbent's production decision. Predation lowers the entrant's profitability and entry becomes a negative net value investment. For the remainder, we make the following assumption:

**A.4** There exists a vector $t \in \mathbb{R}^+$ with $D_1 > 0$ such that $\pi(c_1, c_i, D_1, 0) - K > 0$.

With this assumption, we require that there exists a leveraged financial policy that confers a positive net value to entry. This guarantees the existence of a separating financial policy for the low cost entrant. If A.4 is not satisfied, separation cannot occur as the use of debt leads to a predatory response by the incumbent which renders the low cost firm's entry unprofitable. In this case, neither firm has an incentive to enter the market.

Lemma 1 confirms the 'deep pocket' argument. Telser (1966) argues that entrants enter the output market more vulnerable financially than the incumbent. The incumbent exploits this weakness by preying upon the entrant to cause its bankruptcy and induce its exit. We provide a formal representation of Telser's argument. We propose that the entrant's
financial weakness is the result of asymmetric information in financial markets. Financiers cannot distinguish between entrants. Efficient entrants issue debt to signal their quality to financiers. In doing so, these entrants invade the market heavily leveraged in comparison with incumbents. This renders entrants vulnerable to predation by incumbents. Hence, the entrant’s financial vulnerability (assumed by Telser, 1966) can be rationalized by the fact that financiers cannot distinguish among entrants, while they have complete information about the incumbent’s type. In Chapter IV, we consider the case when financiers cannot distinguish among incumbents.

Lemma 2: Necessary conditions for a separating equilibrium are that
\[ \lambda_1 = \lambda_2 = \lambda_6 = 0, \lambda_7 > 0. \]

Proof: i) Since \( D^* > 0, r^* > 0, \lambda_1 = \lambda_2 = 0 \) by the Kuhn-Tucker slackness conditions.

ii) Rewriting (4.4) and (4.5), we have:

\[
-r\left\{ \frac{N_0}{N + N_0} (1 - F(\hat{a}_1) + f(\hat{a}_1)BC) - \frac{\lambda_6}{r} - \lambda_7 \frac{N_0}{N + N_0} (1 - F(\hat{a}_2) + f(\hat{a}_2)BC) - \lambda_9 (1 - F(\hat{a}_1)) + \lambda_8 \frac{N}{N + N_0} (1 - F(\hat{a}_1) + f(\hat{a}_1)BC) \right\} = 0 \tag{4.10}
\]

\[
-D\left\{ \frac{N_0}{N + N_0} (1 - F(\hat{a}_1) + f(\hat{a}_1)BC) - \lambda_7 \frac{N_0}{N + N_0} (1 - F(\hat{a}_2) + f(\hat{a}_2)BC) + \lambda_9 (1 - F(\hat{a}_1)) + \lambda_8 \frac{N}{N + N_0} (1 - F(\hat{a}_1) + f(\hat{a}_1)BC) \right\} = 0 \tag{4.11}
\]

These two equations imply that \( \lambda_6 = 0. \)

iii) Suppose \( \lambda_7 = 0. \) (4.7) implies that \( \lambda_8 \leq 1. \) From (4.4) and (4.6), we know that

\[ \lambda_9 = \lambda_8 - \lambda_3 \tag{4.12} \]

Hence, \( \lambda_9 \leq 1. \) Rewriting (4.4) yields

\[
\left( \frac{(1 - \lambda_9)N_0 + (\lambda_8 - \lambda_9)N}{N + N_0} \right) (1 - F(\hat{a}_1)) + \frac{(N_0 + \lambda_8 N)}{N + N_0} f(\hat{a}_1)BC = 0 \tag{4.13}
\]

For this to hold, we need \( (1 - \lambda_9)N_0 + (\lambda_8 - \lambda_9)N < 0. \) But \( 1 - \lambda_9 \geq 0 \) and \( \lambda_8 - \lambda_9 = \lambda_3 \geq 0. \) We reach a contradiction. Hence, \( \lambda_7 > 0. \) Q.E.D.

This lemma is analogous to Lemma 2 of the previous chapter. The two main points of this lemma are:

i) The cash flow constraint is not necessarily binding. A closer examination of all expressions in (4.3) reveals that these expressions depend only on the product \( Dr, \) the interest payments.
Hence for any value of $Dr$, $D$ can always be chosen such that constraint $vi)$ is satisfied. ii) The self-selection constraint for the high cost entrant is always binding in equilibrium. This reflects the fact that we are solving for the least cost separating equilibrium. Signalling is costly for firm 1. It chooses a financial policy that minimizes signalling costs. Hence, this policy is such that firm 2’s self-selection constraint is just binding. If $vii)$ is not binding, firm 1 can substitute equity for debt, raising firm 2’s expected profits by decreasing its bankruptcy costs. Such substitution is done until the self-selection constraint becomes binding. This would allow firm 1 to raise its own return. Hence, firm 2’s self-selection constraint is binding in equilibrium.

As in the preceding chapter, we can show that dividends are too costly to use. They are excluded from the efficient financial mix that minimizes signalling costs.

**Proposition 2:** At the optimum, $t'(c_1)$ is characterized by $d^* = 0$.

**Proof:** (4.4) may be rewritten as

$$\left( \frac{N_0 + \lambda_8 N}{N + N_0} \right) (1 - F(\hat{a}_1) + f(\hat{a}_1)BC) - \lambda_9 (1 - F(\hat{a}_1)) = \lambda_7 \frac{N_0}{N + N_0} (1 - F(\hat{a}_2) + f(\hat{a}_2)BC)$$

Suppose $\lambda_5 = 0$ and rewrite (4.8) as

$$\left( \frac{N_0 + \lambda_8 N}{N + N_0} \right) (F(\hat{a}_1) - f(\hat{a}_1)BC) - \lambda_9 F(\hat{a}_1) = \lambda_7 \frac{N_0}{N + N_0} (F(\hat{a}_2) - f(\hat{a}_2)BC)$$

Since $f(\cdot)$ is uniform and $\hat{a}_1 < \hat{a}_2$, if $F(\hat{a}_2) - f(\hat{a}_2)BC = 0$, $F(\hat{a}_1) - f(\hat{a}_1)BC < 0$. This would mean that $\lambda_9 < 0$ by (4.8). Hence $F(\hat{a}_2) - f(\hat{a}_2)BC \neq 0$. Since $\lambda_7 > 0$, we can compute the ratio of these two equations to obtain

$$\frac{\left( \frac{N_0 + \lambda_8 N}{N + N_0} \right) (1 - F(\hat{a}_1) + f(\hat{a}_1)BC) - \lambda_9 (1 - F(\hat{a}_1))}{\left( \frac{N_0 + \lambda_8 N}{N + N_0} \right) (F(\hat{a}_1) - f(\hat{a}_1)BC) - \lambda_9 F(\hat{a}_1)} = \frac{(1 - F(\hat{a}_2) + f(\hat{a}_2)BC)}{(F(\hat{a}_2) - f(\hat{a}_2)BC)}$$

After cross-multiplication and a few manipulations, we have

$$(F(\hat{a}_2) - f(\hat{a}_2)BC) \frac{N_0(1 - \lambda_9) + N(\lambda_8 - \lambda_9)}{N + N_0} = -\lambda_9 f(\hat{a}_2)BC$$

This holds if and only if $N_0(1 - \lambda_9) + N(\lambda_8 - \lambda_9) < 0$. As seen in the proof of Lemma 2, this is not the case. We reach a contradiction. Hence, $\lambda_5 > 0$ and $d^* = 0$. Q.E.D.

The cost to firm 1’s stockholders of foregoing a dividend of one dollar is $F(\hat{a}_1) - f(\hat{a}_1)BC$. If the dividend is not paid, stockholders lose it in bankrupt states since, if the firm goes bankrupt, creditors are residual claimants. But the foregone dividend increases the firm’s cash flow and decreases its expected bankruptcy costs marginally. Since

$$F(\hat{a}_2) - f(\hat{a}_2)BC > F(\hat{a}_1) - f(\hat{a}_1)BC$$
the cost of foregoing the dividend is higher for the high cost entrant than the low cost
firm. A high cost entrant benefits more from a dividend payment than a low cost firm.
If firm 1 increases its dividend payment by one dollar, it increases firm 2’s return from
misrepresentation. To keep firm 2 on its self-selection constraint, firm 1 would have to
increase its loan by
\[
\frac{F(\hat{a}_2) - f(\hat{a}_2)BC}{r(1 - F(\hat{a}_2) + f(\hat{a}_2)BC)}
\]
as an extra dollar of debt costs \(r(1 - F(\hat{a}_i) + f(\hat{a}_i)BC)\) to firm \(i\). Because \(\hat{a}_1 < \hat{a}_2\), we have
\[
\frac{F(\hat{a}_2) - f(\hat{a}_2)BC}{r(1 - F(\hat{a}_2) + f(\hat{a}_2)BC)} > \frac{F(\hat{a}_1) - f(\hat{a}_1)BC}{r(1 - F(\hat{a}_1) + f(\hat{a}_1)BC)}
\]
Hence, firm 1 decreases its expected profits when paying a dividend and offsetting it with
an appropriate loan increase to keep firm 2 on its self-selection constraint. When increasing
marginally its dividend payment and increasing its loan to keep firm 2 on its self-selection
constraint, firm 1 moves to a lower isoprofit line and hence, decreases its return. This is
illustrated in Figure 4 of Chapter IV. We do not replicate the explanation of that figure as
it is similar to the one provided in the previous chapter.

The proof of Proposition 2 depends on the assumption that the distribution function
is uniform. This assumption is not needed in the previous essay to prove a similar result.
In Chapter IV, bankruptcy costs are assumed to be zero. Hence, the FOCs do not depend
on the density function. In this essay, bankruptcy costs are positive. Marginal bankruptcy
costs are \(f(\hat{a}_i)BC\). This implies that the density function plays an important role in the
determination of the optimal level of dividends. Suppose that \(f(\hat{a}_2) > f(\hat{a}_1)\) and that there is
a large difference between both densities. This may be interpreted as the marginal bankrupt
state being more likely for firm 2 than for firm 1. In this case, at the margin, bankruptcy
becomes increasingly more likely for firm 2 than for firm 1. By paying out dividends,
firm 1 decreases firm 2’s cash flow from misrepresentation. This increases the probability
of bankruptcy for firm 2 faster than for firm 1. Hence, it is possible that a positive level of
dividends minimizes signalling costs. A necessary condition for dividends being positive in
firm 1’s separating strategy is that bankruptcy costs are positive and that the distribution
of states of nature is non-uniform. However, we keep our initial assumption about the
distribution of \(a\). In the least cost separating equilibrium, if the distribution is uniform,
dividends are absent. Dividends play an important role in equilibrium even if they are zero.
Positive dividends may render signalling too costly and prevent the separating solution from
occurring. Again, we remind the reader that we abstract from any tax considerations.

In our model, dividends have a different interpretation than in many models of divi­
dend signalling. We only consider dividends paid prior to the production period. Hence,
announced dividends are paid out for sure by the firm since they are financed with cash

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raised in equity and debt markets instead of being generated from production random returns. This complicates comparisons between our model and alternate models of dividend signalling such as Bhattacharya (1979, 1980). Ambarish, John & Williams (1987) consider a signalling model in which dividends play an active role. They assume that investors pay personal taxes on dividends and that they have a demand for liquidity to satisfy. This demand is assumed to be decreasing in the paid dividend. These elements are absent from our model. As they note, if the demand for liquidity is independent of dividends, dividends are not part of the equilibrium signal. Finally, debt is assumed away in their model. Hence, the effects on the bankruptcy probability described above cannot occur in their equilibrium.

Lemmas 3 and 4 characterize the use of equity by the low cost entrant.

**Lemma 3:** If $E^* > 0$ and $N^* > 0$, $\rho(t^*(c_1), c_1, c_i, 0) = 0$ and $\Phi(t^*(c_1), c_1, c_i, 0) = 0$.

**Proof:** a) If $E^* > 0$ and $N^* > 0$, $\lambda_3 = \lambda_4 = 0$. From (4.7), we have that $\lambda_8 = 1$. Remember that $\lambda_7A_2 = 0$. From (4.12), we know that $\lambda_9 = 1$. This implies that $\rho(t^*(c_1), c_1, c_i, 0) = 0$ and $\Phi(t^*(c_1), c_1, c_i, 0) = 0$. Q.E.D.

If firm 1 uses equity, bankruptcy costs constitute the only separating costs and financiers earn a competitive return on their investment. $BC$ must be high enough to bring firm 2's return from misrepresentation to zero. Define $\bar{t} := (K, r(K), 0, 0, 0)$ where $r(K)$ solves for

$$\rho(K, r, 0, 0, 0, c_1, c_i, 0) = 0$$

(4.14)

The financial policy $\bar{t}$ corresponds to a policy in which debt finances the totality of the fixed cost and the lending rate is the actuarially fair interest rate for the low cost entrant. We have

$$\Pi(\bar{t}, c_2, c_i, 0) = \int_{\hat{a}_2}^{a_h} [R(a, c_2, c_i, K, 0) - K(1 + r(K))] dF(a) - F(\hat{a}_2)BC$$

as firm 2's return from misrepresentation if the low cost entrant uses the financial policy $\bar{t}$. If $\Pi(\bar{t}, c_2, c_i, 0) < 0$, firm 2 incur losses if it mimics firm 1. This means that expected bankruptcy costs are larger than the expected return from production. Firm 1 can substitute equity for debt and increase firm 2's return from misrepresentation. Doing so, firm 1 also decreases its own bankruptcy costs. By substituting one dollar of equity for one dollar of debt, firm 1 economizes on its expected bankruptcy costs. As for firm 2, there exists small shifts from debt to equity that keep $\Pi(\bar{t}, c_2, c_i, 0) \leq 0$. Firm 1 changes its financial structure until the self-selection constraint binds, thus decreasing its expected bankruptcy costs. Since financiers earn zero profit, firm 1's securities are fairly priced. Hence, the only effect of these transfers on firm 1's value is a decrease in expected bankruptcy costs. Consequently, it uses

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43 It can be shown that $r(K)$ is the unique solution to the following equation.
as much equity as it can until firm 2’s self-selection constraint becomes binding. At this point, more equity and less debt would increase firm 2’s return adversely and would render its entry profitable. If \(\Pi(\tilde{\ell}, c_2, c_1, 0) > 0\), bankruptcy costs are not large enough to separate both types of entrant. Hence, rents must be transferred to securityholders. Lemma 3 tells us that if this is the case, the low cost entrant finances only with debt and the rents transfer is done in credit-markets. This is shown formally in Lemma 4.

A.5 \(\Pi(\tilde{\ell}, c_2, c_1, 0) < 0\).

**Lemma 4:** Equity is used by the type 1 entrant if and only if A.5 holds.

**Proof:** a) i) Suppose \(\Pi(\tilde{\ell}, c_2, c_1, 0) = 0\). We know that

\[
\frac{\partial \Pi(t, c_2, c_1, 0)}{\partial E} = 1 - F(\hat{a}_2) + f(\hat{a}_2)BC > 0
\]

and

\[
\frac{\partial \Pi(t, c_2, c_1, 0)}{\partial N} = -\frac{N_0}{(N + N_0)^2} A_2 = 0
\]

by assumption as \(A_2 = 0\). On the other hand,

\[
\frac{\partial \Pi(t, c_2, c_1, 0)}{\partial D_r} = -(1 - F(\hat{a}_2)) - f(\hat{a}_2)BC < 0
\]

Decreasing \(D_r\) and increasing \(E\) increases \(\Pi(t, c_2, c_1, 0)\). Since \(\Pi(\tilde{\ell}, c_2, c_1, 0) = 0\), this financial substitution is not profitable for the low cost entrant as it provokes entry by the type 2 entrant. Hence, equity is not used in this situation.

ii) Suppose \(\Pi(\tilde{\ell}, c_2, c_1, 0) > 0\). Then, bankruptcy costs are not large enough to separate both types. Firm 1 has to transfer rents to financiers to increase firm 2’s costs from misrepresentation, i.e., we must have \(\rho(t, c_1, c_1, 0) > 0\) or \(\Phi(t, c_1, c_1, 0) > 0\). But in this case, by Lemma 3, we know that equity is not used.

b) If \(\Pi(\tilde{\ell}, c_2, c_1, 0) < 0\), as reported above, we have

\[
\frac{\partial \Pi(t, c_2, c_1, 0)}{\partial E} = 1 - F(\hat{a}_2) + f(\hat{a}_2)BC > 0
\]

and

\[
\frac{\partial \Pi(t, c_2, c_1, 0)}{\partial N} = -\frac{N_0}{(N + N_0)^2} A_2 > 0
\]

by assumption as \(A_2 < 0\). On the other hand,

\[
\frac{\partial \Pi(t, c_2, c_1, 0)}{\partial D_r} = -(1 - F(\hat{a}_2)) - f(\hat{a}_2)BC < 0
\]

\[44\] This derivative is correct as we show in Lemma 2 that \(\Pi(\cdot)\) depends only on \(D_r\).
Decreasing debt or increasing equity has a positive effect on $\Pi(t, c_2, c_1, 0)$. By continuity, there must exist a small transfer from debt to equity that keeps $\Pi(l, c_2, c_1, 0) \leq 0$. This transfer is desirable for firm 1 as it decreases its expected bankruptcy costs. Q.E.D.

If $BC$ are large and A.5 holds, equity is used in equilibrium. This is possible because large bankruptcy costs imply that separation does not require a high degree of leverage. If bankruptcy costs are small enough such that $\Pi(l, c_2, c_1, 0) > 0$, firm 1 finances only with debt. More specifically, if $BC = 0$, firm 1 does not use equity at all. This result is different from the conclusion reached in the second essay with regard to the use of equity. There, we argue that equity may be used if the relative marginal signalling cost of equity with respect to debt is smaller for the low cost firm than for the high cost firm, computed on the high cost firm's self-selection constraint. It is possible that this condition is satisfied and that the low cost firm uses equity. But in the present essay, this condition is never satisfied. The marginal signalling cost of equity for the high cost firm computed on its self-selection constraint is always zero since this constraint says that firm 2 cannot earn positive returns from misrepresentation, i.e., $A_2 = 0$. This means that the marginal cost of equity with respect to debt is always larger for the low cost firm. As a result, if $BC = 0$, to minimize signalling costs, the low cost entrant would always use debt in its separating financial strategy.

This lemma underlines the advantage of debt contracts over different types of financial contract in signalling. Suppose a low cost firm signals its value by signing a contract with a third party, promising to give this party a share of its rents at the end of the period. Assume that this contract is binding. The rents transfer must be such that misrepresentation becomes non-profitable. This contract is equivalent to financing with equity in our model. Lemmas 1 and 4 tell us that a debt contract is more efficient in signalling the firm's value than a contract using only equity. A debt contract minimizes signalling costs for the type 1 firm. Debt is preferred to equity financing, to the contract described above or even to a binding promise of a public burning of resources at the end of the period. In relative terms, debt is less costly than equity financing for the type 1 firm. The main reason for this is that a debt contract shrinks the set of solvent states for the borrowing firm. This set shrinks faster for the low value firm than for the high value firm. This contributes to lower signalling costs. At low debt levels, the marginal signalling cost of equity relative to debt is almost proportional to the firm's value. Since the low cost firm has higher value, it is not profitable for the low cost firm to signal with equity. Debt is then preferred. However, at high debt levels, if bankruptcy costs are large, debt contracts may be too expensive to use and the low cost entrant may use equity partially. We now show that the type 1 entrant

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45 The only potential point of non-differentiability is when $\alpha_2 \rightarrow \alpha_1$ or $\alpha_4$. But we assume having an interior solution for $\alpha_2$. 

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always earns positive expected returns from adopting the strategy \( t'(c_1) \) that solves (4.3).

**Lemma 5:** \( \Pi(t'(c_1), c_1, c_i, 0) > 0 \).

**Proof:** By Lemma 2, we know that \( \Pi(t'(c_1), c_2, c_i, 0) = 0 \). One can easily show that

\[
\Pi(t'(c_1), c_1, c_i, 0) - \Pi(t'(c_1), c_2, c_i, 0) > 0
\]

This proves the assertion of the lemma. \( Q.E.D. \)

Firm 1 always earns positive expected returns despite being preyed upon. Since the self-selection constraint binds, the type 2 firm earns zero expected profit. Since type 1 has lower cost, it earns higher profits than type 2 for the same financial policy. Even if the low cost entrant faces the incumbent's predation, signalling is profitable as the low cost firm earns positive returns. The low cost firm prefers to enter the market and be preyed upon than to not separate and stay out. Having completely characterized the separating equilibrium of the financial stage, we now look at the question of existence of the equilibrium.

5. Existence of the Equilibrium

If predation is not strong enough to deter entry by the low cost firm, i.e., if A.4 holds, we can show that a separating equilibrium always exists. By Lemma 5, we know that the low cost entrant earns positive returns when entrant 2's self-selection constraint is binding. By assumption, the average expected value of entry is negative. Consequently, if financiers cannot distinguish between both types of entrant, they refuse to finance any entry project. Since the low cost entrant's separating strategy yields positive returns, the low cost firm always prefers it to any pooling solution. This means that signalling costs never exceed the gains from separation. Hence, if A.4 holds, a separating equilibrium always exists. This is presented formally in the next proposition.

**Proposition 3:** A separating equilibrium exists if and only if A.4 holds.

**Proof:**

a) If a separating equilibrium exists, it must be the case that there exists a financial structure for which entry is profitable for the low cost firm. Hence, A.4 holds.

b) Suppose A.4 holds. We consider two cases.

i) Suppose A.5 holds. Financiers earn competitive returns (Lemmas 3 and 4). The securityholders' return functions (2.4), (2.5) and (2.6) are continuous in \( t \). By (2.7), we know that \( \Pi(0, 0, K, N(K), 0, c_2, c_i, 0) > 0 \) where \( N(K) \) solves for \( \Phi(0, 0, K, N, c_1, c_i, 0) = 0 \). By A.5, \( \Pi(0, c_2, c_i, 0) < 0 \). By continuity, there exists \( t'(c_1) \) for which \( \Pi(t'(c_1), c_2, c_i, 0) = 0 \) and \( \rho(t'(c_1), c_1, c_i, 0) = \Phi(t'(c_1), c_1, c_i, 0) = 0 \). By Lemma 5, \( \Pi(t'(c_1), c_1, c_i, 0) > 0 \). This
implies that firm 2's self-selection constraint and firm 1's participation constraint are satisfied. Hence, a separating equilibrium exists.

ii) Suppose $A.5$ does not hold. By Lemma 4, no equity is used. $\Pi(t, c_2, c_i, 0)$ is decreasing in $r$ and $\rho(t, c_2, c_i, 0)$ is increasing in $r$. Suppose\(^{46}\) that $D = K$. For $r = r(K)$, we know that $\Pi(t, c_2, c_i, 0) \geq 0$, and $\rho(t, c_1, c_i, 0) = 0$. Define $\hat{r}$ such that $\hat{a}_2 = a_h$. Then, $\Pi(K, \hat{r}, 0, 0, 0, c_2, c_i, 0) < 0$ and $\rho(K, \hat{r}, 0, 0, 0, c_1, c_i, 0) \geq 0$ since $\hat{r} \geq r(K)$. By continuity, there must exist $r^* \in [r(K), \hat{r}]$ such that

$$
\Pi(K, r^*, 0, 0, 0, c_2, c_i, 0) = 0, \quad \rho(K, r^*, 0, 0, 0, c_2, c_i, 0) \geq 0 \quad \text{and} \quad \Pi(K, r^*, 0, 0, 0, c_1, c_i, 0) > 0
$$

by Lemma 5. This implies that a separating equilibrium exists with $t^*(c_1) = (K, r^*, 0, 0, 0)$. Q.E.D.

This result is quite strong. It says that signalling costs are never too large to preclude separation. It relies on the assumption that entrants only get a competitive wage if they do not enter the market. This assumption means that firm 1’s participation constraint is automatically satisfied when firm 2’s self-selection constraint is binding. If there exists a separating strategy, it is profitable for the type 1 entrant to undertake it. If the type 1 entrant has access to other non-competitive assets, signalling costs may become too expensive and the separating strategy would not be profitable. In this case, no entry would occur as the low cost entrant would prefer to undertake an alternative project. In this case, the difference between $c_1$ and $c_2$ would become a determinant of entry. As this difference grows, separation is done at a lower cost by the low cost entrant.

There is a major difference between this essay and the previous one. In each essay, the proof of existence of the equilibrium depends on the signalling firm’s alternative project. In each case, the low cost firm’s return dominates the return of the high cost type for any given financial policy. In the present essay, both types earn the same return in their alternate project. This means that when the high cost firm’s self-selection constraint becomes binding, separation is always profitable and a separating equilibrium always exists. In Chapter IV, the low cost firm’s alternate return is in general larger than the high cost firm’s self-selection return. When the type 2 firm’s self-selection constraint is binding, the type 1 firm does not necessarily earn more from separation than in its alternate project. Its participation constraint may not be satisfied and the separating solution may fail to be an equilibrium. In this case, the existence of a separating equilibrium depends, among other things, on the size of the difference between both firms’ cost. There is no doubt that the assumption about the value of alternate projects for low cost entrants have an impact on the existence of the equilibrium. But this assumption does not change the nature of the results. We

\(^{46}\) This is done without loss of generality as all expressions depend only on $D_r$. 

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feel that this representation of Telser (1966)'s deep pocket argument is unaffected by this assumption. The following theorem summarizes the results.

**Theorem 1:** If A.4 holds, a separating equilibrium exists and is characterized by:

i) \( t'(c_2) = 0^5; u^*(c_2) = 0; \)

ii) \( t'(c_1) \) that solves (4.3) and is described by Lemmas 1, 3 and 4 and Proposition 2; \( u'(c_1) = 1; \)

iii) \( s^*(c_i) \) that solves (4.2) and is characterized by Proposition 1;

iv) \( m^*(t) = \begin{cases} 1 & \text{if } t = t'(c_1) \\ 0 & \text{if } t \neq t'(c_1) \end{cases} \)

**Proof:**

i) By constraint vii) in (4.3), we know that \( \Pi(t'(c_1), c_2, c_i, 0) = 0 \) (Lemma 2). Hence the high cost entrant has no positive incentives to enter the market with \( t'(c_1) \). Any other financial policy is refused by financiers. Hence, \( (t'(c_2), u^*(c_2)) \) is optimal for the type 2 entrant.

ii) Given the financiers' beliefs, if the type 1 entrant chooses \( t \neq t'(c_1) \), it cannot secure financing and consequently earns 0. By Lemma 5, we know that \( \Pi(t'(c_1), c_1, c_i, 0) > 0 \), hence \( (t'(c_1), u^*(c_1)) \) is optimal for the low cost entrant, i.e., it solves problem (4.1).

iii) As shown in Proposition 1, \( s^*(c_i) \) is optimal for the incumbent.

iv) Given the entrant's strategy, the financiers' beliefs are rational and fulfilled in equilibrium.

The strategies described in i) to iv) characterize the equilibrium and satisfy the definition of an equilibrium \( (E) \). By Proposition 3, we know the equilibrium exists. Q.E.D.

With perfect information, the low cost firm finances with equity and entry is profitable. With asymmetric information, the low cost entrant has to issue debt to distinguish itself from inefficient entrants. This entails a predatory response by the incumbent. In some cases (A.4 does not hold), predation is sufficient to discourage entry. If A.4 does not hold, predation may lower its return enough such that entry becomes unprofitable. This means that no separating equilibrium exists. In other cases (A.4 holds), predation is not sufficient to discourage entry. Entry remains a profitable strategy in spite of predation. In these cases, we show that a separating equilibrium exists and that the low cost entrant enters the market. However, predation increases the probability of default. Suppose the entrant goes bankrupt in stage S.4. Depending on what happens in financial markets (debt restructuration, refinancing, etc.), predation may bring a temporary or permanent exit of the bankrupt entrant in future periods. A more sophisticated model of dynamic financing would be required to address these issues in the model. However, these problems have not been tackled convincingly in the finance literature. Giammarino (1985) is an exception.
For the next section, we assume that A.5 does not hold: $\Pi(\bar{t}, c_2, c, 0) \geq 0$. Bankruptcy costs are too small to separate both firms. As shown in Lemma 4, under these conditions, no equity is used by firm 1. Debt becomes the only financing and separating element of the low cost entrant’s financial policy. This yields a more intuitive model of separation similar to the reduced form model of the previous chapter.

6. Reduced Form of the Model

As mentioned earlier, only the interest payments $Dr$ are relevant to the return of each agent. As the firm borrows more than the fixed cost $K$, the extra liquidities are kept within the firm. If the firm goes bankrupt, creditors recover the portion $D-K$ of the loan. Hence, the only risky part of the loan is $K$ and $Dr$, the interest payments. Since no equity is used in equilibrium, $Dr$ constitute the only endogenous variable of the model.

Problem (4.3) may be rewritten as:

$$\max_{Dr} \Pi(Dr, c_1, c, 0)$$ (6.1)

subject to:

i) $Dr \geq 0$

ii) $\Pi(Dr, c_2, c, 0) \leq 0$

iii) $\bar{\rho}(Dr, c_1, c, 0) \geq 0$

where $\Pi(Dr, c_e, c, 0) := \Pi(D, r, 0, 0, 0, c_e, c, 0)$ for $e = 1, 2$

and $\bar{\rho}(Dr, c_1, c, 0) := \rho(D, r, 0, 0, 0, c_1, c, 0)$.

Lemma 6: Over the relevant range (interior default probabilities),

i) $\bar{\rho}(Dr, c_1, c, 0)$ is increasing and concave in $Dr$;

ii) $\Pi(Dr, c_e, c, 0)$ is decreasing and convex in $Dr$ for $e = 1, 2$.

Proof: i)

$$\frac{\partial \bar{\rho}(\cdot)}{\partial Dr} = 1 - F(\hat{a}_1) \quad \text{and} \quad \frac{\partial^2 \bar{\rho}(\cdot)}{\partial Dr^2} = -f(\hat{a}_1) \frac{d\hat{a}_1}{dDr} < 0$$

ii) for $e = 1, 2$:

$$\frac{\partial \Pi(\cdot)}{\partial Dr} = -\left(1 - F(\hat{a}_e)\right) - f(\hat{a}_e)BC \frac{d\hat{a}_e}{dDr} < 0$$

\footnote{Results on the curvature of $\Pi(\cdot)$ directly depend on the assumption that $F(a)$ is uniform. But this is not critical to the derivation of the results.}

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Total differentiation of (2.2) yields
\[ \frac{d\hat{a}_t}{dD_r} = 1 \]

We have
\[ \frac{\partial^2 \Pi(\cdot)}{\partial D_r^2} = f'(\hat{a}_t) \frac{d\hat{a}_t}{dD_r} > 0 \quad Q.E.D. \]

By assumption (A.5 does not hold), bankruptcy costs are not sufficient to separate both firms. The type 1 entrant must transfer rents to debtholders to signal itself. This implies that constraint iii) in (6.1) is not binding in equilibrium. As shown in Lemma 2, constraint ii) is binding in equilibrium. Problem (6.1) is represented in Figure 7. Because of the curvature of the functions derived in Lemma 6, the solution is at \( D_r^* \). At this point, the type 2 entrant has no incentives to enter the market. Debtholders earn positive rents which constitute a separating cost for the low cost entrant. But this cost is not large enough to bring its return to zero. This problem is analogous to the equivalent formulation in the previous chapter. The only differences come from the different levels of the self-selection constraint for firm 2 and the participation constraint of the efficient firm.

FIGURE 7
Leveraged Signalling Equilibrium
In Chapter IV, we show how debt is used to transfer rents to debtholders. There are two ways of doing it. First, the low cost entrant can borrow $K$ and pay a high interest rate on the loan. This would increase the lender’s return and decrease the firm’s profit. Or, the low cost firm can borrow more than $K$ and pay $r(K)$ on the loan $D$. This would also transfer rents to debtholders. Dividends are zero in this model. Hence, the extra liquidities $D - K$ are kept within the firm. If the firm goes bankrupt, the bank recuperates these excess funds. Hence, this portion of the loan should be priced at the riskless rate of interest. Since it is not, rents are transferred to debtholders.

Even if financial markets are competitive, some financiers may earn positive rents in equilibrium. The reason being that these rents are paid voluntarily to debtholders as part of a signalling equilibrium. It is the signalling function of the debt contract that causes these excess rents to persist over time. In the previous chapter, we provide a full discussion of the presence of these rents in competitive industries and suggest ways in which these rents may be dissipated in equilibrium. These rents persist in the context of the game we describe; but they may be dissipated prior to the start of the game. This would not have any impact on subsequent play. See Giammarino & Lewis (1985) and Stiglitz & Weiss (1984) for a discussion of abnormal returns in competitive industries in signalling models.

7. Conclusion

In this essay, the focus is on asymmetric information in financial markets to explain Telser (1966)'s deep pocket argument. Telser (1966) suggests that predators try to financially exhaust new entrants in their market by engaging in price wars. The problem with his argumentation is that the entrant's financial vulnerability is not justified formally. All related work more or less assumes that the entrant is financially weaker than the incumbent. We provide a formal representation of Telser's argument. We find in the economy good and bad entrants. As in a 'lemons' problem, the average quality of projects is negative. Since financiers cannot distinguish between good and bad entrants, financial markets are closed to any entrant. Good entrants may signal their quality by issuing debt. It allows them to separate from bad entrants. But it also leads to a predatory response by the incumbent. The incumbent tries to decrease the market price to increase the probability of default of the entrant and gain future benefits arising from the entrant's bankruptcy. The entrant anticipates being preyed upon but may still prefer to enter heavily leveraged than to stay out. In this case, entry has a positive value even in the presence of predation. In other cases, predation is successful in convincing new entrants to stay out as it yields a negative value to entry. This is likely to occur when entry has a low value in the absence of predation, i.e., relatively high marginal cost or high fixed cost faced by the efficient entrant.
In our model, predation has some real effects on entry and exit. In some models of signalling and predation, as in Roberts (1985), the incumbent signals about some parameter of demand to the entrant. A low cost incumbent engages in price wars to signal to the entrant that it has low cost and that staying in the market is not profitable for the entrant. This signal may be interpreted as predation by the incumbent. In a separating equilibrium, signalling has no 'real' effect on exit as it occurs in the same circumstances as in the presence of perfect information. Predation may have an impact on the entry decision as it lowers the entrant's profits in the signalling period. In our model, predation has some effects on exit as it lowers the entrant's probability of solvency. If the entrant goes bankrupt, predation may induce its exit for a temporary or permanent length of time. There are also real effects on the entry decision. Suppose predation renders entry by a leveraged low cost entrant unprofitable. This entrant cannot use only equity and signal in equity markets. As we have shown, such signalling implies that all rents would be transferred to stockholders. The low cost firm does not gain from signalling and has no incentives to enter. No financing is available and entry is prevented. Deep pocket strategies have real effects on entry and exit decisions. This is in opposition to other signalling models of predation in which exit occurs in the same circumstances as with perfect information. In this model, we combine financial signalling and deep pocket strategies to derive real effects on entry and exit decisions.

As in Chapter IV, we show that the efficient financial signal uses debt. If bankruptcy costs are not too large, only debt constitutes the financial signal. In some cases, it can provide a rationalization for using credit markets to signal in the output market. For example, signalling in equity markets is equivalent to a binding promise to give money to a third party, like charity. We may interpret our results as a debt contract being cheaper than a promise to give money to charity. This may be contrasted with Giammarino & Lewis (1985) who assume away debt in a financial signalling model.

In Chapters IV and V, signalling is costly. High quality firms have to expend resources to signal their true value to uninformed agents. Even if financial markets are competitive, some financiers may receive positive rents from some projects. These rents come from the signalling incentives of low cost entrants. In some cases, they have to signal their value by conceding to creditors rents generated in the output market. These rents are consistent with competitive financial markets. They are offered voluntarily by low cost firms to secure funds and enter the market. They are value creating for the low cost entrant and persist in equilibrium. A more complete characterization of the credit market is needed to determine how these rents may be dissipated in a general equilibrium framework.

There are implications for the theory of financial structure. In the presence of asymmetric information in financial and output markets, financial structure becomes an important
parameter of the output game. It is value creating as it allows good entrants to signal their quality and enter the market. Without financial signalling, they may not be able to secure funds to finance the fixed cost and may have to stay out of the market.

Interactions between financial and production sides of firms alter the efficiency of financial signalling. In the absence of predation, the low cost entrant would always be able to separate from the high cost firm and enter the market. But since the entrant’s financial signal leads to predation by the incumbent, financial signalling affects the value of entry. There are circumstances in which predation is sufficient to discourage all entry. This implies that financial signalling is not always efficient in communicating the entrant’s value to financiers. In these circumstances, financial signalling has a real impact on market structure. It would be interesting to compare financial signals with other types of signal to see the relative efficiency of each type. However, since entrants must signal before their entry, they have a limited range of signals available to them.

In a Modigliani-Miller world, the dividend policy of the firm is irrelevant to any output or investment decision. In our signalling model, the dividend policy is a relevant choice to the firm’s value. It turns out that it is an important signalling tool. Contrary to the results obtained in the previous essay, we show that, with bankruptcy costs, if the distribution of states of nature is non-uniform, dividends may be used in the efficient separating financial policy. With the uniform distribution, the optimal level of dividends is zero. So necessary conditions for positive dividends in the efficient signal are that bankruptcy costs are positive and states of nature are not distributed uniformly. This result is different from what is usually observed empirically. But we note that we abstract from important determinants of dividend policy such as taxes, shareholders’ demand for liquidity, etc.

There are interesting extensions to this essay. We facilitate the derivation of the separating solution by assuming that the average value of entrants is negative. This precludes any pooling solution from occurring since financiers reject any pooling financial contract. By assuming a positive entry value, entrants may pool in equity markets. This would mean that, in some cases, signalling costs may be too high and that the low cost entrant would prefer the pooling solution. This is likely to depend on the gap between the cost of each type of entrant.

Another interesting addition would be to extend the model to two periods. This would allow us to endogenize bankruptcy costs and benefits from a rival’s bankruptcy. This may add new insights into the model. But, it would not be easy. One would have to explicitly model refinancing or liquidation decisions in case of bankruptcy. But, the actual state of the theory does not allow for a satisfactory treatment of these problems.
CHAPTER VI

CONCLUSION

This thesis focuses on asymmetric information in output and financial markets to derive strategic interactions between production and financial decisions. In the presence of asymmetric information in financial markets, financial choices become relevant to the firm’s market value. In imperfect output markets, firms interact strategically. The financial policy becomes a potential strategic tool in the hand of an oligopolist to gain advantages over its rivals in the output market. In this thesis, we argue that firms, when choosing their financial policy, rationally anticipate its effects on the extent of competition in their industry and use their financial structure for strategic purposes.

In the first essay, we show that in the presence of incentive effects created by debt, a common lender to both firms of a duopoly may facilitate a partial collusion of the industry by keeping interest rates down and limiting the firms’ incentives to increase output. We propose a natural interpretation for this model. In an international trade context, this result suggests that freeing financial markets from trade barriers may decrease the amount of competition in international oligopolies.

The last two essays provide important theoretical links between financial and output market structures. In the presence of asymmetric information in output and financial markets, we show that the informed player’s financial policy may become a simultaneous signal of its quality in both markets. By revealing its private information in financial markets, the firm can secure financing at actuarially fair prices. This information is also valuable in the output market as it may give the high value firm a strategic advantage over low value firms and rivals. As the firm’s quality is a determinant of the output market structure, financial policy becomes an indirect determinant of the industry’s structure. By revealing the firm’s private information to financiers, financial structure conveys simultaneously valuable information to the output market which determines the market structure and the extent of competition.

In the second essay, we assume that incumbents have private information about their type. A low cost incumbent can use its financial structure to signal its type. Entrants observe the signal and correctly infer the incumbent’s type. If the incumbent has low cost, they choose not to enter. The incumbent’s financial policy becomes an entry deterring signal and a determinant of market structure. In the third essay, entrants have private information about their cost level. A low cost entrant must signal its type to be able to enter the market. Doing so, it must issue debt. The entrant enters the market heavily leveraged in comparison with the incumbent. This yields incentives for the incumbent to engage in a price war in
the hope of causing the entrant's bankruptcy. The entrant's financial structure becomes a determinant of output market structure and the extent of competition following entry.

The integration of the last two essays would constitute an interesting extension of this thesis. By assuming bilateral uncertainty about the entrant's and incumbent's type, one could derive conditions under which an incumbent preys upon an entrant, and more interestingly, an entrant preys upon an incumbent. The specific economic environment and the underlying information structure in which the industry evolves may completely characterize the preying incentives of the different firms. Such research would provide interesting insights into the 'deep pocket' story by endogenizing the identity of the predator and the prey. In general, this is assumed to be exogenous, the incumbent being the predator and the entrant, the prey. But there may exist cases in which the entrant preys upon the incumbent. Asymmetric information in output and financial markets and explicit consideration of financial decisions may allow for such endogenization.

The fact that we consider only financial signalling constitutes a limitation to our results. In these types of model, signalling its quality is usually costly. By assuming away output, price or any other 'real' signal, we cannot solve for the least cost signalling equilibria. This thesis allows us to focus on the properties of financial signalling equilibria. It would be interesting to characterize completely each firm's signal possibilities. One could derive properties of the efficient mix of financial and real signals. However, we conjecture that this would be a hard task. One would need to include in the model two production periods to allow for real signals. The main difficulty would be to characterize two period financial contracts. The theory for this type of contracts is still at an early stage and would need further developments before being incorporated in the model.

This thesis demonstrates that, if one believes in an economic environment characterized by informational asymmetries, there exist potential interactions between financial and production decisions. These interactions imply that financial structure may become an important determinant of output market competition and output market structure in various oligopolistic games. In these games, the explicit consideration of financial variables allows us to provide theoretical links between financial policy and industry structure. Our results are based on the presence of informational asymmetries in output and financial markets as well as on the presence of imperfect (oligopolistic) output markets. These assumptions are sufficient to yield a strategic value to financial decisions. This is taken into account by firms when making financial choices. Financial structure constitutes an additional tool available to firms to influence the outcome of output games.
REFERENCES


Maksimovic, V., "Oligopoly, Price Wars and Bankruptcy," Mimeo, Faculty of Commerce and Business Administration, University of British Columbia, 1986.


School of Business, Stanford University, 1985.


Stiglitz, J.E., "Credit Markets and the Control of Capital," *Journal of Money, Credit and Banking*, 17, 1985a, 133-152.


We state the vector-valued version of the Mean Value Theorem.\textsuperscript{46} It is used in the proof of Proposition 1.

\textit{Mean Value Theorem:} Let $S$ be an open subset of $\mathbb{R}^n$ and assume that $f: S \to \mathbb{R}^m$ is differentiable at each point of $S$. Let $x$ and $y$ be two points in $S$ such that $L(x, y) := tx + (1-t)y \subseteq S$ with $t \in [0, 1]$. Then for every vector $a \in \mathbb{R}^m$, there is a point $z \in L(x, y)$ such that $a \{f(x) - f(y)\} = a \{f'(z)(x - y)\}$.

\textit{Proof of Proposition 1.}\textsuperscript{49} The dual bank financial equilibrium is characterized by $\rho_i^{ij} = 0$, which corresponds to equation (4.2). With one bank, we have the equation (4.5), with:

$$\rho_i^{ij} = \int_{S_i}^{s_j} \left\{ R_i^1 \frac{dq_i}{dr_i} + R_i^2 \frac{dq_j}{dr_i} \right\} dF(s_j) \quad (A.1.1)$$

By assumption, $R_i^j < 0$. By (3.2), $R_j^j(s_j) < 0$ for all $s_j \leq \hat{s}_j$. We know that

$$R_i^j = \frac{dp}{dq_i} q_i \quad \text{and} \quad R_j^j = \frac{dp}{dq_j} q_j + p(q_i, q_j, s_j) - c'(q_j) < 0 \quad \forall s_j \leq \hat{s}_j \quad (A.1.2)$$

Because $R_i^j \geq 0$, we have $p(q_i, q_j, s_j) - c'(q_j) \geq 0$. By symmetry, $|R_i^j| > |R_j^j|$.\textsuperscript{50} By (3.3), the equilibrium is stable. This means that the own interest rate effect is dominant:

$$\left| \frac{dq_i}{dr_i} \right| > \left| \frac{dq_j}{dr_i} \right| \quad (A.1.3)$$

This implies that $\rho_i^{ij} < 0$. Then by (4.5),

$$\rho_i^{ij} > 0 \quad (A.1.4)$$

The same analysis applies to $\rho_j^{ij}$. We may now use the Mean Value Theorem with point $x$ representing the single bank equilibrium and $y$, the dual bank equilibrium:

$$f(x) = \begin{pmatrix} \rho_i^{ij} \\ \rho_j^{ij} \end{pmatrix} \quad \text{and} \quad f(y) = \begin{pmatrix} \rho_i^{ij} \\ \rho_j^{ij} \end{pmatrix} = 0^2$$

by equation (4.2); and

$$x = \begin{pmatrix} \overline{q}_i \\ \overline{q}_j \end{pmatrix} \quad \text{and} \quad y = \begin{pmatrix} \overline{q}_i \\ \overline{q}_j \end{pmatrix}$$

\textsuperscript{46} This version is taken from Apostol (1973).
\textsuperscript{49} This method of proof is borrowed, at a low interest rate, from Brander & Spencer (1983).
\textsuperscript{50} The symmetry of both firms also means that their respective output enters symmetrically in the inverse demand function.
The derivative is:
\[ f'(z) = \nabla \left( \begin{pmatrix} \rho_i^1 \\ \rho_j^1 \\ \rho_i^2 \\ \rho_j^2 \end{pmatrix} \right) = \left( \begin{pmatrix} \rho_i^1 \\ \rho_j^1 \\ \rho_i^2 \\ \rho_j^2 \end{pmatrix} \right) \]

This matrix is evaluated at an intermediate point between the single bank equilibrium interest rates and the dual bank equilibrium rates. We know that at each equilibrium, it is negative definite: in the single bank case, it is dictated by the Second Order Conditions; in the other case, by the stability of the equilibrium. We assume that this property holds at least for every point in between both equilibria. This means that the matrix has a positive determinant and that the diagonal terms are negative. By the Mean Value Theorem, we know that:

\[ \Delta \]

Denoting \( \left| \nabla \left( \begin{pmatrix} \rho_i^1 \\ \rho_j^1 \\ \rho_i^2 \\ \rho_j^2 \end{pmatrix} \right) \right| = \Delta \) and using Cramer's rule, we obtain:

\[ r_i^f - r_i^a = \frac{\rho_i^1 \rho_j^j - \rho_j^1 \rho_i^j}{\Delta} \]

In a symmetric equilibrium, \( \rho_i^f = \rho_j^f \), and \( |\rho_j^f| > |\rho_i^f| \). This implies that \( r_i^f < r_i^a \), using (A.1.4) and the properties of \( \nabla \left( \begin{pmatrix} \rho_i^1 \\ \rho_j^1 \\ \rho_i^2 \\ \rho_j^2 \end{pmatrix} \right) \). Similarly, one may show that \( r_j^f < r_j^a \).

Each firm faces a lower interest rate in the single bank structure. Because the own output effect of the interest rate is dominant (by (A.1.3)), the aggregate output decreases with the drop in the interest rate. In a symmetric equilibrium, this lowers each firm’s output. Or, similarly, each firm’s reaction function is shifted in. Hence, the equilibrium output is lower under the single bank structure, i.e., \( q_i^s > q_i^f \) and \( q_j^s > q_j^f \). Q.E.D.

**Proof of Corollary 1.1:** By symmetry, we know that \( r_i^a = r_j^a =: r_a \) and \( r_i^f = r_j^f =: r_f \). Define \( q^f := q_i(r_f, r_f) \) and \( q^a := q_i(r_a, r_a) \). We may write

\[ W^i(r_a, r_a) = \int_{s_i}^{s_h} R^i(q^a, q^a, s_i) \, dF(s_i) - (1 + r_0) \]

and

\[ W^i(r_f, r_f) = \int_{s_i}^{s_h} R^i(q^f, q^f, s_i) \, dF(s_i) - (1 + r_0) \]

If the inverse demand function is concave and \( R^i_{q_i} < 0 \), then \( R^i \) is concave in \( q \) along the 45° line (\( q_i = q_j \)):

\[ \frac{\partial^2 R^i}{\partial q^2} = R^i_{q_i} + R^i_{q_j} + R^i_{q_i} + R^i_{q_j} < 0 \]

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Since the interest rates are positive, we know that $q'$ is larger than the symmetric full equity Cournot solution. Hence $q'$ is larger than the symmetric fully collusive output that maximizes $R^i$. By Proposition 1, $q'_i < q'^*_i$, for $i = 1, 2$. By concavity,

$$R^i(q', q', s_i) > R^i(q^a, q^a, s_i) \quad \forall s_i \in [S_l, S_h]$$

Hence $W^i(r_f, r_f) > W^i(r_a, r_a)$.

b) By the assumption of competition for the credit industry (second concept), $(1 + r^*_o)$ is the maximized value of $\rho'(q_i(r_i, r_f), q_j(r_f, r_i), r_i)$ with respect to $r_i$. $(1 + r^*_o)$ is the maximized value of the same function with respect to $r_i$ and $r_j$. Hence $(1 + r^*_o) \geq (1 + r^*_o)$. Q.E.D.
APPENDIX 2

In a pooling solution, both types of incumbent choose the same financial policy. Financiers cannot update their priors since no information about the incumbent's type is conveyed by the firm's financial choices. Entrants come into the market as entry has a positive average value by Assumption A.3. The type 1 incumbent solves the following maximization problem:

$$\max_{\delta} \Pi(s, c_1, c_e)$$

subject to:

i) $D \geq 0$, ii) $r \geq 0$, iii) $E \geq 0$, iv) $N \geq 0$, v) $d \geq 0$

vi) $E + D - K - d \geq 0$

vii) $q\rho(s, c_1, c_e) + (1 - q)\rho(s, c_2, c_e) \geq 0$

viii) $q\Phi(s, c_1, c_e) + (1 - q)\Phi(s, c_2, c_e) \geq 0$

Suppose $\bar{s}(c_1)$ solves (A.2.1). We define

$$\Pi_0 := \Pi(\bar{s}(c_1), c_1, c_e)$$

as the maximum return to the type 1 firm under the pooling solution. The difference between $\bar{s}(c_1) - K$ and $\Pi_0$ determines the gain from separation and characterizes the condition (EC2) for the existence of a separating equilibrium.

Since the informed agent (incumbent) moves first, any financial policy satisfying the constraints in (A.2.1) may be supported as a pooling equilibrium given the appropriate beliefs. However, these beliefs are often unreasonable and unnecessarily pessimistic. We find good examples of this in Stiglitz & Weiss (1984). By computing the pooling solution that yields the maximum return to firm 1, we feel that a 'reasonable' pooling solution is being characterized.