Essays on financial contracting

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Jukka Vauhkonen

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Abstract

This thesis consists of an introductory chapter and four essays on financial contracting theory. In the first essay, we argue that many adverse selection models of standard one-period loan contracts are not robust to changes in market structure. We argue that debt is not an optimal contract in these models, if there is only one (monopoly) financier instead of a large number of competitive financiers.

In the second essay, we examine the welfare effects of allowing banks to hold equity in their borrowing firms. According to the agency cost literature, banks' equity stakes in their borrowing firms would seem to alleviate firms' asset substitution moral hazard problem associated with debt financing. We argue that this alleged benefit of banks' equity holding is small or non-existent when banks are explicitly modelled as active monitors and firms have access also to market finance.

In the third essay, we extend the well-known incomplete contracting model of Aghion and Bolton to attempt to explain the empirical observation that the allocation of control rights between entrepreneur and venture capitalist is often contingent in the following way. If the company's performance (eg earnings before taxes and interest) is bad, the venture capital firm obtains full control of the company. If company performance is medium, the entrepreneur retains or obtains more control rights. If company performance is good, the venture capitalist relinquishes most of his control rights.

The fourth essay is a short note, in which we show that the main result of the model of Aghion and Bolton concerning optimality properties of contingent control allocations in an incomplete contracting environment holds only if an additional condition is satisfied.

Key words: financial contracts, security design, capital structure, incomplete contracts

Tiivistelmä

Väitöskirja koostuu johdantoluvusta ja neljästä rahoitussopimusten teoriaa käsittelevästä tutkimusluvusta. Ensimmäisessä tutkimusluvussa väitetään, että monet velkasopimusten optimaalisuutta selittävät haitallisen valikoitumisen mallit, jotka perustuvat näennäisesti ei-kriittisiin oletuksiin, eivät ole kestäviä markkinarakenteen muutoksille. Tutkimuksessa väitetään, ettei velkasopimus ole optimaalinen sopimus näissä malleissa, jos oletus kilpailullisista rahoitusmarkkinoista korvataan oletuksella, että monopolirahoittaja on yritysten ainoa rahoituksen lähde.

Toisessa tutkimusluvussa selvitetään hyvinvointivaikutuksia, joita mahdollisesti syntyy, jos pankkien sallitaan tehdä osakesijoituksia luotottamiinsa yrityksiin. Agentuurikustannusmallien perusteella pankkien osakesijoitukset luotottamiinsa yrityksiin näyttäisivät lievittävän velkarahoitukseen liittyvää yritysten moraalikato-ongelmaa. Tutkimuksessa osoitetaan, että pankkien osakeomistusten edellä mainittu mahdollinen hyöty on pieni tai olematon, kun pankit mallitetaan yritysten monitoroijiksi ja kun mallissa otetaan huomioon, että ainakin osa yrityksistä pystyy hankkimaan rahoitusta suoraan rahoitusmarkkinoilta.

Kolmannessa tutkimusluvussa laajennetaan Aghionin ja Boltonin tunnettua epätäydellisten sopimusten teoriaan perustuvaa mallia ja rakennetaan teoreettinen malli, jolla pyritään selittämään seuraavia empiirisiä havaintoja päätösvallan jakamisesta yrittäjän ja pääomasijoittajan välillä. Jos yrityksen kannattavuutta kuvaava signaali (esimerkiksi yrityksen tuotot ennen veroja ja korkokuluja) on huono, pääomasijoittaja saa tyypillisesti kaiken päätösvallan yrityksessä. Jos yrityksen kannattavuus paranee, yrittäjä saa osan päätösvallasta. Jos yrityksen kannattavuus on erinomainen, pääomasijoittaja luopuu suurimmasta osasta päätösvaltaoikeuksiaan.

Neljäs tutkimusluku on lyhyt kommentti edellä mainittuun Aghionin ja Boltonin malliin. Siinä osoitetaan, että Aghionin ja Boltonin mallin tärkein tulos, mikä liittyy päätösvallan ehdollisen jakautumisen optimaalisuusominaisuuksiin epätäydellisten sopimusten mallissa, pätee vain tietyn ehdon vallitessa.

Asiasanat: rahoitussopimukset, optimaaliset sopimukset, pääomarakenne, epätäydelliset sopimukset

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I am particularly proud to be one of the original members of the 'basement unit' of the Department of Economics, which consisted of some FPPE researchers and other collegues at the University of Helsinki. Intellectually speaking, I owe much to this band of original, funny and professional people – Juha-Pekka Niinimäki, Jukka Pirttilä, Tuomas Takalo, Tom Dahlström, Hanna Freystätter, Marita Laukkanen, Ville Mälkönen and Jussi Snellman. We always have a good time when we get together. Besides being great friends, Juha-Pekka and Tuomas have provided insightful comments on the essays of the thesis. I also wish to thank Ari Hyytinen and Mikko Leppämäki for their comments on some of the essays.

Most of all, I want to thank my wife, Aija Salminen-Vauhkonen, for her love and patience, as well as our little daughter, Roosa, to whom this thesis is dedicated.

Helsinki, December 2004
Jukka Vauhkonen

Contents

Preface

This thesis consists of an introductory chapter and four essays. The fourth essay has been published in *Economics Bulletin*.

Introduction

Financial contracting, conflicts of interest and the allocation of cash flow and control rights

Jukka Vauhkonen

1 What economists mean by financial contracting

In an influential recent survey, financial contracting is defined as the theory of what types of deals are made between financiers and those in need of financing (Hart 2001, p. 1). This thesis is a collection of theoretical essays examining financial contracts between a risk-neutral investor and a risk-neutral entrepreneur who uses the funds to finance investment projects. In essays 1 and 2, we examine the kinds of deals that are made when the entrepreneur has private information on his characteristics (essay 1) or on the decisions he takes (essay 2). In essays 3 and 4, we examine the kinds of deals that are made when contracts are incomplete.

The theory of financial contracts originated in the failures of general equilibrium theory. Until the 1970s, much of the formal modelling of economics focused on general equilibrium models in which markets are complete and information is perfect. In general equilibrium models, atomistic agents were viewed to interact only through the price system, where prices convey all relevant information. Institutions were thought to be simply a veil through which markets could see. Equilibrium was understood to be determined by the laws of supply and demand.

General equilibrium theory produced some remarkable theoretical results, most of all the fundamental theorems of welfare economics, the formalisation of Adam Smith's invisible hand conjecture. However, through time it became increasingly evident that general equilibrium theory is unable to explain many real-world phenomena, especially the high levels of unemployment. There were also a host of other empirical puzzles that were hard to reconcile with the standard theory. The economics of information, initiated in seminal articles by Akerlof (1970), Mirrlees (1971), Spence (1974), and Rotschild and Stiglitz (1976), provided new tools to tackle these issues.

The modern theory of financial contracting builds largely on the ideas of *the economics of information* and, to a lesser extent, the theory of *incomplete contracting*. The starting point of many financial contracting models is that those who need outside financing may have better information than their financiers on factors which affect the extent to which they can honour their commitments. Moreover, these factors may be directly under the control of those in need of financing. A pathbreaking insight of the economics of information is that the incentives to hide or reveal this private information can crucially affect the properties of market equilibrium and the structure of financial contracts and institutions. The vast literature on asymmetric information, which is authoritatively surveyed by Stiglitz (2000, 2002), has shown that asymmetric information may have the following striking consequences. First, a market equilibrium may not exist (Rotschild and Stiglitz 1976). Second, there may exist equilibria with rationing (Keeton 1979 and Stiglitz and Weiss 1981). Third, the existing equilibria may be Pareto-inefficient. Fourth, in the terminology of Stein (2002), some *curative* mechanisms may endogenously arise to mitigate the effects of information (and agency) problems. These curative mechanisms include, for example, corporate governance, capital structure, incentive contracts and financial intermediation.

The models that explain financial contracts as responses to incentive problems and asymmetric information have been highly influential. However, it is a limitation of many of these models that they are static in the following sense. First, the parties sign a financial contract determining, for example, how the project returns are to be divided. Then, given the terms of the contract, they take decisions based on their preferences. Then, the project ends and the returns are divided between the parties. After that, the parties separate. Most real-world economic relationships are, however, more complex. The financial contracting literature based on incomplete contracts (Aghion and Bolton 1992, Hart 1995, 2001) tries to capture such complexities. The starting point of this literature is that the relationship between entrepreneur and financier is dynamic and that the parties are unable to write contracts that take account of all contingencies that may affect the contractual relationship. Contracts can be incomplete if, for example, courts or other third parties cannot verify the ex post values of certain variables. In that case, contracts cannot be made conditional on these variables, as nobody can settle the possible disputes between contracting parties. Another source of incompleteness is that some important future variables must be left out of the contract because they are difficult or impossible to describe initially.

An important question in the incomplete contracting literature is the following. Given that an incomplete contract is silent about future contingencies and given that some future decisions must be taken in response to these contingencies, how will this be accomplished? The answer in the literature is that although future decisions cannot be determined in the initial contract, the contract can determine how the *control rights*, ie the rights to make decisions, are allocated between the parties. Thus, this literature provides a theory of financial contracts in terms of how control rights are allocated between firm insiders and outside investors.

As discussed above, financial contracts can be interpreted as curative mechanisms intended to mitigate the contractual, informational, and agency problem between financiers and those in need of finance. In fact, *the security design approach* explicitly interprets financial contracts as optimal or equilibrium responses for overcoming various frictions between agents, such as asymmetric information and unforeseen contingencies. The main objective of this strand of literature is to explain why and when some real world financial contracts, such as standard debt contracts, are optimal. In this thesis, essays 1, 2 and 4 belong to this branch of the literature. Essay 2, in turn, belongs to the other branch of the financial contracting literature, *the capital structure approach*.[1] This approach takes the forms of available securities (most often debt and equity) as given, and examines the optimal mix that firms should issue in the face of various frictions between agents.

1.1 How firms finance their investments

Any elementary textbook on corporate finance will say that besides using retained earnings firms can issue a number of distinct securities in countless combinations to finance their investments. Small and medium sized enterprises typically resort to standard bank loans. Larger firms often issue common stock or preferred stock. Alternatively, they can issue a variety of different corporate debt claims, which can be classified by maturity, repayment provisions, seniority, security, interest rates (floating or fixed), issue procedures (public or private placement), and currency of debt (see Brealey and Myers 2003, ch. 14 and 25). Firms also use some other sources of finance such as convertible securities and venture capital finance.

How does the firm choose the best mix of securities from almost countless possible combinations? In one of the most celebrated articles in economic literature, Modigliani and Miller (1958) showed that this question is irrelevant in perfect markets, where there are no taxes nor informational or incentive problems between agents. They showed that in perfect markets, it makes no difference to the firm whether it finances its project by debt, equity or some other security.

[1] In section 1.2, we divide the literature into smaller sub-categories to highlight the differences between the essays.

In short, they defined the conditions under which the value of the firm is determined by its real assets and not by the securities it issues. Nowadays, there is a broad consensus that the assumptions of Modigliani and Miller (1958) do not describe the real world very well. However, their article was an important benchmark and much of the literature in corporate finance over the last forty years has been concerned 'what is missing in Modigliani and Miller' (Hart 2001).

Besides taxes – a subject that is not addressed in this thesis – economists have mainly focused on two principal missing elements: incentive problems and asymmetric information. The so-called traditional capital structure literature, initiated by Jensen and Meckling (1976) and Myers and Majluf (1984), and surveyed in Harris and Raviv (1992) and Zingales (2000), presents theories in which it makes a difference whether the firm finances its investments by debt or equity. Jensen and Meckling (1976) showed that there can be a tradeoff between debt and equity if there are *moral hazard* problems between shareholders and the manager and between shareholders and debt holders. Since Jensen and Meckling (1976), there has emerged a myriad of agency models with different conflicts of interest and different agency costs suggesting that the firm's capital structure does matter. In Myers and Majluf (1984), the focus is not on moral hazard but on *asymmetry of information* about the value of the firm's assets as between the firm's insiders and investors. The key insight of Myers and Majluf (1984) is close to the seminal result of Akerlof (1970) in that if there is an asymmetry of information as between investors and firm insiders, then the firm's equity may be under-priced by the market. In this case, the firm prefers debt to equity when external finance is required. Thus, again, the choice of capital structure is not irrelevant.

In organising the literature and in relating my essays to it, it is useful to consider which issues the traditional capital structure literature does not cover. The capital structure literature takes contracts to be exogenous securities. The security design literature, in contrast, addresses a deeper question: what determines the specific form of contract (security) under which investors supply funds to the firm. By directly addressing this question, security design models avoid the shortcoming of models where firms are, a priori, restricted to issuing only debt and equity. The suggestion of the security design literature is that real world financial contracts, such as standard debt contracts, should not be taken as given but should be derived as equilibrium responses to conflicts of interest between entrepreneur and financiers. In three of four of essays here, the contract forms are endogenously derived. While the traditional capital structure literature focuses on the firm's optimal choice between equity and bonds, in reality the firm's choice between different sources of finance is more difficult. There are many other available sources of funds, such as loans from banks and other financial intermediaries. In essay 2, we examine the firm's choice of capital structure in a model where the firm can choose between direct (market) finance and intermediated (bank) finance.

1.2 Linking the essays to each other

The financial contracting literature can be organised in many ways. In the following table, we organise the literature in terms of whether financial contracts (securities) are exogenous or endogenous and whether the contracts allocate cash flow or control rights. The table helps to highlight some broad differences between my essays.

Table 1. **Financial contracting literature**

	Allocation of rights	
	cash flow rights	control rights
exogenous	Traditional capital structure literature, essay 2	Corporate governance literature, essay 2
Form of security		
endogenous	Traditional security design literature, essay 1	Incomplete contracting theory of financial contracts, essays 3 and 4

The capital structure literature can be found in the top-left corner of the table, as the models of capital structure take contracts as exogenous and characterise them in terms of how they allocate the cash flows among the investors. Essay 2, 'Banks' equity stakes in their borrowing firms: a corporate finance approach' belongs to this branch of literature.

As discussed above, the security design literature differs from the traditional capital structure literature in that contract are (at least partly) endogenous. In the above table, we reserve the phrase 'traditional security design literature' (lower-left corner) for those theories that are concerned with the allocation of cash flows from an investment project among investors so as to resolve conflicts between the investors and the firms's manager.[2] Essay 1, Are adverse selection models of debt robust to changes in market structure' belongs to this branch of literature.

Corporate governance (upper-right corner) deals with the ways in which suppliers of finance to corporations assure themselves of getting a return on their investment (see Shleifer and Vishny 1997 and Bolton et al 2002). Corporate governance is a broader concept than capital structure.[3] In traditional capital structure literature, debt and equity are associated only with a particular pattern of cash flows. Corporate governance literature focuses more on the *control rights* (board rights, voting rights, liquidation rights etc) attached to different securities. When asking how managers are led to act in the financiers' interests, the corporate governance literature also examines the roles of, for example, legal systems, takeover threats and concentrated ownership in disciplining managers. Essay 2 includes some features of the corporate governance literature, as securities in that essay are characterised not only by cash flow rights but also by control rights.

Finally, some recent literature focuses on the endogenous allocation of control rights between entrepreneurs and those who provide finance (lower-right corner). The allocation of control rights is important only if contracts are incomplete. Otherwise, the contracting parties could write a binding contract that lays down each party's obligations in each conceivable eventuality, and imposes large penalties if any party violates the contract. Therefore, the starting point of the literature on the lower-right corner is that contracts are inherently incomplete. Essay 3, Financial contracts and contingent control rights' and essay 4, An incomplete contracts approach to financial contracting, belong to the literature which examines the optimal allocation of control rights between entrepreneur and investor, when the parties have conflicting interests and when contracts are incomplete.

As illustrated in the above table, my essays belong to somewhat separate branches of the financial contracting literature. However, the essays share some common basics. First, all the essays examine problems of financing risk-neutral entrepreneurial firms. Thus, risk-

[2] Broadly defined, security design literature would also cover the literature in thee lower-right corner of the table. For the sake of clarity, however, we divide the security design literature into two categories.

[3] Corporate governance deals with many issues that are only indirectly related to financial contracting. Therefore, strictly speaking, corporate governance is not a branch of the financial contracting literature in the same sense as the other branches of literatures in table 1 are.

sharing and intra-firm issues are ignored. Second, all models are partial equilibrium models. Third, all models are short-run models in the sense that entrepreneurs have no credit history and that entrepreneurs' possible future needs for outside finance are not addressed. Thus, relationship lending and reputational issues are not addressed. Fourth, in contrast to some interesting recent literature (see Manove and Padilla 1999, Coval and Thakor 2001, and Hyytinen 2003), we assume that entrepreneurs and financiers are perfectly rational.

The rest of this introductory essay is organised as follows. In section 2, we provide an overview of the literature which is directly related to the essays. Section 3 presents an outline of the main results of the thesis.

2 An overview of the literature

2.1 Adverse selection and security design

In an ideal world the contracts between lender and borrower could be extremely complex, as they would have to specify all the obligations of the two parties in every possible future contingency. However, real world financial contracts are often relatively simple. The key question in security design literature is how to explain these relatively simple real world contracts, especially the existence of standard debt contracts.

A simplified characterisation of the standard one-period debt contract is the following. The debt contract specifies the amount borrowed, B, the required interest rate, r, and the borrower's required repayment, R(X), which is the following function of the borrower's project return X: $R(X) = \min[X,(1+r)B]$. A substantial amount of literature has tried to explain why the borrower's required repayment is set in such a way. As shown by Freixas and Rochet (1997, p. 93), it is difficult to explain the standard debt contract in symmetric information models, where the characteristics of a debt contract are determined only by risk-sharing considerations. In this section, we briefly review two alternative explanations based on two kinds of asymmetric information: asymmetric information with respect to project returns and asymmetric information with respect to type of borrower.

The best-known security design models are the costly state verification models (CSV), first developed by Townsend (1979) and Gale and Hellwig (1985). In the CSV models the lender cannot observe the project return unless he performs a costly audit. Since returns are not verifiable without cost, the payoffs in the non-verification region must be based on the borrower's announcement of the returns. Townsend (1979) and Gale and Hellwig (1985) analyse incentive-compatible contracts, which induce borrowers to truthfully report returns. They show that optimal contracts are analogous to debt. Returns are verified only when they fall short of the fixed required payment. When the reported returns exceed the required payment, the lender receives only the fixed payment. The subsequent literature has shown that the optimality of debt holds quite generally in the CSV models. The standard one-period CSV model with risk neutrality, deterministic verification, one lender and one type of borrower has been extended to include risk-aversion, stochastic verification, multi-period environments, several investors and many borrower types. The overall conclusion of allowing these extensions is that optimal contracts still have many features of debt.[4] Thus, debt contracts seem to be quite robust in the CSV context. Nevertheless, the CSV models have some shortcomings as explanations of debt.[5] As a consequence, some alternative explanations have been introduced in recent years.

According to another branch of literature, the standard debt contract can be interpreted as an optimal response to an adverse selection problem between lenders and different types of borrowers. In adverse selection models some innate characteristics of borrowers are not freely observable to lenders. The aim of the literature is to characterise contracts that borrowers can use as credible signals of their type or, alternatively, that lenders can use as screening devices. In essay 1 of this thesis, we take a different route. We study the robustness of the adverse selection-based explanations of debt contracts and argue that many of these models are not robust to changes in market structure.

Two often cited security design papers in which good borrowers try to signal their quality by their contract offers are Nachman and Noe (1994) and Boyd and Smith (1993). In Nachman and Noe (1994), borrowers try to raise external capital to finance profitable investment opportunities. The probability distributions of project returns are borrowers' private information. Highly productive firms face the

[4] For details, see an excellent survey by Allen and Winton (1995).

[5] See Hart (1995, p. 121–125).

standard adverse selection problem in that their security designs may be imitated by firms with lower productivity. This results in undervaluation of higher productivity firms and overvaluation of lower productivity firms. The adverse selection problem in Nachman and Noe (1994) is similar to that of Myers and Majluf (1984), who argued that under asymmetric information firms that are forced to raise external capital prefer debt to equity. A shortcoming in Myers and Majluf (1984) is that they consider only a restricted set of securities, essentially debt and equity. Nachman and Noe (1994) examine whether the results of Myers and Majluf (1984) hold under more general conditions. They restrict attention to contracts which provide non-decreasing payments to lenders with respect to the firm's earnings and which have a limited liability feature. Given these restrictions, they characterise the conditions which guarantee that debt contracts emerge as unique equilibrium pooling contracts. They discover that a somewhat stronger condition than the first-order stochastic dominance is needed to guarantee that debt is uniquely optimal.

In contrast to Nachman and Noe (1993), Boyd and Smith (1993) do not restrict admissible contract forms to be monotonic in project returns. The key feature of their model is that they add costly state verification to a simple adverse selection model with two types of borrowers. They derive the conditions under which a truthful revelation of type occurs and under which the equilibrium contracts are standard debt contracts. Thus, they focus on separating contracts and show that costly state verification allows debt contracts to emerge as separating equilibrium contracts as long as differences among borrower types are not too great or ex post verification costs are sufficiently high.

In Nachman and Noe (1994) and Boyd and Smith (1993) borrowers are the ones who design the contracts. However, in the credit market context it is not obvious which of the parties should 'move' first, borrowers or lenders. Innes (1993) and Wang and Williamson (1998) analyse adverse selection models where lenders design the contracts. Innes (1993) derives equilibrium financial contracts in a model where high-quality borrowers have 'better' profit distributions in the sense of the monotone likelihood property. He shows that so long as admissible lender payoff functions are restricted to be non-decreasing in firm profit, equilibrium (pooling) contracts are the standard debt contracts.

In all adverse selection models presented above, lenders know only the ex-ante distribution of different borrower types. Wang and Williamson (1998) note that, in reality, lenders can make some inferences on borrowers' types by inspecting their performances, credit histories, industry affiliations, and so forth. In their model, they assume that by paying a fixed ex ante screening cost a lender can perfectly learn a borrowers's type. They also assume that lenders can use their monitoring technology stochastically, that is, they can commit to screen only a pre-determined fraction of loan applicants. The central idea in their paper is that the threat of ex ante screening works as a self-selection mechanism; lenders offer good and bad borrowers different contracts with different payoff schedules and different ex ante screening probabilities and borrowers choose the contracts directed at them. Furthermore, they show that debt contracts emerge as separating equilibrium contracts in a competitive environment with a continuum of risk-neutral and identical lenders.

To summarise the discussion on adverse selection security design models, a number of recent models show that debt may be an optimal contractual response to adverse selection. However, a limitation of these models is that the optimality of debt rests on some rather special restrictive assumptions. First, to obtain debt as an optimal contract one must either restrict the contract space by arbitrary monotonicity restrictions (all models above except Boyd and Smith 1993) or by assuming that ex-post verification costs are sufficiently high (Boyd and Smith 1993). Second, as suggested in essay 1 of this thesis, at least some adverse selection models of debt are not robust to changes in market structure.

2.2 Incomplete contracts, venture capital and contingent control rights

In the previous sub-section, we reviewed some security design literature that motivates the use of debt-like contracts. In the articles reviewed, debt is associated only with a particular pattern of cash flows. However, financial securities are also associated with particular patterns of control rights. For example, debt holders' rights may include the right to liquidate the company when it does not pay its debts, the right to take possession of assets that serve as collateral for the loans, the right to vote on a decision to reorganise the company, and the right to remove managers in a reorganisation. Shareholders' rights, in turn, may include the right to vote on important corporate matters, such as mergers and liquidations, and in elections of boards of directors.

The security design literature has also focused on the allocation of these ownership and control rights among different securities (see Allen and Winton 1995, ch. 4, and Hart 2001). As discussed in section 1.2, the allocation of control rights is irrelevant if contracts are complete. Therefore, the starting point of this literature is that financial contracts are inherently incomplete.[6] The best-known examples of this literature examine the optimality properties of the (contingent) control allocation induced by standard debt contracts. In an incomplete contracting model of Aghion and Bolton (1992), it may be optimal to allocate control to the entrepreneur in the good state of the world and to the investor in the bad state of the world. According to the interpretation of Aghion and Bolton (1992), debt financing implements this particular kind of state-contingent control allocation. (We say more about Aghion and Bolton (1992) in sections 3.3. and 3.4 and in essays 3 and 4.) In related work, Bolton and Scharfstein (1990) and Hart and Moore (1998), explicitly model the idea that debt is a contract that gives the creditor the right to grab collateral in case of default. Incentives for the entrepreneur to repay the borrowed funds are provided by the ability of the creditor to seize the entrepreneur's assets.

A typical feature of the debt contract is that the lender obtains certain control rights, such as the right to take possession of some of the firm's assets pledged as collateral if the borrower defaults on a payment or violates certain covenants. Thus, basically, the state-contingent control allocation inherent in ordinary debt contracts is 'all-or-nothing': the entrepreneur has full control over the firm unless he defaults on his debt, in which case the lender obtains control. Recently, there has been much theoretical and empirical interest in *venture capital financing*, where the state-contingent contracting is much more elaborate than in ordinary debt contracts. In an empirical study with US data, Kaplan and Strömberg (2000) show that in venture capital financings, control shifts among a number of dimensions – voting rights, board rights, liquidation rights, redemption rights etc – and shifts at different level of performance. In essay 3, we modify Aghion and Bolton (1992) and introduce an

[6] It is useful to distinguish between two strands of incomplete contracting literature. The first strand simply *assumes* that contracts are incomplete and concentrates on the role of different mechanisms and institutions in mitigating the efficiencies generated by incomplete contracts. This is the approach applied by Aghion and Bolton (1992) and Hart (1995), among others. The second strand of literature derives the contractual incompleteness *endogenously* (see Al-Najjar et al (2002) and the references therein). Essays III and IV of this thesis belong to the first strand of literature.

incomplete contracting model which is consistent with some empirical findings of Kaplan and Strömberg (2002).

Although venture capital accounts for only a small fraction of total corporate investments, the research on venture capital financing is important and challenging for at least two reasons. First, venture capital finance seems to be essential for many small risky high technology firms in their early stages. Microsoft, Intel, Apple, Federal Express, Cisco Systems and Genentech are examples of firms that were initially venture backed by capital. Second, as argued by Kaplan and Strömberg (2002), venture capitalists are the real world entities who most closely approximate the investors of theory. Therefore, comparing the characteristics of real world financial contracts to their counterparts in financial contracting theory provides precious insights on the relevance of different financial contracting theories.

Within theoretical literature of venture capital financing, essays 3 and IV are perhaps most closely related to Schmidt (2000) and Dessein (2002) (see also Berglöf 1994, Hellman 1998 and Kirilenko 2001). Like us, Schmidt (2000) examines the optimal state-contingent contracts between entrepreneur and investor (venture capitalist) in a model with three possible states of the world. However, Schmidt (2000) focuses on the optimal state-contingent allocation of cash rights whereas we concentrate on the optimal state-contingent allocation of control rights. Like us, Dessein (2002) builds a model that is consistent with some of the empirical findings of Kaplan and Strömberg (2002). Unlike us, however, he focuses mainly on the adverse selection problem between better informed entrepreneurs and less informed investors, and shows that the entrepreneur relinquishes control to the investor in order to signal his concordance.

2.3 Optimal mix of intermediated and direct finance

In essays 1, 3, and 4, we abstract from differences among different sources of finance. In essay 1, the only source of finance is the monopoly financier. In essays 3 and 4, in turn, the entrepreneur contracts with one of the many similar (venture capital) financiers, and ex ante competition between financiers guarantees that the entrepreneur extracts the expected surplus of the project. These kinds of assumptions are, of course, widely used in economics. For example, much of the capital structure literature abstracts from the role of intermediated finance and much of the theory of financial intermediation[7] abstracts from the role of direct finance. However, recently a number of authors have presented models in which intermediated and direct finance coexist. Essay 2 belongs to that strand of literature.

One of the most fundamental issues with regard to financial intermediaries, such as banks, concerns the question of what banks can do that cannot be accomplished in the capital markets through direct contracting between investors and firms. The extensive literature has provided a multitude of explanations, many of which build on the postulate that borrowers are likely to possess more information than lenders on their creditworthiness, on the spope of actions available for them, and on their willingness and ability to repay the acquired funds. As a consequence, potential lenders are faced with the problems of adverse selection and moral hazard. In many models, banks' raison d'etre stems from the assumption that banks are better than capital market investors in producing information ('monitoring') that can be used to alleviate these adverse selection and moral hazard problems.

If banks produce information that capital market investors cannot produce, then how is it that banks and capital markets can co-exist? To address that question, the recent literature has examined not only the benefits of bank financing but also the costs. The best-known papers examining the costs of bank finance are Sharpe (1990), Diamond (1991) and Rajan (1992).[8] In Sharpe (1990) and Rajan (1992), the cost of bank finance related to the fact that the bank that initially lent to the firm obtains an ex-post informational monopoly over other banks, and successful firms face a switching cost if they decide to change banks. Rajan (1992) shows that the firm's portfolio choice of borrowing source and the choice of priority for its debt claims are part of its attempt to circumscribe the powers of banks. In Diamond (1991), new borrowers borrow from banks initially. Successful firms can build a reputation that allows them to issue direct debt, which is less expensive. In all these models, some firms prefer bonds to bank loans. Bolton and Freixas (2000) extend these models by assuming that firms can also issue equity.

In the papers just discussed, firms choose between bank loans and bonds but do not mix these. However, many firms are not exclusively funded by banks or small, uninformed bondholders, but by a mixture of both (mixed finance). The papers that focus on the optimal mix of

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[7] For a recent survey on financial intermediation, see Gorton and Winton (2002).

[8] For later contributions, see Hoshi et al (1993), Chemmanur and Fulghieri (1994), Boot and Thakor (1997) and Holmström and Tirole (1997).

bank loans and bonds include Besanko and Kanatas (1993), Diamond (1993a, b), Berglöf and von Thadden (1994), Detragiache (1994), and Repullo and Suarez (1998,) as well as essay 2 in this thesis. Essay 2 is most closely related to Berglöf and von Thadden (1994) and Repullo and Suarez (1998) in that in all of these the key role of (informed) bank finance is to reduce the entrepreneurial moral hazard by imposing a credible threat of liquidation. However, our model differs from the rest in that we assume that the bank can also hold shares in its borrowing firm. Thus, our model contributes to the literatures of both mixed finance and the benefits of banks' shareholdings (see Gorton and Winton 2002, p. 42–47).

3 Contents of the thesis

3.1 Are adverse selection models of debt robust to changes in market structure?

In essay 1, we argue that the result of the optimality of debt in the adverse selection model of Wang and Williamson (1998) is not robust to changes in market structure. We modify the model of Wang-Williamson (1998) by assuming that there is only one (monopoly) lender instead of a continuum of lenders. We show that in this case debt is no longer an optimal contract for all types of borrowers. Furthermore, we argue that our critique applies to some other models of adverse selection, at least to Innes (1993), Boyd and Smith (1994) and Nachman and Noe (1994).

All the models mentioned are based on the following seemingly innocuous assumptions. First, entrepreneurs have private information about the quality of their ex post profit distributions. Second, profit distributions are ordered by the monotone-likelihood-property. Third, financiers' payoff functions are restricted to be monotonically non-decreasing in firm profits. Fourth, financial markets are competitive. We argue that the models of debt that are based on these four asssumptions are not robust to changes in market structure, specifically, to a replacement of the assumption of perfect financial markets with the assumption of a monopoly financier.

We present our argument by extending the model of Wang and Williamson (1998). As the reasons for the optimality of debt contracts are similar in the models mentioned above, we argue that these models also are likely to fail in same robustness test.

3.2 Banks' equity stakes in borrowing firms: a corporate finance approach

In essay 2, we examine the potential advantages of allowing banks to hold equity in their borrowing firms. The essay builds on the observation that bank equity holdings are relatively small in most countries where banks are allowed to hold equity (see eg Santos 1998). In light of the theoretical literature, this is somewhat surprising. For example, one of the basic observations of the capital structure literature is that debt-financed firms are subject to the standard 'asset substitution' or 'risk shifting' effect of debt financing, as the debt contract gives equity holders an incentive to invest suboptimally. According to the well-known result of Jensen and Meckling (1976), this agency cost of debt financing can be reduced by financing the firm with equity. Thus, on the basis of their result, allowing banks to hold equity in their borrowing firms would seem to reduce the firms' asset substitution problem of debt financing.

This simple idea has been formalised by John et al (1994). However, we argue that there are three major limitations in their model. First, in John et al (1994), the bank is treated only as a passive substitute for the firm's capital structure: the bank can reduce the asset substitution problem only by financing the firm with an appropriate mix of debt and equity. Thus, in contrast to most of the modern banking literature, John et al (1994) abstracts from the bank's role as a monitor. Second, in their model, there is no direct finance. Third, while the role of equity is to reduce the asset substitution problem, the role of debt is not clearly specified.

We extend the analysis of John et al (1994) in several ways. First, we explicitly model banks as monitors of firms. Second, we allow firms to choose between bank finance and direct finance. Third, we explicitly define the roles of both debt and equity. We examine the entrepreneurs, who are characterised by their initial wealth and a liquidation value of their projects as regards their choice of the firm's capital structure. Firms can engage in two kinds of moral hazard. First, there is the asset substitution problem of debt financing. Banks differ from uninformed investors in that, subject to a cost, they can observe the firm's choice between socially efficient safe project and socially inefficient risky project. The bank can use the information to liquidate the project at the interim date. In contrast, uninformed investors are unable to observe the project choice. Second, the entrepreneur can simply divert or steal the provided outside funds ('take the money and run'). Following Burkart et al (1999) and La Porta et al (2002), we assume that diverting the funds is costly for the entrepreneur: he has to engage in some legal or illegal manoeuvres to divert funds take the risks of possible legal challenges, and so on. Furthermore, we assume that it is more costly to divert funds raised by equity than funds raised by debt (see Shleifer and Vishny 1997). In this moral hazard model, we examine the entrepreneur's choice between bank finance (either in the form of debt or a combination of debt and equity), market finance, and mixed finance (a mixture of bank finance and market finance).

Our major result is that the potential benefits of allowing banks to invest in equity in their borrowing firms may be small or nonexistent when the above-mentioned realistic complications are introduced. The broad intuition is that allowing the bank to hold equity may not yield much additional benefit (in terms of reduction of entrepreneurial moral hazard), when markets for direct finance and the bank's ability to monitor are explicitly taken into account. In other words, our model suggests that the bank's ability to monitor and the firm's possibility to raise direct finance may accomplish more or less the same ends as allowing banks to hold equity in their borrowing firms.

3.3 Financial contracts and contingent control rights

In Essay 3, we examine the optimal allocation of control rights between entrepreneur and investor. The essay builds on the observations that the allocation of control rights is often contingent on some observable measures of firm performance and that the (voting) control is sometimes shared between insiders of firm and financiers. According to an empirical study of real world venture capital contracts, Kaplan and Strömberg (2002) observe that control rights are often conditional on different measures of firm performance in the following way. If the firm's performance is poor, the venture capitalist obtains full control of the firm. If the company performance is intermediate, the entrepreneur obtains or retains more control rights. If the company performs very well, the venture capitalist relinquishes most of his control rights. We extend the model of Aghion and Bolton (1992) to build a model which is consistent with these empirical findings.

As is well-known, the allocation of control rights is important only if the contracts between entrepreneur and investor are incomplete and if there is a conflict of interest between the contracting parties. In our model, the conflict of interest arises because, besides monetary returns, the project also yields some non-transferable, non-observable and non-verifiable private benefits for the entrepreneur. The amounts of monetary returns and private benefits depend on the state of nature and an interim action, which is taken after the state of nature has been realised. In an ideal world, the parties would write a contingent contract at date 0 that would make the choice of action contingent on the realisation of the state of nature. However, we assume that such contracts are not viable because contracts are incomplete in the sense that neither the action nor the state of nature can be written into the initial contract. The initial contract can, however, specify which of the parties has the *right* to choose the action at an interim date. Furthermore, this right to choose the action can be made contingent on an observable and verifiable signal which imperfectly correlates with the state of nature.

In the above environment, we examine how the cash flow and control rights are divided between investor and entrepreneur, who has all the bargaining power ex ante and ex post. Aghion and Bolton (1992) first studied this problem in a model with two actions, two signals and two states of nature. They argue that under certain conditions, it is strictly optimal to allocate control to an investor with a bad signal and to an entrepreneur with a good signal. They interpret this contingent control allocation as the control allocation induced by standard debt contracts. In other words, Aghion and Bolton (1992) is a model of 'all-or-nothing' shifts in control. However, as argued by Kirilenko (2001) and Kaplan and Strömberg (2002), for example, control is not an indivisible right held at any time by either an investor or an entrepreneur and that the state-contingent contracting is often much more elaborate than the control rights inherent in ordinary debt contracts. To build a model with flavor of the rich state-contingent contracting observed in practice, we extend the two-action, two-signal, two-state-of-nature model of Aghion and Bolton (1992) to a three-action, three-signal, three-state-of-nature model.

The second, and more substantial, difference between our model and that of Aghion and Bolton (1992) is that we model joint control differently. A standard result in incomplete contracting literature is that joint control or sharing of control[9] is generally not optimal (see eg Hart 1995). We argue that one reason for the non-optimality of joint control is the assumption[10] that the parties payoffs in case of

[9] Joint control generally refers to the case where each of the contracting parties has the right to veto the firm into a standstill. Sharing of control, in turn, generally refers to the case where decisions are made by majority rule and none of the parties has voting control.
[10] Some may argue that this is, in fact, the *definition* of joint control.

disagreement are zero. We argue that this assumption is more reasonable in *buyer-seller*[11] models (Hart and Moore 1988, Hart 1995) than in entrepreneur-investor–models (such as Aghion and Bolton 1992). In buyer-seller–models, contractual renegotiation rules, ie the rules that govern the process of renegotiation, cannot be prescribed, as the parties cannot write long-term contracts. In an entrepreneur-investor model, the parties do write a long-term contract, namely, the initial financing contract. It seems obvious that entrepreneur and investor can include the rules that govern the process of renegotiation in their initial contract. In our model, it is optimal for the entrepreneur (who designs the contract) to set the rules for choosing the action under joint control as follows. First, the entrepreneur proposes some action. Then, the investor either accepts the proposed action, in which case the action is taken, or turns downs the proposition, in which case the parties may renegotiate. If the renegotiation fails, then each of the parties obtains control with probability ½.

These two extensions to the model of Aghion and Bolton (1992) enable us to build a model which is consistent with the empirical findings of Kaplan and Strömberg (2000). More specifically, we show that when the size of the investment project is intermediate (or, equivalently, for intermediate conflicts of interest) the following *signal-contingent allocation of control* is optimal. If the signal of the firm performance is good, the entrepreneur retains control. If the signal is intermediate, joint control is optimal. If the signal is bad, the investor obtains control.

3.4 An incomplete contracts approach to financial contracting: a comment

The fourth essay is closely related to the third essay. The essay is a short comment on the article of Aghion and Bolton (1992). We show that Aghion and Bolton (1992) overlook one type of contract, the *investor control contract with signal contingent cash* flow *rights*. We show that, as a consequence, their principal result must be qualified.

[11] In stylised buyer-seller models with relationship-specific investments (see eg Hart 1995, ch. 2), the parties cannot write a contract specifying the terms of trade for the good (a 'widget') which they may want to exchange at some future date, because the type of the traded good cannot be described. Thus, at the date of trading, the parties negotiate on the price of the good from scratch. If the negotiation fails, the trade does not take place and the parties payoffs are zero.

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Essay 1

Are adverse selection models of debt robust to changes in market structure?

Jukka Vauhkonen

Abstract

Many adverse selection models of standard one-period debt contracts are based on the following standard assumptions. First, entrepreneurs have private information about the quality of their profit distributions. Second, profit distributions are ordered by the monotone-likelihood-ratio property. Third, financiers' payoff functions are restricted to be monotonically non-decreasing in firm profits. Fourth, financial markets are competitive. We argue that debt is not an optimal contract in these models if there is only one (monopoly) financier instead of a large number of competitive financiers.

1 Introduction

One strand of the security design literature[1] focuses on deriving the conditions under which the standard debt contracts are equilibrium financial contracts in adverse selection models. The main result of this literature, whose principal contributions are Innes (1993), Nachman and Noe (1994) and Wang and Williamson (1998), is that debt contracts are uniquely optimal financial contracts, when the following four key assumptions hold. First, entrepreneurs have private information about their return distributions. Second, higher quality borrowers have better return distributions in terms of the monotone-likelihood-ratio property.[2] Third, financiers' admissible payoff functions are non-decreasing in firm return. Fourth, financial markets are competitive. In this paper, we show that debt contracts are not optimal for all borrowers in the model of Wang and Williamson (1998), if the assumption of competitive financial markets is replaced by the assumption that the monopoly financier is the only source of finance. More importantly, we argue that other adverse selection models of debt which satisfy the four key assumptions may fail in the same robustness test.

The idea that debt financing may alleviate the problem of asymmetric information between the firm and its potential financiers has its origins in the pioneering work of Myers and Majluf (1984). Myers and Majluf (1984) argue that debt financing minimises the underpricing losses from security issuance when there is asymmetric information on the value of the firm's current assets. However, as an explanation of the optimality of debt contracts, their model has the shortcoming that the admissible securities consist only of debt and equity. To remedy this problem, the subsequent research has tried to generalise the results of Myers and Majluf (1984) by examining optimal security designs in asymmetric information models when contracts are endogenous.

Standard contract theory suggests that when contracts are endogenous, optimal contracts should be contingent on all relevant information. This generally implies that optimal contracts will be

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[1] This literature is surveyed in Dowd (1992) and Allen and Winton (1995).

[2] For debt to be a uniquely optimal (pooling) contract in Nachman and Noe (1994), the return distributions of different types must be ordered by *strict conditional stochastic dominance*, which is a somewhat stronger condition than the monotone likelihood ration property or first-order stochastic dominance (see Nachman and Noe 1994, p. 18–21, for details).

extremely complex (see Hart and Holmström 1987). However, most real world financial contracts are rather simple. The security design literature examines what kind of assumptions must be made, for example, on the nature of information and on the distributions of project returns to ensure that some simple contracts such as standard debt contracts are optimal. The central finding of Innes (1993), Nachman and Noe (1994) and Wang and Williamson (1998) is that only some rather standard assumptions need to be made to guarantee that standard debt contracts are optimal responses to the adverse selection problem.

Innes (1993) derives equilibrium financial contracts in competitive risk neutral capital markets, where high quality entrepreneurs have better profit distributions in the sense of the monotone-likelihood property, and where financiers know the distribution of quality types in the population but not the quality of any particular borrower. The key result of Innes (1993) is that, when the entrepreneur's investment size is fixed and the financier's payoff is monotonically nondecreasing in firm profits, the equilibrium pooling contract is the standard debt contract. The signaling model of Nachman and Noe (1994) differs from the screening model of Innes (1993) in that informed borrowers try to signal their quality to financiers by their contract offers. Nachman and Noe (1994) show that the debt contract is the uniquely optimal pooling contract if and only if the cash flows of different types of borrowers are ordered by strict conditional stochastic dominance (see ftn 2 below). Wang and Williamson (1998) introduce ex ante screening to the two quality type version of the model of Innes (1993), and show that debt contracts are optimal separating contracts, when the monitoring technology allows financiers to commit to stochastic ex ante screening.

A typical feature of adverse selection models with competition between financiers (or insurers, as in Rotschild and Stiglitz 1976) is that low quality borrowers have an incentive to mimic high quality borrowers. In signalling models, low quality borrowers have an incentive to offer contracts similar to those offered by high quality borrowers. In screening models, low quality borrowers have an incentive to choose contracts directed at high quality borrowers. Obviously, to reduce or eliminate the mimicking, financiers and high quality borrowers try to design contracts for high quality borrowers that are unattractive to low quality borrowers. When project returns are ordered according to the monotone-likelihood-ratio property, high quality borrowers' returns are more concentrated on the upper end of the probability distribution of returns. In that case, low quality borrowers' incentives to mimic high quality types are reduced when the contracts designed by or directed at high quality types provide the borrower with relatively low payoffs with low project returns and relatively high payoffs with high project returns. As shown by Innes (1994), Nachman and Noe (1994) and Wang and Williamson (1998), when project returns are ordered by the monotone-likelihood -ratio property and the parties' payoff functions are restricted to be monotonic[3], the competitive contracts designed by or directed at high quality types are the standard debt contracts.

It is clear that this explanation of the optimality of debt fails when a monopoly financier is the only source of finance. The objective of the monopoly financier is to extract all expected project surpluses from borrowers. A consequence of assuming that the project distributions are ordered by the monotone-likelihood-ratio property is that low quality borrowers' projects yield lower expected returns than those of high quality borrowers. This implies that when the types of borrowers are unknown to the monopoly financier, it is *high quality borrowers* who have an incentive to mimic low quality borrowers, as the financier extracts lower expected surpluses from low quality types. Obviously, to extract as much profit as possible, the monopoly financier designs the contract(s) in such a way that high quality types' benefits of mimicking low quality types are as low as possible. As high quality borrowers' returns are more concentrated on the upper end of the return distribution, the financier offers borrowers such monotonic contracts that provide them with relatively high payoffs when returns are low and relatively low payoffs when returns are high. It is obvious that such contracts are very different from standard debt contracts.

In this article, we formalise the above argument by extending the model of Wang and Williamson (1998). We show that their result for the optimality of standard debt contracts is not robust to changes in the market structure. More specifically, we show that the standard debt contracts are not optimal for all borrowers in their model, when the only source of finance is a monopoly financier. We utilise the model of Wang and Williamson (1998), because the intuition underlying our results is easy to see in their relatively simple model with only two types of borrowers. However, we emphasise that our argument applies also to other adverse selection-based models of debt, which are based

[3] In the absence of this restriction, the equilibrium contracts take the 'live-or-die' form (see Innes 1993) such that the financier receives all the returns if the return realisation is lower than some threshold level and nothing if the return is at least as high as the threshold level.

on the above four key assumptions and where, therefore, the mimicking problem is similar to that of Wang and Williamson (1998).

Our model has some similarities with the model of Besanko and Thakor (1987). In an adverse selection model, they also examine how the terms of contracts between the firms and financiers differ in monopoly and competitive models. However, they focus on the effects of market structure on collateral requirements and credit rationing, whereas we focus on the effects of market structure on the form of the optimal contract.

In section 2 we present the model. In section 3 we examine the properties of separating equilibria, characterise the specific form of profit-maximising separating contracts, and compare our results to those of Wang and Williamson (1998). Section 4 concludes.

2 The model

There is one major difference between our model and that of Wang and Williamson (1998). We assume that there is only one (monopoly) financier, whereas Wang and Williamson (1998) assume that there is a continuum of competive lenders. Otherwise, the models are essentially identical.

There are three types of risk-neutral agents: type g borrowers, type b borrowers, and the monopoly financier. There is a continuum [0,1] of borrowers with the share of type g borrowers being α and the share of type b borrowers being $1-\alpha$. Borrowers are endowed with an investment project which requires k units of funds to undertake, $0 < k < 1$. Borrowers have no own funds and the only source of outside funds is the monopoly financier. If undertaken, projects yield random returns according to the distribution function $F_i(x)$ and corresponding probability density function $f_i(x)$, where the subscript $i = g, b$ denotes the type of borrower. We assume that $f_i(x) > 0$ for $x \in [0,1]$ and that $f_i(x)$ is continuous on [0,1].

The following assumption is a typical way of ordering projects in adverse selection models.

Assumption 1. Type g borrowers' projects are better than type b borrowers' projects in the sense of the monotone-likelihood property

$$\frac{f_g(x)}{f_b(x)} < \frac{f_g(y)}{f_b(y)}; x, y \in [0,1]; x < y \tag{2.1}$$

As shown by Wang and Williamson (1998), the following property is a consequence of the above assumption.

Corollary 1. Type g borrower's return distribution, $F_g(x)$, first-order stochastically dominates type b borrower's return distribution, $f_b(x)$. Thus, for every non-decreasing function $u : \Re \rightarrow \Re$, we have (i)

$$\int u(x) dF_g(x) \geq \int u(x) dF_b(x)$$

or, equivalently, (ii)

$F_g(x) \leq F_b(x)$ for every x.

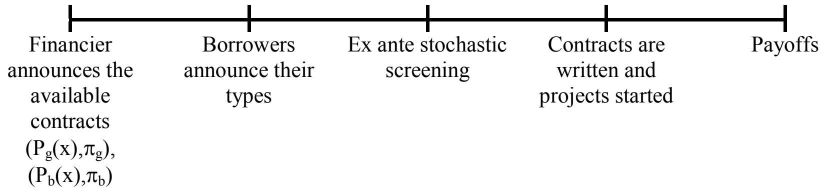
First-order stochastic dominance implies that any expected utility maximiser who prefers more to less prefers $F_g(x)$ to $F_b(x)$ and that the graph of $F_g(x)$ is uniformly below the graph of $F_b(x)$ (see Mas-Colell et al 1995, p. 195–197).

We assume that borrowers know their own types but the financier learns the type of a borrower only by paying a fixed cost of screening, c. The screening technology is such that it permits the financier to commit to screen a fraction of the pool of loan applicants. A similar assumption is utilised in Mookherjee and Png (1989) and Krasa and Villamil (1994), in the costly state verification context.

There are three types of potential (monopolistic) equilibrium configurations in our model. First, in the separating monopolistic equilibrium with a menu of contracts the financier offers a menu of two contracts, and both types of borrowers choose the contracts directed at them. In an alternative separating equilibrium, the financier offers only one contract, which is accepted only by type g borrowers. The third potential equilibrium is the pooling equilibrium, where the financier offers only one contract and both types of borrowers accept that contract.

The time line of the model in the most interesting case, where the financier offers a menu of two contracts and both types of borrowers choose the contracts directed at them is the following[4]

[4] We show in proposition 3 that the financier prefers a menu of two separating contracts to either one separating contract or a pooling contract provided the cost of screening is sufficiently low.



At date 0, the financier announces the available contracts. The contracts are denoted by the pairs $(P_i(x),\pi_i)$, $i = g, b$, where $P_i(x)$ denotes type i borrower's payoff as a function of the project return, x, and where π_I, $i = g, b$, denotes the probability that the borrower who announces to be of type i is screened.

We constrain the payoff functions to satisfy the following critical assumption, which is standard in adverse selection models of debt.

Assumption 2. Borrowers' and financier's payoff functions are constrained to be monotonically nondecreasing in project return x

$$x \leq y \Rightarrow P_i(x) \leq P_i(y) \text{ and } x - P_i(x) \leq y - P_i(y);\ x, y \in [0,1],\ i = g, b.$$

Although most common securities satisfy this assumption, it seems that little attempt has been made in the literature to justify it (this view is shared by Nachman and Noe 1994, p. 6, ftn 2). One motivation for the use of the monotonicity constraint is provided by Innes (1993, p. 30). He assumes that the borrower may be able to sabotage the firm ex post. That is, after observing a perfect signal of firm profits, the borrower may be in a position to sabotage the firm by burning as much of the profit as he chooses. Then, the borrower would choose to burn profits in any decreasing segment of his payoff function and a non-monotonic contract would never be chosen.[5] Nachman and Noe (1994, p. 6, ftn 2) provide another motivation. If the firm could engage in refinacing after observing a signal of its profits, it could raise the available cash flow to the level needed to avoid a higher payout at a low cash flow. Again, the effect of having this refinancing opportunity is that a non-monotonic contract would never be chosen.

At date 1, borrowers announce their types, ie they inform the financier which of the two contracts they prefer.

[5] See Innes (1993) for a discussion on the optimal financial contracts under adverse selection and without the monotonicity constraint.

At date 2, the financier screens the borrower, who claims to be type i with probability π_i. We assume that the financier can commit to punish a borrower who claims to be type i but turns out to be the other type, by refusing to lend to him[6]. The financier obviously wants type i borrower to choose a type i contract. The role of stochastic screening is to induce borrowers to self-select and thus to choose the contracts targeted at them at the lowest possible screening costs. Note that the role of screening in our model is quite different from that in many other financial contracting models, where the financier screens all loan applicants and uses the screening technology to detect the potential cheaters and unprofitable borrowers.

At date 3, contracts are signed and projects are started. At date 4, the returns are realised and the payoffs divided between the parties.

Finally, we put two simplifying restrictions on the parameter values, which allow us to restrict our attention to self-selective separating contracts. In what follows, parameters μ_b, c and $\bar{u}$ denote, respectively, the mean investment return for a type b borrower, a fixed and strictly positive screening cost, and a fixed and strictly positive reservation utility level of borrowers.

Assumption 3. $c < \min[\mu_b - \bar{u} - k, \bar{u}]$

Assumption 4. $\alpha > 1/2$.

Assumption 3 requires that the mean investment return for a type b borrowers satisfy $\mu_b \geq k + c + \bar{u}$. This condition implies that both types of projects are assumed to be socially profitable. In addition, assumption 3 requires the screening cost be lower than the borrower's strictly positive reservation utility. Assumption 4 is a technical assumption, which greatly simplifies our analysis. It guarantees that the menu of separating contracts, which is our main interest, always yields the financier higher profits than alternative contracts.[7]

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[6] We assume that the financier can commit to use punishments which, in our static model, are not credible ex-post. We assume that the financier uses these punishments to create and maintain the reputation of being a tough financier. Of course, reputational issues cannot be satisfactorily analysed in a static model like this. See Khalil (1997) and Khalil and Parigi (1998) for analyses of optimal contracts when the principal cannot commit to an audit policy.

[7] Note that assumptions that are close to assumption 4 are widely used in adverse selection models. In Rotschild and Stiglitz (1976), for example, the existence of the separating equilibrium requires that the proportion of *low-quality* types be high enough.

3 Profit-maximising separating contracts

In this section, we derive the profit-maximising menu of separating contracts under the assumption that the monopoly financier is the only source of finance. We show that these profit-maximising contracts are very different from standard debt contracts. In the appendix, we derive the properties of profit-maximising pooling contracts and separating contracts that attract only one type of borrower. In proposition 3 below, we also show that the profit-maximising menu of separating contracts provides the financier with greater profits than the other alternatives, provided the screening cost is sufficiently low.

3.1 Financier's maximisation problem

By 'separating equilibrium with a menu of contracts' we mean a pair of contracts ($P_i(x)$, π_i), i = g, b, which is the solution to the following constrained minimisation problem

$$\begin{aligned} \underset{[(P_g(x),\pi_g),(P_b(x),\pi_b)]}{\mathrm{Min}} & \left\{ \alpha\left[\int_0^1 P_g(x)dF_g(x)+\pi_g c\right]\right. \\ & \left. +(1-\alpha)\left[\int_0^1 P_b(x)dF_b(x)+\pi_b c\right]\right\} \end{aligned} \tag{3.1}$$

s.t.

$$0 \le P_i(x) \le x, x \in [0,1]; i = g, b. \tag{3.2}$$

$$x \le y \Rightarrow P_i(x) \le P_i(y);\ x, y \in [0,1],\ i = g, b. \tag{3.3}$$

$$x \le y \Rightarrow x - P_i(x) \le y - P_i(y);\ x, y \in [0,1], \tag{3.4}$$

$$\int_0^1 P_i(x)dF_i(x) \ge (1-\pi_j)\int_0^1 P_j(x)dF_i(x);\ i, j = g, b; j \ne i \tag{3.5}$$

$$\int_0^1 P_i(x)dF_i(x) \geq \bar{u}; i = g, b. \tag{3.6}$$

According to (3.1), the financier's profits are maximised when the sum of the borrowers' expected payoffs and the screening costs is minimised. Condition (3.2) is the limited liability constraint. Conditions (3.3) and (3.4) restate our assumption 2 of the monotonicity requirements for borrowers' and financier's payoff functions.

Conditions (3.5) and (3.6) are the standard incentive compatibility and the participation constraints, respectively. According to incentive compatibility constraints (3.5), a type i borrower must receive higher expected payoffs if he truthfully reveals his type than if he does not. The left hand side of (3.5) denotes borrower i's expected payoffs when he reports his true type. The right hand side denotes the expected payoffs when he cheats. With probability $1-\pi_j$, cheating is not detected and he receives payments according to type j's payoff function. With probability π_j, cheating is detected and the project is not funded, in which case his payoff is zero[8]. The participation constraints (3.6), in turn, state that the expected payoffs must be at least as large as the strictly positive reservation utility, $\bar{u}$.

3.2 Properties of separating contracts

In this section, we derive a number of results that help in solving the optimisation problem (3.1) subject to constraints (3.2)–(3.6). We first show that the separating equilibrium contracts have the following properties. First, only type g borrowers' incentive compatibility constraints are binding. Second, only the borrowers who claim to be of type b are screened with a positive probability. Third, the participation constraints bind for both type g and type b borrowers. These properties are established by the following lemmas.

First, utilising the auxiliary lemmas 1 and 2, we show in lemma 3 that the type g borrower's incentive compatibility constraint (3.5) is binding.

[8] We, for convenience, normalise this payoff to zero. This normalisation does not affect our qualitative results.

Lemma 1. In a separating equilibrium, if condition (3.5) is a strict inequality for i, then π_j is zero.

Proof: Suppose not. In other words, suppose that condition (3.5) is a strict inequality for i and $\pi_j > 0$. Then, the financier can offer an alternative contract $(P_j^*(x), \pi_j^*)$ with $P_j^*(x) = P_j(x)$, $\pi_j^* = \delta\pi_j$, and $0 < \delta < 1$ for type j. This alternative separating contract reduces the cost of screening while the conditions (3.5) and (3.6) remain unbinding. Therefore, in a separating equilibrium, if condition (3.5) is a strict inequality for i, then π_j is zero. QED

The intuition underlying this lemma is clear. If the incentive compatibility constraint (3.5) is a strict inequality and π_j is positive, then the financier can increase his profits by lowering the screening probability, π_j. If the decrease in π_j is small enough, the incentive compatibility constraint for type i remains unbinding. The same argument holds for any $\pi_j > 0$. Thus, if condition (3.5) is a strict inequality for i, then π_j must be zero.

Lemma 2. In a separating equilibrium, if (3.5) is a strict inequality for type i borrowers, then (3.6) must be an equality for type i borrowers.

Proof: Suppose that conditions (3.5) and (3.6) are both inequalities for type i. In that case, by lemma 1, (3.5) can be written as $\int_0^1 P_i(x)dF_i(x) > \int_0^1 P_j(x)dF_i(x)$. Now, the financier can offer type i an alternative separating contract $(P_i^*(x), \pi_i^*)$ with $P_i^*(x) \leq P_i(x)$, $x \in [0,1]$, with strict inequality for some $x \in [0,1]$ and $\pi_j^* = \pi_j$. This alternative contract increases the financier's profits without violating the incentive compatibility and participation constraints. Thus, (3.5) and (3.6) cannot both be strict inequalities for type i borrowers. QED

If both (3.5) and (3.6) are strict inequalities for type i, the financier can increase his profit by lowering the payoff to borrower i. The financier can lower the payoff to the point where either (3.5) or (3.6) becomes binding without violating the separating equilibrium conditions (3.2)–(3.6).

Lemma 3. In a separating equilibrium, the incentive compatibility constraint (3.5) is binding for i = g.

Proof: Suppose not, ie suppose that (3.5) is a strict inequality for i = g. Then $\int_0^1 P_g(x)dF_g(x) > \int_0^1 P_b(x)dF_g(x) > \int_0^1 P_b(x)dF_b(x) \geq \bar{u}$. The first of these inequalities follows from lemma 1. The second inequality is due to the monotonicity of $P_b(x)$ and first-order stochastic dominance. The third inequality follows from the participation constraint of type b borrowers. On the other hand, by lemma 2, condition (3.6) can now be written as $\int_0^1 P_g(x)dF_g(x) = \bar{u}$. This is a contradiction. QED

Thus, in a separating equilibrium, type g borrowers are indifferent between type g and type b contracts. This is a standard result in adverse selection models: at least one type's incentive compatibility constraint is binding in the separating equilibrium.

Next, we show that in a separating equilibrium with a menu of contracts, borrowers claiming to be of type b are screened with positive probability and that the participation constraints are binding for both types of borrowers.

Lemma 4. In a separating equilibrium, $\pi_b > 0$.

Proof: Suppose not. In other words, suppose that $\pi_b = 0$ and $\pi_g = 0$ (in a separating equilibrium with a menu of contracts it is always true that at least one of the screening probabilities is positive). By lemma 3, condition (3.5) for i = g can now be written as $\int_0^1 P_g(x)dF_g(x) = \int_0^1 P_b(x)dF_g(x)$. Consider now an alternative pooling contract, $P^*(x) = P_b(x)$. The financier earns higher profits with this pooling contract, since borrowers' payoffs remain the same while the screening costs fall to zero. Thus π_b cannot be zero in equilibrium. QED

The above lemma states that borrowers claiming to be type b are screened with positive probability in a separating equilibrium. In a separating equilibrium the financier uses his screening technology and the associated penalties (the financier declines to fund the project) to prevent type g borrowers from pretending to be type b borrowers. Without screening a positive proportion of type b borrowers it is impossible to achieve self-selection in this model.

Lemma 5. In a separating equilibrium, the participation constraint (3.6) is binding for i = g.

Proof: Suppose not. Then the candidate separating equilibrium conditions (3.5) and (3.6) for type $i = g$ would be $\int_0^1 P_g(x)dF_g(x) > \bar{u}$ and, by lemma 3, $\int_0^1 P_g(x)dF_g(x) = (1-\pi_b)\int_0^1 P_b(x)dF_g(x)$. Consider now an alternative pair of contracts $(P_g^*(x),\ \pi_g^*)$ and $(P_b^*(x),\ \pi_b^*)$, with $P_g^*(x) \le P_g(x), x \in [0,1]$, with strict inequality for some $x \in [0,1]$, and with $\int_0^1 P_g^*(x)dF_g(x) = \bar{u}$, $\pi_g^* = \pi_g$, $P_b^*(x) = P_b(x), x \in [0,1]$, and $\pi_b^* = 1 - \left(\bar{u} / \int_0^1 P_b(x)dF_g(x)\right) > \pi_b$. This alternative pair of contracts satisfies conditions (3.5) and (3.6) and increases the financier's expected returns per type g borrower by $\Delta R \equiv \int_0^1 P_g(x)dF_g(x) - \bar{u}$ and his screening costs by $\Delta C \equiv c\left(\int_0^1 P_g(x)dF_g(x) - \bar{u}\right) / \int_0^1 P_b(x)dF_g(x)$, compared with the candidate separating equilibrium contract. Thus, the alternative pair of contracts increases the financier's profits compared to the candidate separating equilibrium contract, if $\Delta R > \Delta C$ or if $c < \int_0^1 P_b(x)dF_g(x)$. This condition is satisfied, since $\int_0^1 P_b(x)dF_g(x) > \int_0^1 P_b(x)dF_b(x) \ge \bar{u} > c$, where the first inequality follows from first-order stochastic dominance, the second from the participation constraint for type b and the third from assumption 3. Therefore, condition (3.6) must be binding for $i = b$ in a separating equilibrium. QED

In many adverse selection models with two types of agents, a high quality agent's payoff is set above his reservation level to discourage him from pretending to be a low quality type agent. Here, by lemma 5 and similarly as in Wang and Williamson (1998), by utilising the screening technology, the financier is able to extract all the project surplus from the high quality borrowers.

Lemma 6. In a separating equilibrium, the incentive compatibility constraint (3.5) is not binding for $i = b$.

Proof: Suppose that condition (3.5) is binding for $i = b$. Then, by the binding condition (3.5) for type b, the first-order stochastic dominance property and lemma 5,

$\int_0^1 P_b(x)dF_b(x) = (1-\pi_g)\int_0^1 P_g(x)dF_b < \int_0^1 P_g(x)dF_g(x) = \bar{u}$. The above chain of equalities and inequalities contradicts the participation constraint (3.6) for i = b. Consequently, (3.5) cannot be an equality for i = b in a separating equilibrium. QED

This is a standard result in adverse selection models: typically only one of the two types of agents has an incentive to mimic the other type. In our model, only type g borrowers have an incentive to mimic type b borrowers.

Lemma 7. In a separating equilibrium, the participation constraint (3.6) is binding for i = b.

Proof: Follows directly from lemmas 2 and 6. QED

This also is a standard result in adverse selection models, where typically the participation constraints of the lowest quality type agents are binding.

Lemma 8. In a separating equilibrium, $\pi_g = 0$.

Proof: Suppose not. Then by lemma 6, condition (3.5) for type b is $\int_0^1 P_b(x)dF_b(x) > (1-\pi_g)\int_0^1 P_g(x)dF_b$, where $\pi_g > 0$. Now, the financier can offer an alternative contract, with $P_g^*(x) = P_g$, $\pi_g^* = \delta\pi_g$ and $0 < \delta < 1$ for type g. This alternative contract reduces the costs of screening without violating the separating equilibrium conditions (3.2)–(3.6). Therefore, in a separating equilibrium, $\pi_g = 0$. QED

By lemma 8, by pretending to be a type g borrower a type b borrower would not receive his reservation utility in expected value. As a result, borrowers claiming to be of type g need not be screened, since they indeed are type g borrowers with certainty. Lemmas 4 and 8 accord with the findings of De Meza and Webb (1988) and Wang and Williamson (1998). Also in their models only one type of borrowers is screened.

3.3 Characterisation of profit-maximising separating contracts

In this section we study the structure of profit-maximising separating contracts. First we derive the profit-maximising contract forms for type b borrowers and then for type g borrowers.

The financier's optimisation problem can be simplified by utilising the results of the previous section. First, since the participation constraints bind for both types of borrowers (lemmas 5 and 7), the financier's expected profits from good and bad borrowers are essentially fixed at $\alpha(\mu_g - \bar{u})$ and $(1-\alpha)(\mu_b - \bar{u})$. Second, by lemma 8, $\pi_g = 0$. Using these results, the financier's optimisation problem (3.1) reduces to a problem of minimising the screening costs $(1-\alpha)\pi_b c$ subject to binding participation constraints of both types of borrowers and to the binding incentive compatibility constraint of type g borrowers (Lemma 3). Thus, the profit-maximising separating contract for type b is the solution to the following problem

$$\underset{P_b(x),\pi_b}{\text{Max}}\ (-\pi_b)$$

s.t.

$$\int_0^1 P_b(x)dF_b(x) = \bar{u} \tag{3.7}$$

$$\bar{u} = (1-\pi_b)\int_0^1 P_b(x)dF_g(x) \tag{3.8}$$

Proposition 1. A unique profit-maximising contract directed at type b is an 'inverse debt' contract with $P_b(x) = x$, $x \in [0, \bar{P}_b]$; $P_b(x) = \bar{P}_b$, $x \in [\bar{P}_b, 1]$ for some $\bar{P}_b \in (0,1)$.

Proof: Formulate the Lagrangean of the maximisation problem above

$$
\begin{aligned}
L = -\pi_b + \lambda_1 \left[\bar{u} - \int_0^1 P_b(x) f_b(x) dx \right] \\
+ \lambda_2 \left[(1-\pi_b) \int_0^1 P_b(x) f_g(x) dx - \bar{u} \right]
\end{aligned} \tag{3.9}
$$

We maximise L with respect to π_b, $P_b(x)$ and $\lambda_i \neq 0$, $i = 1,2$, subject to feasibility and monotonicity constraints (3.2), (3.3) and (3.4). We immediately see that the first-order condition with respect to π_b implies that $\lambda_2 < 0$. In order to derive more results, we rewrite (3.9) as

$$
L = -\pi_b + (\lambda_1 - \lambda_2)\bar{u} + \int_0^1 \left[\frac{f_g(x)}{f_b(x)}(1-\pi_b) - \frac{\lambda_1}{\lambda_2} \right] \lambda_2 f_b(x) P_b(x) dx \tag{3.10}
$$

It can be shown that the other Lagrange constraint is also negative. Suppose conversely that $\lambda_1 > 0$. Then the term inside the square brackets in (3.10) is positive. This implies that $P_b(x) = 0$ is optimal for all $x \in [0,1]$. This cannot be true, since setting $P_b(x) = 0$ would violate (3.7). Consequently, both Lagrange constraints must be negative. Now, examine the term in the square brackets. Given that λ_1, $\lambda_2 < 0$ there must exist some values of $x \in [0,1]$ for which this term is negative. Otherwise, $P_b(x) = 0$ is optimal for all $x \in [0,1]$. Likewise, there must exist some values of $x \in [0,1]$ for which the term in square brackets is positive. Otherwise, $P_b(x) = x$ would maximise L for all $x \in [0,1]$. This is impossible, since it would violate condition (3.7). Because the term in the square brackets is continuous and increasing in x, there must exist a value $\bar{x} \in (0,1)$ for which this term is equal to zero. For $x \in [0, \bar{x})$, the term in square brackets is negative and for $x \in (\bar{x}, 1]$ it is positive. Now, given the feasibility and monotonicity constraints (3.2) and (3.3), we see that the optimal payoff schedule $P_b(x)$ is $P_b(x) = x$, $x \in [0, \bar{x}]$; $P_b(x) = P_b(\bar{x})$, $x \in [\bar{x}, 1]$. Denote $P_b(\bar{x})$ by $\bar{P}_b$. This completes the proof. QED

By proposition 1, the profit-maximising separating contract for type b can be characterised by the pair $(\bar{P}_b, \pi_b)$, where $\bar{P}_b$ corresponds to the gross loan interest rate in standard loan contracts; but now this payment accrues to a *borrower* instead to a financier. Using (3.7) and (3.8), $\bar{P}_b$ and π_b are determined by the following two equations

$$\int_0^{\overline{P}_b} x dF_b(x) + \overline{P}_b\left[1 - F_b(\overline{P}_b)\right] = \overline{u} \tag{3.11}$$

$$\overline{u} = (1-\pi_b)\left\{\int_0^{\overline{P}_b} x dF_g(x) + \overline{P}_b\left[1 - F_g(\overline{P}_b)\right]\right\} \tag{3.12}$$

Simplify the above equations by integrating by parts.

$$\overline{P}_b - \int_0^{\overline{P}_b} F_b(x)dx = \overline{u} \tag{3.13}$$

$$\overline{u} = (1-\pi_b)\left[\overline{P}_b - \int_0^{\overline{P}_b} F_g(x)dx\right] \tag{3.14}$$

It is easy to show that there exists a unique pair $(\overline{P}_b, \pi_b)$, which solves (3.13) and (3.14). Since (3.13) is continuous and increasing in $\overline{P}_b$, there exists a unique $\overline{P}_b$ solving (3.13). Inserting this unique $\overline{P}_b$ into (3.14) and solving for π_b yields a unique solution for π_b.

Proposition 1 establishes the striking result that the profit-maximising contract for type b is a mirror image of the standard debt contract. This result is close to the result of Boyd and Smith (1993). They examine a model with both adverse selection and costly state verification. They show that in the absence of costly state verification but in the presence of adverse selection problem, not all contracts will be debt contracts in the equilibrium.

By Proposition 1, the result of Wang and Williamson (1998) of the optimality of debt is not robust to changes in the market structure. Furthermore, the models of Innes (1993) and Nachman and Noe (1994) are also likely to fail the same robustness test, as their results are based on the same assumptions and mechanisms as Wang and Williamson (1998).

An intuition of the optimality of the inverse debt contract for a type b borrower is the following. Of those contracts that satisfy the feasibility and monotonicity constraints and the participation constraint for type b, the inverse debt contract gives borrowers the lowest payoffs in high-profit states. As high quality borrowers have more probability weight in high-profit states than low-quality borrowers, the inverse debt contract is the least attractive feasible and monotonic type b contract for type g borrowers. Therefore, the inverse debt contract induces as much self-selection as possible by type g borrowers and minimises the screening probability, π_b, needed to induce a type g borrower to truthfully reveal his type.

The next proposition characterises the properties of profit-maximising contracts for type g.

Proposition 2. Any feasible and monotonic contract that satisfies type g's participation constraint (3.6) with equality is the profit-maximising contract directed at type g.

Proof: By lemma 5, the participation constraint (3.6) is binding for type g borrowers in the separating equilibrium. In addition, by lemma 6, any feasible and monotonic contract for type g that satisfies (3.6) with equality is unattractive for type b borrowers. Thus, any feasible and monotonic contract that satisfies type g's participation constraint maximises the financier's expected returns from type g borrowers and is unattractive for type b. QED

According to Proposition 2, both debt contracts and inverse debt contracts are among the continuum of optimal contracts for type g.

So far we have only shown that the contracts characterised in propositions 1 and 2 are the profit-maximising separating contracts when both types of borrowers accept the contracts directed at them. However, there may be other separating contracts and pooling contracts that may yield the financier higher profits. First, there may exist a separating equilibrium, where the financier offers a single contract that attracts only one type of borrower. Second, there may exist a pooling equilibrium, where the financier offers a single contract that attracts both types of borrowers. The next proposition shows that focusing on a menu of separating contracts implies no loss of generality as long as the monitoring cost is sufficiently low.

Proposition 3. When assumption 3 holds, a monopoly financier earns higher profits by offering a menu of separating (inverse debt) contracts rather than a pooling contract that attracts both types of borrowers or a separating contract that attracts only one type of borrower.

Proof: See appendix.

4 Conclusion

In this essay, we derive the profit-maximising financial contracts in an environment where (1) there is one financier and many borrowers, (2) investment opportunities are heterogeneous, differing in their probability distribution of returns, (3) type g borrowers' profit distribution is better than that of type b borrowers in terms of the monotone-likelihood-ratio property, (4) borrowers know their own types, (5) the net social value of all types of projects is positive, (6) the type of a firm can be learned only by paying a fixed ex ante screening cost, (7) the screening technology permits commitment to stochastic ex-ante screening, (8) the financier can commit to punish borrowers found guilty of falsifying their types by denying a loan and (9) project returns are costlessly verifiable.

The main result of this inquiry is the following. When higher quality borrowers' projects are better in the sense of the monotone-likelihood property, the profit-maximising contracts are 'inverse debt' contracts. This finding is in contrast with the results of Wang and Williamson (1998), who establish that the standard debt is an optimal contract in an otherwise identical model but with a large number of small and independent financiers. Our results cast doubt on the robustness of the results of Wang and Williamson (1998), since in reality debt seems to be a prevalent contract form irrespective of the degree of competition between financiers.

Furthermore, we argue that also some other adverse selection-based models of debt may not be robust to changes in the market structure (such as Innes 1993 and Nachman and Noe 1994). These models are based on the same key assumptions as Wang and Williamson (1998), and thus the role of debt is similar. Therefore, these models are likely to fail in the robustness test proposed in this article.

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Appendix 1

Proof of proposition 3

Proposition 3. When assumption 3 holds, a monopoly financier earns higher profits by offering a menu of separating (inverse debt) contracts rather than a pooling contract or a separating contract that attracts only one type of borrower.

Proof: We first derive the forms of profit-maximising pooling contracts and separating contracts that attract only one type of borrower. Then, we show that the separating menu of contracts, characterised in proposition 1, equations (3.12) and (3.13), and proposition 2, provides the financier higher profits than does any separating contract that attracts only one type of borrower or any pooling contract.

Profit-maximising single separating contracts

Instead of the menu of two different separating contracts the financier can alternatively offer only a single contract that attracts only type g borrowers. The optimal form of such a contract follows from the following basic observations. First, any contract directed at type g, $(P_g(x), 0)$, where $P_g(x)$ is some monotonic payoff schedule such that $\int_0^1 P_g(x)dF_g(x) = \bar{u}$, is unattractive for type b borrowers, since, by definition of the first-order stochastic dominance, $\int_0^1 P_g(x)dF_b(x) < \int_0^1 P_g(x)dF_g(x) = \bar{u}$. Second, any contract with $\int_0^1 P_g(x)dF_g(x) = \bar{u}$ maximises the financier's expected profits among the single separating contracts, as the financier extracts all the surplus from type g borrowers. The following result is a consequence of these observations.

Proposition A1. Any contract $(P_g(x), 0)$ with a monotonic payoff schedule $P_g(x)$ satisfying $\int_0^1 P_g(x)dF_g(x) = \bar{u}$ is an optimal separating contract among the contracts that attract only one type of borrower.

It is easy to see that the lender's expected payoff with any such contract is

$$\Pi_{S1} = \alpha(\mu_g - \bar{u} - k) \tag{A1.1}$$

Profit-maximising pooling contracts

The analysis of pooling contracts is fairly straightforward, as there is no screening in the pooling equilibrium. The monopolistic pooling equilibrium contracts are characterised by a common payoff schedule P(x). The financier's problem is to choose an optimal pooling payment schedule, P(x), to minimise (A1.2) subject to conditions (A1.3)–(A1.6).

$$\underset{P(x)}{\mathrm{Min}}\left[\alpha \int_0^1 P(x)dF_g(x) + (1-\alpha)\int_0^1 P(x)dF_b(x)\right] \tag{A1.2}$$

s.t.

$$0 \le P(x) \le x, x \in [0,1] \tag{A1.3}$$

$$x \le y \Rightarrow P(x) \le P(y); x, y \in [0,1] \tag{A1.4}$$

$$x \le y \Rightarrow x - P(x) \le y - P(y) \tag{A1.5}$$

$$\int_0^1 P(x)dF_i(x) \ge \bar{u}; i = g, b. \tag{A1.6}$$

The optimal pooling contract maximises the financier's profits, which is equivalent with the minimisation problem (A1.2), subject to feasibility, monotonicity and participation constraints (A1.3)–(A1.6).

Proposition A2. The unique optimal pooling contract P(x) satisfies $P(x) = P_b(x)$, where $P_b(x)$ is characterised by proposition 1 and equations (3.13) and (3.14).

Thus, the optimal pooling contract is the same inverse debt contract that the financier offers to type b borrowers in a separating equilibrium with a menu of contracts. Optimality follows from the fact that this contract provides the financier the highest possible payoffs from type g borrowers among the contracts that satisfy type b borrower's participation constraint with equality. Thus, the optimal pooling contract is the least attractive contract from the good borrower's point of view among the contracts that give bad borrowers exactly their reservation utility.

The lender's expected profit from offering the profit-maximising pooling contract is

$$\Pi_P = \alpha\left(\mu_g - \int_0^1 P_b(x)dF_g(x) \right) + (1-\alpha)(\mu_b - \bar{u}) - k \tag{A1.7}$$

The first term denotes the financier's expected payoffs from type g borrowers. In the pooling equilibrium, the lender cannot extract all expected project surpluses from type g borrowers. The second term denotes the lender's expected payoffs from type b borrowers, from whom the lender is able to extract all expected project surpluses.

Comparison of Different Contracts

In this section we compare the financier's expected profits in the three different cases. Let us start the comparison by defining the lender's profits from offering a menu of separating contracts

$$\begin{aligned}\Pi_{S2} &= \alpha(\mu_g - \bar{u}) + (1-\alpha)(\mu_b - \bar{u}) \\ &\quad - c(1-\alpha)\left(1 - \frac{\bar{u}}{\int_0^1 P_b(x)dF_g(x)}\right) - k\end{aligned} \tag{A1.8}$$

where Π_{S2} denotes the financier's expected profits when he offers an optimal menu of two separating contracts, and the borrowers choose the contracts directed at them. The first two terms denote the financier's expected returns from type g and b borrowers, respectively. The third term denotes the cost of screening a fraction of type b borrowers, where the probability of screening is obtained from the binding incentive compatibility constraint of type g borrowers.

Now, we show that the financier's profit, Π_{S2}, from offering a menu of separating contracts is higher than his profit, Π_{S1}, from offering a separating contract that attracts only type g borrowers, or his profit Π_P from offering a pooling contract. To show this, consider the differences $\Delta_1 \equiv \Pi_{S2} - \Pi_{S1}$ and $\Delta_2 \equiv \Pi_{S2} - \Pi_P$

$$\Delta_1 = (1-\alpha)\left\{\mu_b - \bar{u} - c\left[1-\left(\bar{u} / \int_0^1 P_b(x)dF_g(x)\right)\right] - k\right\} \tag{A1.9}$$

$$\Delta_2 = \alpha\left(\int_0^1 P_b(x)dF_g(x) - \bar{u}\right) - c(1-\alpha)\left(1 - \bar{u} / \int_0^1 P_b(x)dF_g(x)\right) \tag{A1.10}$$

$\Delta_1 > 0$ by assumption 3 and the fact that $\int_0^1 P_b(x)dF_g(x) > \bar{u}$. $\Delta_2 > 0$, if $c < \alpha \int_0^1 P_b(x)dF_g(x)/(1-\alpha)$. This is satisfied, since $\int_0^1 P_b(x)dF_g(x) > \bar{u}$ and by assumption 4. This completes the proof. QED

Essay 2

Banks' equity stakes in borrowing firms: a corporate finance approach

Jukka Vauhkonen

Abstract

In most countries, banks' equity holdings in their borrowing firms are fairly small. In light of the theoretical literature, this is somewhat surprising. In particular, according to agency cost models, allowing banks to hold equity would seem to alleviate firms' asset substitution moral hazard problem associated with debt financing. This idea is formalised in John, John, and Saunders in a model where banks are modelled as passive investors and where bank loans are the only source of outside finance for firms. In this paper, we argue that this alleged benefit of banks' equity holding is small or non-existent when banks are explicitly modelled as active monitors and firms also have access to market finance.

1 Introduction

A well-known agency cost of debt, identified, for example, by Jensen and Meckling (1976), is that debt-financed entrepreneurs may benefit from investing in suboptimal projects. As shown by Jensen and Meckling (1976), this 'asset substitution' effect may be alleviated by financing the firm with equity. It is natural to think that banks, as creditors, also face this asset substitution problem, and that a bank's holding of equity in the borrowing firm may improve the efficiency of the entrepreneur's project choice.

This simple idea is modelled by John et al (1994). They examine the firm's risk choice in a model where the chosen riskiness of the firm's investment project is the entrepreneur's private information and where banks are the only source of outside finance. Banks finance firms with debt and/or equity, which are characterised merely as claims on the projects' cash flows. In this simple framework, John et al (1994), find, not surprisingly, that allowing banks to invest in equity reduces the risk-taking incentives of firms.

At first glance, the idea of John et al (1994) is persuasive. However, in this paper, we argue that the benefits of banks' equity holdings may be small or even non-existent when two realistic complications are introduced to the framework of John et al (1994). First, we explicitly model banks as monitors. In John et al (1994), banks can reduce the asset substitution problem only by financing firms with an appropriate mix of debt and equity claims. In other words, they treat the bank merely as a passive substitute for the firm's capital structure. In contrast, we assume that banks can employ a costly (interim) monitoring technology to reduce the asset substitution moral hazard problem. Second, we assume that, in addition to (informed) bank finance, firms have access to (uninformed) market finance. We are not aware of any other studies explicitly modelling banks' equity holdings in borrowing firms when firms have access to market finance.

Our critique of John et al (1994) is close to that of Gorton and Winton (2002) directed regarding some other models of banks' equity holdings, such as Berlin et al (1996) and Mahrt-Smith (2000). In their models, as argued by Gorton and Winton (2002, p. 44), subordinating the bank's loans accomplishes the same ends as having the bank hold equity. We, in turn, show that monitoring by the bank and the firm's access to market finance may accomplish the same ends as having the bank hold equity. Our critique may also be seen as a theoretical support to the well-known empirical observation that banks' equity holdings are rather small in most countries.

We consider the following model. Entrepreneurs are characterised by their initial wealth w, $0 \leq w < 1$. They need 1–w units of funds from outside financiers to carry out a unit-sized investment project at date 0. The entrepreneur can invest either in a socially efficient good project or in a socially inefficient bad project at date 1. The good project yields a certain fixed return and is socially efficient. The bad project is socially inefficient but its success return is higher than that of the good project. This assumption, together with the assumption that the entrepreneur is wealth-constrained, implies that there is the standard asset substitution problem between entrepreneur and debt holders. The role of equity is to ameliorate this asset substitution problem.

In order for debt to have a special role, we introduce an additional moral hazard problem to the framework of John et al (1994). Following Boyd et al (1997) and La Porta et al (2002), and to be discussed below, we assume that the entrepreneur can 'divert' or 'steal' the invested funds ('take the money and run'), albeit at a cost.[1] An important assumption of our model is that the entrepreneur's cost of diverting funds raised by debt is higher than the cost of diverting funds raised by equity.[2] This assumption allows us to build a model, in which both debt and equity have distinct roles to play. Equity is superior to debt in alleviating the asset substitution moral hazard problem, and debt is superior to equity in reducing the diversion moral hazard problem.

There are two types of outside financiers: banks and uninformed financiers, such as small shareholders and bondholders. Uninformed financiers do not observe the project choice at any cost. The bank, in turn, can commit to monitor the entrepreneur's project choice at an interim date. This assumption is restrictive but fairly standard (see eg Diamond 1991, Rajan 1992 and Repullo and Suarez 1998). The information acquired by monitoring enables the bank to liquidate the project, if the continuation payoff of the bad project (the good project is never liquidated) does not guarantee him a sufficient continuation payoff. Although liquidation is inefficient ex post, the bank may be able to impose a credible threat of liquidating the bad project. This threat of liquidation may act as a disciplinary device. If the project is

[1] In the absence of this assumption, there would be no role for debt as equity finance would completely eliminate the asset substitution problem. The assumption of costly diversion is a simple way to introduce debt into our model.

[2] We motivate this assumption in section 2.

not liquidated at date 2, it continues until date 3, when the payoffs of the project are divided between financiers and entrepreneur.

In the above model, we examine how entrepreneurs, characterised by their initial wealth and the liquidation value of their projects, choose the firm's capital structure. The entrepreneur can choose between uninformed finance, bank finance, or a mixture of both (mixed finance). We examine the feasibility of different types of finance and characterise the conditions under which a combination of bank loan and equity investment by the bank is the only feasible financing mix for an entrepreneur.

In our model, the feasibility of finance requires that the financing mix be such as to induce the entrepreneur to invest in the good project instead of investing in the bad project or diverting the funds and that the financiers be guaranteed a sufficient rate of return. More technically, the feasibility of finance requires that financiers' participation constraints and the entrepreneur's incentive compatibility constraint ('asset substitution constraint' and 'diversion constraint') are satisfied.

We show that sufficiently wealthy entrepreneurs receive cheap uninformed finance, either in the form of bonds, equity, or a mixture of both. In contrast, firms with lower wealth must rely on more expensive informed finance. Bank loans are feasible for some entrepreneurs with low wealth but high liquidation values for whom the bank can impose a credible threat of liquidation. However, the liquidation threat is not credible for some entrepreneurs with low liquidation values, as the bank's continuation return from letting the bad project continue is higher than the liquidation value. This creates a role for mixed finance.

The role of mixed finance is that it allows a reduction in funds contributed by the bank and thus restores the credibility of the liquidation threat. This enables some entrepreneurs for whom uninformed finance and bank loans are unavailable to finance their projects with mixed finance. However, as in Repullo and Suarez (1998), mixed finance is not feasible for all entrepreneurs, as bank and investor can collude at the expense of uninformed investors. More specifically, the entrepreneur can first invest in the inefficient bad project and then bribe the bank not to liquidate the project by offering the bank a new contract, to the detriment of uninformed financiers. Anticipating this, uninformed financiers do not participate unless the initial contract between entrepreneur, bank, and uninformed investors is renegotiation-proof. For some entrepreneurs with low wealth and low liquidation values, there are no such renegotiation-proof contracts.

To summarise the above discussion, there are some entrepreneurs with low wealth and low liquidation values for whom neither uninformed finance, bank loans nor mixed finance are feasible. Thus, there is a potential role for financing these entrepreneurs with a combination of bank loan and equity investment by the same bank. Our principal finding is that this mode of finance dominates other forms of finance only under quite stringent conditions. The main implication of this finding is that the social benefits of allowing banks to hold equity in their borrowing firms seem rather small, at least in the case studied in this model, where equity is characterised only by its cash-flow rights.

The social benefits of banks' equity holdings in their borrowing firms may be small because of the following two disadvantages of banks' equity stakes. First, in our model, banks' equity holdings exacerbate the entrepreneur's diversion moral hazard problem. Second, the bank's equity stake – given that debt holders are protected by limited liability – reduces the credibility of the bank's liquidation threat by increasing the bank's returns from letting the bad project continue. Mixed finance, in contrast, enhances the credibility of a bank's liquidation threat. Therefore, mixed finance may be feasible for many entrepreneurs for whom a mixture of bank loans and bank's equity investment is not feasible. Despite these disadvantages of banks' equity holdings, allowing banks to hold equity may be welfare increasing, if banks, as equity holders, are less vulnerable to the diversion moral hazard problem than uninformed equity holders.

Besides John et al (1994), there are some other theoretical papers that examine banks' incentives to hold equity in their borrowing firms. James (1995) and Berlin et al (1996) argue that a bank's equity stake may facilitate more effective bank interventions when firms are in financial distress. Sheard (1989) suggest that by holding stock in the firms to which they lend, banks acquire insider information, which facilitates their monitoring of the firms' decisions.[3] Steinherr and Huveneers (1994), in turn, suggest that banks' equity ownership strengthens the long-run relationship between bank and borrower. Unfortunately, they do not work out their idea in a fully specified model. In Mahrt-Smith (2000), it is easier for a firm to acquire additional funds from outside banks, if the informed inside bank holds both debt and equity. Yet another role for banks' equity ownership is provided by Boyd et al (1997) and Santos (1999), who show that

[3] His view, however, is challenged by Berlin et al (1996, p. 890) who argue that large investors acquire similar information whether or not their claim includes an equity component.

banks' investments in equity alleviate the moral hazard problem caused by deposit insurance. Finally, our model is largely based on Repullo and Suarez (1998), which is a model of mixed finance. However, Repullo and Suarez (1998) do not address the issue of banks' equity holding in borrowing firms, which is our main interest.

The rest of the article is organised as follows. In section 2, we present the model. In sections 3, 4, and 5, we examine the feasibility of uninformed finance, bank finance, and mixed finance, respectively. In section 6, we collect the results and present our major results. Section 7 concludes.

2 The model

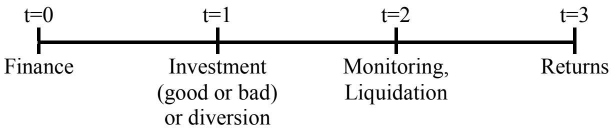
2.1 Ingredients

A. Investment technology

Consider a model with four dates ($t = 0, 1, 2, 3$) and a continuum of risk-neutral owner-managed firms (henceforth, 'entrepreneurs' or 'firms') characterised by their initial wealth, $w \in [0,1)$ and the liquidation value $L \in [0,1)$ of their project. The cost of the project is normalised at one, and the investment is made at date 1. To carry out the investment project, the entrepreneur needs $1-w$ outside funds from informed or uninformed investors at date 0. The entrepreneur can invest either in the socially efficient good project or in the socially inefficient bad project. Alternatively, the entrepreneur can simply divert or 'steal' the borrowed funds. We assume that diversion is costly for the entrepreneur. The returns on the good and bad projects and the costs of diversion will be specified below.

If the entrepreneur invests in the good or bad project, the assets purchased can be liquidated by creditors at date 2. Since $L < 1$, the liquidation is always inefficient ex ante. Note that the firm-specific liquidation value is the same for the good and bad project. At date 3, the liquidation values depreciate to zero. If the project is not liquidated at date 2, it yields monetary returns at date 3. The good project yields a return $S > 1$ with certainty. Bad projects yield a good return G with probability $1/2 < p < 1$ and a bad return 0 with probability $1-p$. For project returns it holds that $G > S > 1 > pG$, implying that bad projects are socially inefficient.

The following time line gives the sequence of events.



B. Financiers

Following Rajan (1992) and Repullo and Suarez (1998), for example, we differentiate between informed (bank) finance and uninformed (market) finance. Banks differ from uninformed investors in that at date 2 they can learn the firm's choice between good and bad project at a cost c. To make this monitoring feasible, we assume that c is sufficiently small, $c < S-1$. On the basis of this information acquired by monitoring, the bank can either liquidate the firm's assets or let the project continue. To avoid the issues related to endogenous monitoring (see eg Khalil 1997 and Khalil and Parigi 1998), we assume that the bank can *commit* to use the monitoring technology. We further assume that the information acquired by monitoring is not verifiable. Because of unverifiability of information, financial contracts cannot be conditional on choice of project.

In contrast to banks, uninformed investors are unable to observe the project choice. We regard uninformed investors as small investors, who either lack the ability to monitor or have no incentive to monitor because of free-rider problems.

The markets for both bank finance and uninformed finance are assumed to be competitive, ie investors' expected rates of return are normalised to zero.

C. Contracts

We allow two types of contracts: debt and equity. The contract between entrepreneur and financier is signed at date 0, and it defines the size of the financier's investment, and his share of the success returns if the project is not liquidated.

The *debt contract* between entrepreneur and type f financier $f \in \{i, u\}$, where i denotes the informed investor (the bank) and u the uninformed investor, is denoted by a pair $(I_{f,d}, D_f)$. $I_{f,d}$ denotes the size of the loan provided by a type f financier, and D_f the required debt repayment.

We assume that debt holders have a right to force the firm to repay the loan early. We can assume, for example, that debt holders can demand an early repayment of the debt under 'materially adverse circumstances' (see eg Brealey and Myers 1996, p. 692–693). In our model, the materially adverse circumstances correspond to the entrepreneur investing in the bad project. Note that the right to call the debt is worthless for the uninformed financier, as he does not observe the entrepreneur's project choice. In contrast, the right to liquidate is valuable to the bank. Although liquidation is inefficient from the social point of view, we show that the bank can in some circumstances use the liquidation threat as a *disciplinary device* that will induce the entrepreneur to invest in the socially efficient good project.

We further assume that bank debt is senior. Thus, in the event of default the bank is paid before other financiers. It seems that seniority is a typical characteristic of bank debt contracts (see eg Gorton and Kahn 1993). Furthermore, in their moral hazard setup, Repullo and Suarez (1998) show that the seniority of informed (bank) debt is a feature of optimal security design.

The standard limited liability assumption implies that, if the project is not liquidated, the type f financier's profit from a debt contract ($I_{f,d}$, D_f) is $R_f = \min[\tilde{x}, D_f] - I_{f,d}$, where $\tilde{x} = S, G$ or 0.

Equity contracts are characterised by a pair ($I_{f,e}$, α_f). The variable $I_{f,e}$ denotes the size of the equity investment made by a type f investor. The variable α_f denotes the type f investor's share of the firm profit (from which debt repayments have been deducted). We assume that at most one type of financier holds equity in any firm. Thus, if a firm raises funds by issuing equity, then equity is held either by the bank or by uninformed investors but not by both. We can show that this assumption implies no loss of generality. Given this assumption, the type f equity holder's return from an equity contract ($I_{f,e}$, α_f), for a return realisation $\tilde{x}$ and for given realised total debt repayments R_T, is simply $\alpha_f \max[\tilde{x} - R_T, 0]$. Note that we treat outside equity merely as a claim on the future cash flows of the project. Thus, we assume that outside equity holders have no control rights in the firm. We, in effect, assume that the firm is controlled by the entrepreneur, who simply controls the board, and thus is able to make decisions that serve his own interests.

As explained above, debt and equity differ in cash flow and liquidation rights. We assume that there is an additional difference between debt and equity: debt is better than equity in protecting financiers from direct expropriation by the entrepreneur. This difference is discussed next.

D. Diversion of funds

The large agency cost literature, initiated by Jensen and Meckling (1976), shows how the separation of ownership and control can induce self-interested managers to waste investors' funds. In our model, the entrepreneur can waste investors' funds in two ways. First, as discussed above, he can invest in the socially inefficient bad project. Second, to be discussed in this subsection, he can simply divert or steal the funds provided by the financier.[4] Of course, in reality the expropriation may take more subtle forms. For example, the entrepreneur can transfer firm resources in the form of salary or invest in the managerial perquisites, as in Jensen and Meckling (1976). For simplicity, however, we follow Boyd et al (1998) by assuming that the entrepreneur can directly divert funds from financiers to himself. In case of diversion, the invested funds yield financiers no profit and no liquidation value (the entrepreneur takes the money and runs).

Following Burkart et al (1998) and La Porta et al (2002), we assume that diversion is costly. The costs of diversion include, among other things, the costs of legal or illegal manoeuvring to divert profits and the costs of taking the risks of legal challenges. Because of the costs of diversion, the entrepreneur's profit from diverting an investment $I_{f,s}$, is only

$$\Pi^{E} = (1 - k_{f,s})I_{f,s} \tag{2.1}$$

In equation (2.1), $k_{f,s}$ denotes the *cost-of-theft parameter* (La Porta et al 2002). The cost-of-theft parameter determines the profits of the entrepreneur, who diverts the investment $I_{f,s}$ made by a type f investor in the form of a type s security (debt or equity). We make the following two key assumptions on the cost-of-theft parameters.

Assumption 1. $k_{i,d} = k_{u,d} = 1$.

Assumption 2. $0 < k_{u,e} \leq k_{i,e} < 1$.

These two assumptions present two important ideas. First, in many countries, it seems to be more difficult for entrepreneurs to expropriate debt holders than equity holders. Debt holders' rights are almost universally more clearly defined than equity holders' rights,

[4] In contrast to Hart (1995, ch. 5) and La Porta et al (2002), for example, we assume that the entrepreneur cannot steal the final cash flows.

which makes it easier for courts to verify a violation of a debt contract (La Porta et al 1998). In particular, debt contracts commonly contain a wide range of covenants requiring the borrower to take or refrain from various actions. If covenants are violated, debtholders receive certain well-defined rights, such as the right to repossess collateral or the right to force the firm into the bankruptcy. As documented by La Porta et al (1998), in most countries the legal rules and enforcement of these rules favour debtholders. Our assumptions 1 and 2 express the idea that debt contracts generally protect financiers against managerial expropriation better than do equity contracts. More specifically, assumption 1 implies that the entrepreneur's profit from diverting funds raised by debt is zero, while the profit from expropriating funds raised by equity is positive by assumption 2.

The second idea, formalised in assumption 2, is that diverting an equity investment made by a bank is at least as costly as diverting an equity investment made by an uninformed investor. This assumption can be defended by several arguments. First, uninformed investors are often too small and too poorly informed to exercise even the control rights they actually have (Shleifer and Vishny 1997). Moreover, the free-rider problem may reduce their incentive to acquire information about the firms. Second, banks may have a large degree of monopoly power (say, because of their informational advantage) over any future credit extended to the firm. This monopoly power may reduce the entrepreneur's incentive to expropriate the bank's equity investment. Third, even in the absence of legal protection against expropriation, banks may be able to impose, using the terminology of Diamond (1984), stricter nonpecuniary penalties (ie loss of reputation) on dishonest firms than can small equity holders.

Although our formulation of the firm's expropriation possibilities is clearly simplistic, we believe that assumptions 1 and 2 capture two important insights. First, legal systems generally protect debtholders better than equityholders and, second, large informed equityholders (such as banks) may be able to reduce the expropriation at least as effectively as small uninformed investors. Moreover, the assumption that the entrepreneur's returns from expropriating debtholders is zero (assumption 1) allows us to create a clear tradeoff between debt and equity. Namely, as will be shown below, equity is superior to debt in alleviating the standard project-choice moral hazard (choice between good and bad project), whereas debt is superior to equity in alleviating the expropriation moral hazard problem (choice between stealing and the good project).

E. Information

Here we collect our assumptions on information. Everyone knows the entrepreneur's initial wealth, w, and the liquidation value, L, at date 0. Informed investors observe the entrepreneur's date 1 choice between good and bad project at a cost c at date 2. However, that choice is unobservable for uninformed investors, and unverifiable for courts. Finally, date 3 returns are observable and verifiable.

2.2 First-best equilibrium and feasible contracts

The first-best equilibrium is particularly easy to define. According to our assumptions, liquidation, diversion of funds and investing in the bad project are all socially inefficient. Thus, in the first-best equilibrium all firms, irrespective of their initial wealth and liquidation value of their projects, should receive finance and invest in the good project. However, as will be shown below, asymmetric information and the imperfect legal protection against the managerial expropriation render the first-best contracts unfeasible for some low-wealth, low-liquidity-value firms.

As the first-best choice of the good project is not contractible, financiers must induce the entrepreneur to choose the good project voluntarily. In other words, the equilibrium capital structure must be incentive compatible. In what follows, we define a *feasible capital structure* as a combination of debt and equity contracts that induces the entrepreneur to choose the good project instead of the bad project or instead of diverting the funds, and that, at the same time, satisfies all parties' participation constraints.

In sections 3–5, we examine the feasibility of uninformed finance, bank finance, and mixed finance, respectively. In section 6, we bring the results together to examine the firm's optimal capital structure.

3 Uninformed finance

Uninformed finance is feasible only if the financial contract between entrepreneur and uninformed investor induces the entrepreneur to choose the good project while satisfying the investor's participation constraint.

Formally, the feasible contract must satisfy three constraints. First, the entrepreneur must prefer the good project to the bad project ('asset substitution incentive compatibility constraint'). Second, the entrepreneur must prefer the good project to diverting the invested funds ('diversion incentive compatibility constraint'). Third, contracts must yield the investor at least zero profits (investor's participation constraint).

We analyse three types of uninformed capital structures. In section 3.1, we examine the case where the firm is financed only with uninformed debt. In section 3.2, we examine the case of pure uninformed equity finance. In section 3.3, we study the case of mixed uninformed finance, where uninformed finance consists of both debt and equity.

3.1 Uninformed debt

By assumption 1, the entrepreneur's profits of diverting funds raised by uninformed debt is zero. Thus, when defining the feasible contract under uninformed debt finance, we can ignore the diversion incentive compatibility constraint.

Given this, uninformed debt is feasible only if the required debt repayment, D_u, is set so as to satisfy the asset substitution constraint and the participation constraint of the uninformed financier

$$S - D_u - w \geq p(G - D_u) - w \tag{3.1}$$

$$D_u - (1 - w) \geq 0 \tag{3.2}$$

The asset substitutution incentive compatibility constraint (3.1) requires that the entrepreneur's profits from investing in the good project be higher than those of investing in the bad project. The uninformed investor's participation constraint (3.2) requires that he must earn non-negative profits.

The assumption of competitive financial markets allows us to set (3.2) as an equality. Solving D_u from the binding participation constraint (3.2) and inserting it into (3.1) yields the following result.

Lemma 1. Any entrepreneur with $w \geq w_{u,d} > 0$, where $w_{u,d} = [p(G-1) - S + 1]/(1-p)$, receives uninformed debt with $I_{u,d} = D_u = 1-w$. For entrepreneurs with $0 \leq w < w_{u,d}$, uninformed debt is not feasible.

We rule out the uninteresting case that all entrepreneurs receive uninformed debt by considering only the non-empty set of parameter values of p, G, and S such that $0 < w_{u,d} < 1$.

Lemma 1 states that only sufficiently wealthy entrepreneurs receive uninformed debt. Uninformed debt is not feasible for some low-wealth entrepreneur, as high leverage would induce them to invest in the bad project. This is the standard asset substitution moral hazard problem of debt financing.

3.2 Uninformed equity

In this section we derive feasible uninformed equity contracts in a situation where all the needed outside finance consists of uninformed equity, ie when $I_{u,e} = 1-w$.

The problem of deriving the feasible uninformed equity contracts is simplified by the following elementary observation. By assumption, $S > pG$. This implies that $(1-\alpha_u)S > (1-\alpha_u)pG$ for all α_u, $0 < \alpha_u \leq 1$. Thus, under equity finance, the entrepreneur's payoff from investing in the good project is always higher than his expected payoff from investing in the bad project. In other words, there is no asset substitution problem when the firm is financed with equity. This observation allows us to ignore the asset substitution incentive compatibility constraint when deriving the feasible equity contract.

However, equity finance gives rise to another moral hazard problem, which was absent under debt finance. Namely, by equation (2.1) and assumption (3.1), some low-wealth firms divert the funds raised by equity rather than invest them in the good project.

Now, uninformed equity is feasible only if

$$(1-\alpha_u)S - w \geq (1-k_{u,e})(1-w) \tag{3.3}$$

$$\alpha_u S - (1-w) \geq 0 \tag{3.4}$$

where (3.3) is the entrepreneur's diversion incentive compatibility constraint and (3.4) the participation constraint of the equity holder. The incentive compatibility constraint is satisfied if the entrepreneur's profits from investing in the good project exceed the profits from diverting the funds. According to the participation constraint, the returns from equity must cover the equity holder's initial equity investment.

We derive the feasible equity contracts similarly as above. In competitive markets, the investor's participation constraint (3.4) binds. Solving α_u from the binding constraint (3.4) and inserting it into (3.3) yields the following result.

Lemma 2. Any entrepreneur with $w \geq w_{u,e} > 0$, where $w_{u,e} = 1 - (S-1)/(1-k_{u,e})$, receives uninformed equity with $I_{u,e} = 1 - w$, $\alpha_u = (1-w)/S$. For entrepreneurs with $0 \leq w < w_{u,e}$, uninformed equity is not feasible.

Again, we consider only the interesting case, where the non-empty set of parameter values of S and $k_{u,e}$ are such that $0 < w_{u,e} < 1$.

Analogously with uninformed debt finance, some low-wealth entrepreneurs are denied funding under uninformed equity finance. However, now the reason is different. Under uninformed debt finance, the asset substitution moral hazard prevents outside financing. Under uninformed equity finance, it is the diversion moral hazard problem that renders uninformed equity infeasible.

The feature of our model that equity finance resolves the asset substitution moral hazard problem whereas debt finance resolves the diversion moral hazard problem provides a prima facie case for mixed uninformed finance. One could expect that some low-wealth entrepreneurs for whom the pure forms of uninformed finance are not feasible could finance their investments with mixed uninformed finance. That possibility is analysed next.

3.3 Mixed uninformed finance

Under mixed uninformed finance, the entrepreneur finances his investment with a combination of uninformed debt and uninformed equity. Thus, the sum of the funds raised by uninformed debt and uninformed equity, $I_{u,d} + I_{u,e}$, equals the total needed outside finance, 1–w.

Denote the required debt repayment under uninformed mixed finance by $D_{u,m}$ and the uninformed investor's share of the profit by $\alpha_{u,m}$. Under uninformed mixed finance, the feasible contract must satisfy the following three constraints

$$(1-\alpha_{u,m})(S-D_{u,m})-w \geq (1-\alpha_{u,m})p(G-D_{u,m})-w \tag{3.5}$$

$$(1-\alpha_{u,m})(S-D_{u,m})-w \geq (1-k_{u,e})I_{u,e} \tag{3.6}$$

$$D_{u,m}+\alpha_{u,m}(S-D_{u,m})-(1-w) \geq 0 \tag{3.7}$$

where (3.5) is the asset substitution incentive compatibility constraint, (3.6) is the diversion incentive compatibility constraint and (3.7) is the uninformed investor's participation constraint.

As shown in Lemmas 1 and 2, any entrepreneur with wealth $w \geq \min[w_{u,d}, w_{u,e}]$ can receive either uninformed debt finance or uninformed equity finance. Therefore, we focus, in particular, on entrepreneurs for whom these pure forms of uninformed finance are not feasible, ie for whom $w < \min[w_{u,d}, w_{u,e}]$.

Proposition 1. The following family of mixed uninformed contracts is feasible for any entrepreneur with wealth $w \geq w_{u,m}$, where $w_{u,m} = w_{u,d} + w_{u,e} - 1 > 0$: $0 < I_{u,d} \leq 1 - w_{u,d}$, $0 < I_{u,e} \leq 1 - w_{u,e}$, such that $I_{u,d} + I_{u,e} = 1 - w$; $D_{u,m} = I_{u,d}$ and $\alpha_{u,m} = (1 - w - D_{u,m})/(S - D_{u,m})$.

Proof: Start by simplifying the incentive compatibility constraints (3.5) and (3.6). First, (3.5) reduces to $S - D_{u,m} \geq p(G - D_{u,m})$. Second, setting (3.7) as an equality, solving for $\alpha_{u,m}$ and inserting $\alpha_{u,m} = (1 - w - D_{u,m})/(S - D_{u,m})$ into (3.6) reduces (3.6) to $S - 1 \geq (1 - k_{u,e})I_{u,e}$. Thus, the feasibility constraints (3.5)–(3.7) reduce to the following two constraints.

$$S - D_{u,m} \geq p(G - D_{u,m}) \tag{3.5'}$$

$$S - 1 \geq (1 - k_{u,e}) I_{u,e} \tag{3.6'}$$

Notice a special feature of the constraints (3.5') and (3.6'). The asset substitution incentive compatibility constraint (3.5') is independent of the amount of equity, and the diversion incentive compatibility constraint (3.6') is independent of the amount of debt. Thus, $D_{u,m}$ can be set to a level at which (3.5') binds without affecting the constraint (3.6'). Similarly, $I_{u,e}$ can be set to a level at which (3.6') binds without affecting the constraint (3.5'). For the least wealthy entrepreneur who receives uninformed mixed finance, both (3.5') and (3.6') must be binding. By Lemma 1, condition (3.6') binds when $w = w_{u,d}$. This implies that for any entrepreneur the maximum size of the debt is $1 - w_{u,d}$. By (3.3) and (3.4), (3.6') binds when $w = w_{u,e}$. Thus, for any entrepreneur the maximum size of the uninformed equity investment is $1 - w_{u,e}$. The least wealthy entrepreneur who receives uninformed finance raises the maximum amounts of both debt and equity. Thus, the critical entrepreneurial wealth required for financing under mixed uninformed finance is determined by $1 - w = (1 - w_{u,d}) + (1 - w_{u,e})$. Solving for w yields $w_{u,m} = w_{u,d} + w_{u,e} - 1$. Thus, an entrepreneur with $w \geq w_{u,m}$ can raise any combination of debt and equity such that $I_{u,d} \leq 1 - w_{u,d}$, $I_{u,e} \leq 1 - w_{u,e}$, and such that the total amount raised, $I_{u,d} + I_{u,e}$, is equal to the needed finance $1 - w$. Finally, because of competition in financial markets, $D_{u,m}$ and $\alpha_{u,m}$ can be set at their competitive levels, $D_{u,m} = I_{u,d} = 1 - w_{u,d}$ and $\alpha_{u,m} = (1 - w - D_{u,m})/(S - D_{u,m})$. QED

We again ruled out the uninteresting case that all entrepreneurs receive mixed finance by considering only the non-empty set of parameter values such that $0 < w_{u,m} < 1$.

The following corollary follows directly from the definition of $w_{u,m}$ and from the assumption that $0 < w_{u,d}, w_{u,e} < 1$.

Corollary 1. The minimum entrepreneurial wealth required for financing under mixed uninformed finance, $w_{u,m}$, is lower than that under uninformed debt finance, $w_{u,d}$, or under uninformed equity finance, $w_{u,e}$.

This result is a simple consequence of the 'dichotomised' nature of our model, conveyed in conditions (3.5') and (3.6'). The maximum amount of debt that any entrepreneur can raise is determined solely by (3.5'). Similarly, the maximum amount of equity is determined solely by (3.6') whereas (3.5') is independent of equity. Because of this dichotomisation, allowing for mixed uninformed finance enables the entrepreneur to supplement his initial financing (debt or equity) from a new source of finance while not affecting his ability to raise finance from the initial source.

4 Bank finance

In this section we introduce an alternative source of finance, bank finance. Bank finance differs from uninformed finance in two ways. First, banks learn, at a cost of c, the entrepreneur's choice between the good and the bad project. Second, by assumption 2, it may be more difficult for entrepreneurs to divert the equity investment made by a bank than that made by uninformed equity holders. In this section we examine how these two differences affect the terms and feasibility of bank finance compared with those of uninformed finance.

We assume that the monitoring technology is similar to that in Repullo and Suarez (1998). By paying a monitoring cost c, the bank learns the entrepreneur's project choice. The information acquired through monitoring, however, is unverifiable to the court. Therefore, the contract between bank and entrepreneur cannot be contingent on monitoring. However, we assume that the bank can use the information acquired by monitoring when deciding between liquidation and continuation of the project at date 2. Namely, we assume that the bank has a right to 'call' the debt, that is, a right to demand that entrepreneur repay the loan before the final maturity date. Furthermore, to avoid the difficulties involved in endogenising the monitoring decision, we assume that the bank can contractually commit to monitor. In addition, we rule out stochastic monitoring.

In our model, liquidation has a disciplinary role. We show that under certain circumstances the bank can impose a credible threat of liquidation. The credible threat of liquidation induces an entrepreneur who would otherwise choose the bad project to choose the good project instead. Importantly, we show (in section 6) that some low-wealth entrepreneurs who are denied uninformed finance receive bank finance because of the inherent discipline.

We examine two types of bank finance. In section 4.1, we examine a situation where the firm is financed only by a bank loan, and in section 4.2 the situation where the bank finances the firm with a combination of debt and equity.

4.1 Bank loans

In this section we assume that all the borrowed funds are in the form a bank loan: $I_{i,d} = 1 - w$. When deriving the feasible bank loan contracts, we can, by assumption 1, ignore the diversion moral hazard constraint. Let us start solving the feasible bank loan contracts by dividing entrepreneurs into two categories: (i) those who would invest in the good project even in the absence of a liquidation threat, and (ii) those who would invest in the good project only in the presence of a (credible) liquidation threat.

For the first group of entrepreneurs, the feasibility conditions are similar to those under uninformed debt finance (conditions 2 and 3) except that the bank's participation constraint (4.2) includes the monitoring cost, c.

$$S - D_i - w \geq p(G - D_i) - w \tag{4.1}$$

$$D_i - (1 - w + c) \geq 0 \tag{4.2}$$

where D_i denotes the required debt repayment of the bank loan. Setting (4.2) as an equality, and inserting D_i into (4.1) yields the following result.

Lemma 3. Under bank lending, the minimum entrepreneurial wealth for inducing the entrepreneur to invest in the good project regardless of the liquidation value of the firm's assets is $\overline{w}_{i,d} = w_{u,d} + c$.

Thus, the entrepreneurs characterised in Lemma 3, if financed by bank loans, would invest in the good project even in the absence of a liquidation threat tied to bank finance.

Now, consider the other group of entrepreneurs, ie those with $w < \overline{w}_{i,d}$. These entrepreneurs invest in the good project at date 1 only if the bank can credibly threaten to liquidate the bad project at date 2.

We show that the bank can impose a credible threat of liquidation for some of these low-wealth entrepreneurs, if the liquidation value of the entrepreneur's project is high enough relative to the entrepreneur's wealth.

The bank loan is feasible for any firm with $w < \overline{w}_{i,d}$ if and only if the liquidation of the bad project is a *subgame perfect* decision for the bank at date 2. The subgame perfectness requires that the bank's return from the liquidation be at least as high as the expected return from letting the bad project continue. Thus, the liquidation threat is credible if and only if $L \geq pD_i$. Insert $D_i = 1 - w + c$ from the bank's binding participation constraint (4.2) of the bank into this inequality and solve for L. It follows that the liquidation threat is credible, if

$$L \geq p(1 - w + c) \tag{4.3}$$

Setting this as equality and solving for w yields the following lemma.

Lemma 4. Under bank lending, the minimum entrepreneurial wealth required for the bank's liquidation threat to be credible is the following function of the liquidation value of the firm's assets: $w_{i,d}(L) = 1 + c - (L/p)$.

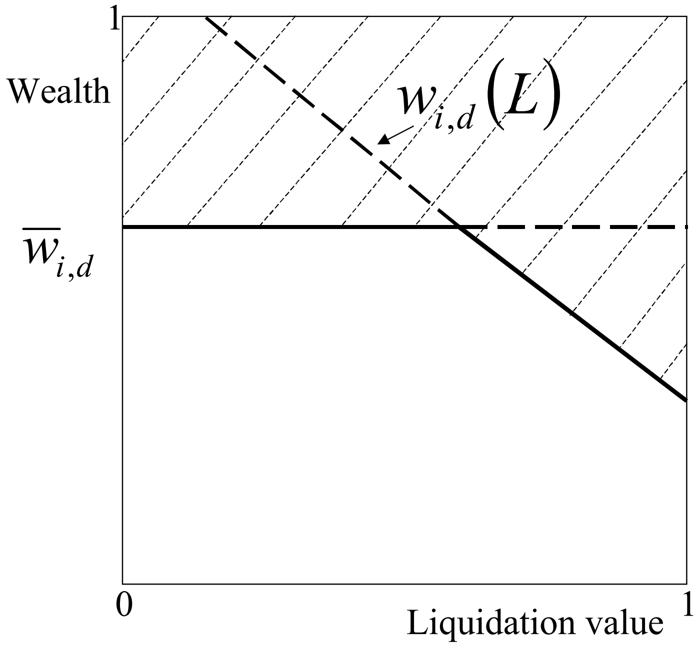
Thus, the bank can impose a credible threat of liquidation for entrepreneurs with $w \geq w_{i,d}(L)$. On the other hand, the bank's threat to liquidate the assets of entrepreneurs with $w < w_{i,d}(L)$ is not credible *ex-post*. Thus, these entrepreneurs, if financed by the bank, would invest in the bad project. Anticipating this, the bank refuses to lend to them.

The next proposition combines the results of lemmas 3 and 4.

Proposition 2. Bank loans are feasible for any entrepreneur with $w \geq \min[\overline{w}_{i,d}, w_{i,d}(L)]$ with terms $I_{i,d} = 1 - w$ and $D_i = 1 - w + c$. Bank loans are not feasible for entrepreneurs with $w < \min[\overline{w}_{i,d}, w_{i,d}(L)]$.

Figure 1 shows how the curves $\overline{w}_{i,d}$ and $w_{i,d}(L)$ divide the (w, L) space into two non-overlapping regions. Bank loans are feasible for all entrepreneurs in the upper region, $w \geq \min[\overline{w}_{i,d}, w_{i,d}(L)]$, and infeasible for all entrepreneurs in the lower region, $w < \min[\overline{w}_{i,d}, w_{i,d}(L)]$.

Figure 1. **Feasibility of bank loans**
This figure shows the region in the (liquidation value, wealth) space, where bank loans are feasible



4.2 Bank's equity stake in the borrowing firm

In this section we begin addressing the principal problem of our paper: What are banks' incentives to hold equity stakes in their borrowing firms?

Suppose that the firm is financed with a mix of bank loan and equity investment by the bank such that $I_{i,d} + I_{i,e} = 1 - w$. For shorthand, we denote this type of finance by mixed bank finance. Denote the required debt repayment and the required share of the final profits under mixed bank finance by $D_{i,m}$ and $\alpha_{i,m}$, respectively. Since, by proposition 2, entrepreneurs with $w \geq \min[\overline{w}_{i,d}, w_{i,d}(L)]$ receive bank loans, we focus in this section on entrepreneurs with $w < \min[\overline{w}_{i,d}, w_{i,d}(L)]$.

Mixed bank finance is feasible for a firm characterised by a pair (w, L) if the debt and equity contracts $(I_{i,d}, D_{i,m})$ and $(I_{i,e}, \alpha_{i,m})$ satisfy the following conditions.

$$\begin{aligned}&(1-\alpha_{i,m})(S-D_{i,m})-w \geq (1-\alpha_{i,m})p(G-D_{i,m})-w \quad \text{or} \\ &L \geq p[D_{i,m}+\alpha_{i,m}(G-D_{i,m})]\end{aligned} \tag{4.4}$$

$$(1-\alpha_{i,m})(S-D_{i,m})-w \geq (1-k_{i,e})I_{i,e} \tag{4.5}$$

$$D_{i,m}+\alpha_{i,m}(S-D_{i,m}) \geq 1-w+c \tag{4.6}$$

Condition (4.4) is the asset substitution incentive compatibility constraint. As discussed in the previous section, this constraint is satisfied if at least one of the following two conditions is satisfied: (i) the entrepreneur invests in the good project even in the absence of a liquidation threat, (ii) the entrepreneur invests in the good project only if the liquidation threat is credible. The presence of equity in the firm's capital structure implies that we must also take the diversion incentive compatibility constraint (4.5) into account. Inequality (4.6) is the informed investor's participation constraint.

The next proposition shows that mixed bank finance is feasible for some entrepreneurs for whom bank loans are not feasible.

Proposition 3. For any entrepreneur with $\overline{w}_{i,m} \leq w < \min[\overline{w}_{i,d}, w_{i,d}(L)]$, where $\overline{w}_{i,m} = \overline{w}_{i,d} + w_{i,e} - 1$ and $w_{i,e} = (S-1-c)/(1-k_{i,e}) > 0$, bank loans are not feasible but the following family of mixed bank finance contracts is feasible: $0 < I_{i,d} \leq 1-\overline{w}_{i,d}$ and $0 < I_{i,e} \leq 1-w_{i,e}$, such that $I_{i,d} + I_{i,e} = 1-w$; $D_{i,m} = I_{i,d} + c$, $\alpha_{i,m} = (1-w+c-D_{i,m})/(S-D_{i,m})$.

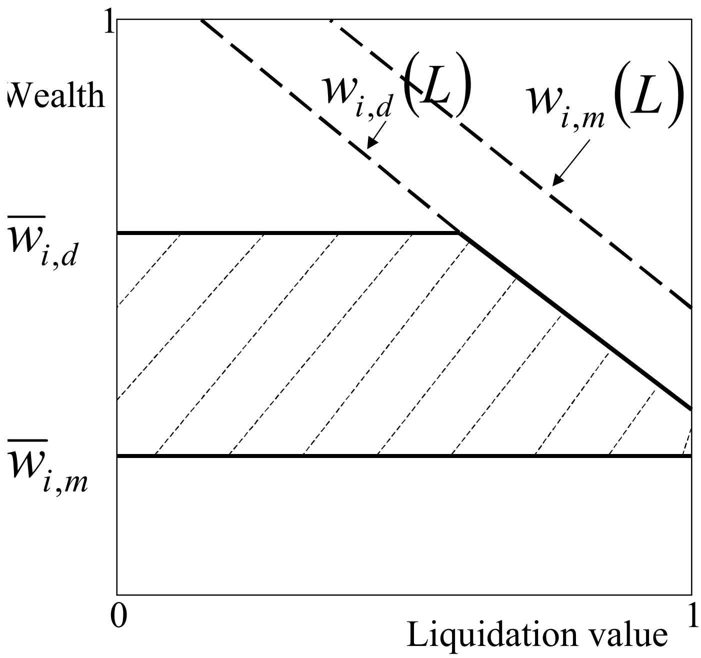
Proof: See appendix.

We ignore the uninteresting case where all entrepreneurs would receive mixed bank finance by considering only the non-empty set of parameter values of the model for which $0 < \overline{w}_{i,m} < 1$.

Figure 2 depicts the shaded region in the (w, L) space, where mixed bank finance is feasible and bank loans are iinfeasible. Mixed bank finance enables entrepreneurs to supplement bank loans with an equity investment from the bank. The maximum size of bank loan that an entrepreneur can raise is determined solely by the project choice incentive compatibility constraint (4.1), which is independent of the amount of outside equity. Thus, the low-wealth entrepreneurs in the shaded region, who cannot raise enough outside funds by bank loans only, are able to finance their investments with a mixture of bank loan and equity investment by the bank.

Note, however, that a disadvantage of the bank's equity stake is that it weakens the credibility of the liquidation threat, as the bank's equity stake in its borrowing firm increases the bank's expected continuation return from letting a bad project continue (see the proof of proposition 3 for details). This result can also be seen from figure 2. In figure 2, the line $w_{i,m}(L)$, which depicts the minimum required wealth level required for the bank's liquidation threat to be credible under mixed bank finance, is situated to the right of $w_{i,d}(L)$, which is the corresponding line under bank lending.

Figure 2. **Region where mixed bank finance is feasible but bank loans are not**
By proposition 3, mixed bank finance is feasible in the shaded region whereas bank loans are not.



5 Mixed finance

In previous sections we examined the feasibility of different capital structures under the assumptions, that entrepreneurs are funded exclusively by the bank or by uninformed investors. In this section we examine the possibility that entrepreneurs may in some circumstances prefer a combination of bank finance and uninformed finance to other forms of finance. We derive the feasible three-party contracts between entrepreneur, bank and uninformed investor, and show that such three-party contracts can indeed improve the feasibility of two-party contracts for some entrepreneurs.

Without loss of generality, in this section we concentrate on the case where the entrepreneur is financed by a combination of bank loan and uninformed debt (such as bonds)[5]. In what follows, we denote the combination of bank loan and uninformed debt simply as *mixed finance*, to differentiate it from mixed bank finance and mixed uninformed finance.

As will be shown below, the benefit of mixed finance is that it improves the credibility of the liquidation threat by reducing the bank's share of the provided funds. As we showed in section 4.1, the bank's liquidation threat is not credible for some entrepreneurs since the liquidation value L of the investment project is low compared to the funds $1-w+c$ contributed by the bank. In this section we show that the introduction of a passive uninformed lender allows some entrepreneurs with low liquidity values to receive mixed finance by enabling the reduction of funds contributed by the bank.

The presence of an uninformed third party complicates the derivation of feasible contracts by introducing the possibility of renegotiation between entrepreneur and bank at the expense of the uninformed lender. By renegotiation, we refer to the possibility that the entrepreneur, after investing in the bad project at date 1, attempts to bribe the bank not to liquidate the project by offering it a new contract that changes the promised debt repayment from $D_{i,M}$ to $D'_{i,M}$ (In what follows, the capital letter M refers to mixed finance). The uninformed lender does not take part in the renegotiation because of his inability to observe the project choice. Moreover, as discussed by Repullo and Suarez (1998), the non-contractibility of the project choice precludes the use of any mechanism that would truthfully reveal this information to the uninformed lender.

[5] We can show that no entrepreneur strictly prefers any other mode of mixed finance.

As investing in the bad project is always inefficient, the uninformed lender accepts the three-party contract only if it is *renegotiation-proof*. Mixed finance contracts are renegotiation-proof if the renegotiated contract is so expensive for the entrepreneur that he invests instead in the good project. Let us consider this possibility. In the renegotiation game, the status quo payoffs of the entrepreneur and the bank are $p(G - D_{i,M} - D_{u,M})$ and $pD_{i,M}$, respectively. In addition, the value of the bank's outside option is the project's liquidation value, $\min[L, D_{i,M}]$. Now, assume that the entrepreneur has chosen the bad project at date 1 and proposes to the bank a new contract at date 2. By the outside option principle[6], the new contract is given by

$$\begin{aligned} D'_{i,M} = D_{i,M}, &\text{ if } pD_{i,M} \geq L \\ &\min[L, D_{i,M}]/p, \text{ otherwise} \end{aligned} \tag{5.1}$$

Thus, the entrepreneur's expected payoff from investing in the bad project is $p(G - D_{u,M} - D'_{i,M})$, where $D'_{i,M}$ is defined in (5.1).

Now, the feasibility conditions of mixed finance are the following. Mixed finance, characterised by contracts $(I_{i,d}, D_{i,M})$ and $(I_{u,d}, D_{u,M})$, is feasible if the following conditions hold.

$$S - D_{u,M} - D_{i,M} \geq p(G - D_{u,M} - D'_{i,M}) \tag{5.2}$$

$$I_{i,d} + I_{u,d} = 1 - w + c, \quad D_{i,M} \geq I_{i,d} + c, \quad D_{u,M} \geq I_{u,d} \tag{5.3}$$

where $D'_{i,M}$ is given by (5.1).

The next proposition characterises the feasible contracts under mixed finance.

Proposition 4. Any entrepreneur with $w \geq w_M(L)$, where $w_M(L) = \overline{w}_{i,d} - L$, receives mixed finance with terms

[6] Roughly speaking, the outside option principle states that the outside option (the option to quit the negotiations and liquidate the project) affects the bank's equilibrium payoff only if the value of the outside option is higher than his equilibrium payoff in a game with no outside option (the status quo payoff). In that case his equilibrium payoff in the renegotiation game must be equal to the value of the outside option. For a more detailed exposition of the outside option principle, see Repullo and Suarez (1998), Sutton (1986) or Osborne and Rubinstein (1990).

$I_{i,d} = L - c$, $D_{i,M} = L$, $I_{u,d} = D_{u,M} = 1 - w - L + c$. Mixed finance is not feasible for entrepreneurs with $w < w_M(L)$.

Proof: See appendix.

We explain proposition 4 as follows. To receive mixed finance, the entrepreneur designs the mixed finance contract so that (i) the bank has the right incentives to liquidate, and, related to the first objective, so that (ii) the bank and the entrepreneur have no incentive to collude. The bank has the right incentive to liquidate when the size of the bank loan is sufficiently low to make the liquidation threat credible. On the other hand, the bank loan should be sufficiently large to reduce the incentives of bank and entrepreneur to collude and renegotiate the initial contract. The conflict between these two objectives is lowest when the terms of the mixed finance contract are those are those in proposition 4.

According to proposition 4, the higher the liquidation value of the firm, the lower the minimum entrepreneurial wealth required for financing under mixed finance. The reason is the following. The maximum size of a bank loan under mixed finance is determined by the liquidation value of the firm's assets. The higher the liquidation value of the firm the larger the share of needed outside finance $(1 - w)$ that can be in the form of a bank loan $(L - c)$ and the lower share need to raised in the form of uninformed debt $(1 - w - L + c)$. The larger the bank loan, the more costly it is for the entrepreneur to collude with the bank and renegotiate terms of the initial contract. If the liquidation value is sufficiently high with respect to needed outside finance, the entrepreneur never chooses the bad project, as he anticipates that renegotiation with the bank is too costly. Conversely, suppose that the liquidation value of the assets is low relative to the needed outside finance. Then, only a small share of needed funds can be raised from the bank and the rest must be raised from the uninformed financier. In that case, it is impossible for the entrepreneur to set the terms of the initial contract in such a way that the bank loan is sufficiently small to preserve the bank's ex post incentive to liquidate the bad project and, at the same time, sufficiently large to eliminate the entrepreneur's and bank's ex post incentive to collude and renegotiate the initial contract. Anticipating that the initial contract is not renegotiation-proof, the uninformed investor is not willing to participate in the funding.

6 The choice between uninformed finance, bank finance and mixed finance

In this section we collect our results. By proposition 1, uninformed finance is feasible for entrepreneurs with $w \geq w_{u,m}$. By proposition 2, bank loans are feasible for entrepreneurs with $w \geq \min[\overline{w}_{i,d}, w_{i,d}(L)]$. By proposition 3, the mixture of a bank loan and an equity investment by the bank is feasible while informed debt is infeasible for entrepreneurs with $\overline{w}_{i,m} \leq w \leq \min[\overline{w}_{i,d}, w_{i,d}(L)]$. By proposition 4, mixed finance is feasible for entrepreneurs with $w \geq w_M(L)$.

These results and the following auxiliary result are utilised in our principal propositions below.

Lemma 5. $\overline{w}_{i,m} < w_{u,m}$ if and only if

$$\Phi(k_{i,e}, k_{u,e}) \equiv \frac{S-1}{1-k_{i,e}} - \frac{S-1}{1-k_{u,e}} > c \tag{6.1}$$

Now, we are ready to present our two principal results.

Proposition 5. Provided that $\Phi(k_{i,e}, k_{u,e}) > c$, for any entrepreneur with $\overline{w}_{i,m} \leq w < \min[w_{u,m}, w_M(L)]$, the only feasible mode of finance is a mixture of bank loan and equity investment by the bank.

Proposition 6. For any entrepreneur with $w_M(L) \leq w < w_{i,m}$, the only feasible mode of finance is mixed finance.

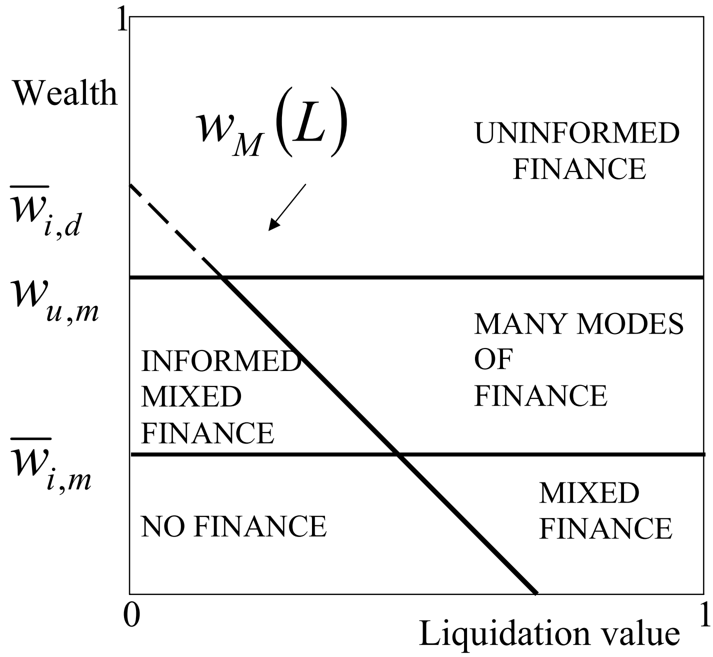
Proposition 5 characterises the conditions under which the only way for some firms to receive finance is to let an informed financier (such as a bank) hold equity in its borrowing firm. For these firms, other modes of finance are not feasible. Bank loans are not feasible because the bank cannot impose a credible threat of liquidation, and mixed finance is not feasible because debt contracts with multiple financiers are not renegotiation-proof. Uninformed finance, in turn, is not feasible since the entrepreneur cannot raise enough uninformed equity (to supplement uninformed debt), as uninformed equity holders are poorly protected against managerial expropriation.

According to condition (6.1), informed bank finance dominates uninformed finance for any entrepreneur only if the entrepreneur's cost of diverting the bank's equity investment is sufficiently low compared to the cost of diverting uninformed investors' equity investment. One interpretation of this result is that, according to our model, banks' equityholding in their borrowing firms should be more common in those countries where uninformed minority equityholders rights are poorly protected against managerial expropriation. In countries where uninformed minority shareholders are well protected, banks' right to hold equity in their borrowing firms provide little if any social benefits.

According to proposition 6, for some entrepreneurs with very low wealth but with sufficiently high liquidation values, the only feasible mode of finance is mixed finance. The benefit of mixed finance compared to other modes of finance is that that the liquidation threat is as effective as possible under mixed finance. As a consequence, high liquidation values allow some very low wealth entrepreneurs to raise mixed finance, since the credible liquidation threat induces them to invest in the good project. Thus, our model yields a testable prediction that investments involving nonspecific, highly liquid and tangible assets are most likely to be financed with mixed finance. This result is close to that in Repullo and Suarez (1998). In Repullo and Suarez (1998), however, firms with low wealth but high liquidation values always prefer informed finance to mixed finance. For those firms in our model, mixed finance is the only feasible mode of finance.

Figure 3 summarises our results. For any wealthy firm with $w \geq w_{u,m}$, the optimal mode of finance is uninformed finance, as it is the cheapest alternative. Mixed finance is the only feasible (and thus optimal) mode of finance for firms in the lower right corner with low wealth but high liquidation values. Provided that lemma 5 is satisfied, the only feasible mode of finance for firms with intermediate wealth but low liquidation values is informed mixed finance. Both mixed finance and informed mixed finance are feasible for firms with intermediate wealth and intermediate liquidation values. For firms with intermediate level of wealth and high liquidation values, all three – mixed finance, informed mixed finance, and bank loans – are feasible.

Figure 3. **Optimal modes of finance**



7 Conclusions

In this paper we examine, in a double moral hazard model, the feasible capital structures for firms characterised by their wealth and their liquidation value. Firms can raise funds to finance their investment projects from three different sources – from the bank, from uninformed investors, or both – by issuing two types of securities, debt or equity. Uninformed (market) finance is cheaper than bank finance, but banks are superior to uninformed investors in reducing entrepreneurial moral hazard because of their ability to monitor the entrepreneur's project choice, and because banks may be better protected against managerial expropriation. Debt and equity are, following the tradition of Jensen and Meckling (1976), characterised by their cash flow rights. The only exception is that debtholders have, in addition to their cash flow rights, the right to liquidate the investment project.

We characterise the conditions under which the only feasible mode of finance for some firms consists of a mixture of bank loan and equity investment by the same bank. In our model, the bank's equity stake in its borrowing firm aligns the bank's and entrepreneur's conflicting interests, allowing some firms who otherwise would not receive finance to invest in (efficient) projects. The role of a bank's equity stake is similar to that in John et al (1994). However, in their model, the bank is a passive substitute for the firm's capital structure. We show that banks may have incentives to hold equity also in our model, where the differences between banks and uninformed investors are clearly specified, and where bank finance and uninformed (market) finance coexist. In addition, in contrast to most other models of universal banking, our explanation of the benefits of bank's equity stakes is not control-related. In our model, the bank may have incentives to hold equity in its borrowing firm even when outside equity is characterised only by its cash flow rights. However, if the rights of small, uninformed equityholders are well-defined and well-protected, the social benefits of banks' equityholding are likely to be small or non-existent.

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Appendix 1

Proof of Proposition 3. The idea of the proof can be seen from figure 2. In terms of figure 2, mixed bank finance can potentially improve the feasibility of bank loans in two ways: 1) If the curve $\overline{w}_{i,m}$, corresponding to the curve $\overline{w}_{i,d}$ in the case of bank loans, is located underneath $\overline{w}_{i,d}$, or 2) if the curve $w_{i,m}(L)$ corresponding to the curve $w_{i,d}(L)$ in the case of bank loans, is located to the left of the $w_{i,d}(L)$ curve. In this proof we show that mixed bank finance improves the feasibility of bank loans because $\overline{w}_{i,m}$ is indeed located underneath $\overline{w}_{i,d}$. We also show that the $w_{i,m}(L)$ curve is *not* located to the left of $w_{i,d}(L)$ curve but rather to the right.

Let us start by showing that the curve $w_{i,m}(L)$ is located to the right of $w_{i,d}(L)$ curve, defined in lemma 4. By rewriting $\alpha_{i,m}(G-D_{i,m})$ as $\alpha_{i,m}(S-D_{i,m})+\alpha_{i,m}(G-S)$ and solving $\alpha_{i,m}(S-D_{i,m})$ from the binding participation constraint (4.6), we can reduce $L \geq p[D_{i,m}+\alpha_{i,m}(G-D_{i,m})]$ to $L \geq p(1-w+c+\alpha_{i,m}(G-S))$. Setting this as an equality and solving for w yields the critical wealth level for the liquidation threat to be credible under mixed bank finance: $w_{i,m}(L)=1+c-(L/p)+\alpha_{i,m}(G-S)$. Since the last term, $\alpha_{i,m}(G-S)$ is positive, it follows that $w_{i,m}(L)>w_{i,d}(L)$. This implies that the $w_{i,m}(L)$ curve is located to the right of the $w_{i,d}(L)$ curve.

Now consider the inequality $(1-\alpha_{i,m})(S-D_{i,m})-w \geq (1-\alpha_{i,m})p(G-D_{i,m})-w$. The derivation of the minimum entrepreneurial wealth, $\overline{w}_{i,m}$, that satisfies this inequality and the derivations of the contract terms $I_{i,d}, I_{i,e}, D_{i,m}$ and $\alpha_{i,m}$ follow the steps of the proof of proposition 1. By following those steps, we get $\overline{w}_{i,m}=\overline{w}_{i,d}+w_{i,e}-1$. Since $0<w_{i,e}<1$, it follows that $\overline{w}_{i,m}<\overline{w}_{i,d}$. Thus, in figure 2, $\overline{w}_{i,m}$ is located below $\overline{w}_{i,d}$.

The findings $\overline{w}_{i,m}<\overline{w}_{i,d}$ and $w_{i,m}(L)>w_{i,d}(L)$ reveal that, for entrepreneurs with $\overline{w}_{i,m} \leq w < \min[\overline{w}_{i,d}, w_{i,d}(L)]$, mixed bank finance is feasible whereas bank debt is not. QED

Proof of Proposition 4. Consider the constraint $S-D_{u,M}-D_{i,M} \geq p(G-D_{u,M}-D'_{i,M})$. Since the participation constraints in (5.3) bind, this reduces to

$S-(1-w+c) \geq p(G-I_{u,d}-D'_{i,M})$, where, by (5.1), $D'_{i,M}=D_{i,M}$, if $pD_{i,M} \geq L$ and $D'_{i,M}=\min[L,D_{i,M}]/p$ otherwise. Suppose first that $pD_{i,M} \geq L$, which implies that $D'_{i,M}=D_{i,M}$. In that case, (5.2) reduces to $S-(1-w+c) \geq p(G-(1-w+c))$. By lemma 3, this holds for all entrepreneurs with $w \geq \overline{w}_{i,d}$.

Suppose next that $pD_{i,M} < L$. In that case, by (5.1), $D'_{i,M}=\min[L,D_{i,M}]/p$. By inserting this into (5.2) and using the fact that the participation constraints in (5.3) bind, we obtain

$$S-(1-w+c) \geq p(G-I_{u,d}-\min[L,I_{i,d}+c]/p) \qquad (5.2')$$

Let us now derive the lowest value of w such that (5.2') is satisfied. For that lowest feasible value of w, the right-hand-side of (5.2') must be as low as possible. It is clear that, for any given L, and given that $I_{u,d}+I_{i,d}=1-w$, the right-hand-side of (5.2') reaches its lowest possible value when $I_{i,d}=L-c$ and $I_{u,d}=1-w-L+c$. Inserting these into (5.2') and solving for w yields the result that (5.2') is satisfied for all entrepreneurs with $w \geq \overline{w}_{i,d}-L$. Finally, by inserting $I_{i,d}=L-c$ and $I_{u,d}=1-w-L+c$ into the binding participation constraints (5.3), we obtain the rest of the terms in the mixed finance contract in proposition 4, $D_{i,M}=L$ and $D_{u,M}=1-w-L+c$. QED

Essay 3

Financial contracts and contingent control rights

Jukka Vauhkonen

Abstract

According to empirical studies of venture capital finance, the division of control rights between entrepreneur and venture capitalist is often contingent on certain indicators of firm's performance. If the signal of the firm performance (eg the firm's earnings before taxes and interest, for example) is bad, the venture capital firm obtains full control of the firm. If the firm's performance improves, the entrepreneur retains or obtains more control rights. If the firm's performance is very good, the venture capitalist relinquishes most of his control rights. In this article, we extend the incomplete contracting model of Aghion and Bolton to construct a theoretical mode, which is in line with these empirical findings.

1 Introduction

In a stimulating paper, Kaplan and Strömberg (2000) examine in detail the characteristics of financial contracts between firms and venture capitalists. In this article, we present a model of the entrepreneur-investor relationship which is consistent with two of their following key findings about the allocation of control rights.

First, contrary to the way control is typically specified in the theoretical literature, it is usually not an indivisible right that can be held at any given time by only one party. Rather, contracting parties typically agree on the division of many different control rights, such as voting rights, board rights and liquidation rights, which can be adjusted through contingent provisions. Thus, in the real world, control is often more like a set of *divisible* variables than a single binary variable.

Second, different control rights are frequently *contingent* on observable indicators of the firm's financial and non-financial performance. In particular, control rights are often allocated in the following way. If the signal of the firm's performance (eg earnings before taxes and interest, for example) is bad, the venture capital firm obtains full control of the firm. If the firm's performance improves, the entrepreneur retains or obtains more control rights. If the firm's performance is good, the venture capitalist relinquishes most of his control rights.

In this paper, we extend the incomplete contracting model of Aghion and Bolton (1992) to build a model that explains why control rights are often contingent and in which control rights are not completely indivisible. There are some papers in which control rights are divisible and some in which they are contingent. Aghion and Bolton (1992) is the best-known example of a model of contingent but indivisible control rights. Kirilenko (2001) and Dessein (2002) develop models of continuous but not contingent control rights. However none of these other papers explains both of these observations.

Obviously, attempting to develop a model of divisible and contingent control rights is a demanding task. To simplify the problem, we approximate divisible and contingent control rights by the following *three-layered signal-contingent control allocation*, where control refers to the right to choose some interim action affecting the profitability of an investment project. If the signal of firm's performance is bad, the investor obtains full control of the firm. If the signal is medium, the parties share control (joint control) and, if the signal is good, the entrepreneur retains/obtains full control. In this essay, we show that this three-layered signal-contingent control allocation may dominate other control allocations.

As our model is a fairly straightforward modification of Aghion and Bolton (1992), we first briefly summarise their model. In their model, the entrepreneur with no initial wealth and a wealthy investor contract on the financing of an investment project, which yields two kinds of returns: monetary returns and non-monetary, non-verifiable and non-transferable private returns for the entrepreneur. The amounts of these returns depend on the realisation of the state of the world and the interim action, which is taken after the state of the world has been realised.[1] Because of private benefits, the parties may have conflicting interests over which action to take. This potential conflict cannot always be solved by ex ante contracts since, by assumption, contracts cannot be contingent on the action or state of the world. Then, it is critical which of the parties has the right to choose the action. By assumption, contracts can be contingent on a publicly verifiable signal of the firm's performance. The central result of Aghion and Bolton (1992) is that it may be optimal to make the control allocation dependent on the signal in the following way. If the signal is bad, the investor obtains control and, if the signal is good, the entrepreneur retains control. In what follows, we refer to this allocation as a *two-layered signal-contingent control allocation*.

As summarised above, Aghion and Bolton (1992) is a model of all-or-nothing shifts of control. In their model, either the entrepreneur or the investor holds all control rights, and the party in control is changed if the signal is higher than some threshold level. However, as Kaplan and Strömberg (2000) emphasize, changes in allocations of control rights are seldom so abrupt in reality. Rather, the entrepreneur's (investor's) share of various control rights is often continuously increasing (decreasing) in the performance of the firm. In this article, we take a step towards explaining continuous and contingent control rights by extending the two-layered signal-contingent control allocation model of Aghion and Bolton into a model of three-layered signal-contingent control right allocation and showing that this three-layered signal-contingent control allocation can dominate other control allocations.

[1] The state of the world can be interpreted, for example, as the original quality of the project or the ability of the entrepreneur. The action can be interpreted, for example, as a choice between defaulting or continuing, the choice of a new employee or the choice of how much to invest in perks.

The other main contribution of this paper is to show that a 50–50 sharing of control rights can be a part of this optimal, three-layered signal-contingent control allocation. This result contrasts with most of the literature, where joint control is typically never optimal[2] (see eg Hart 1995). The principal reason for the nonoptimality is that under the standard definition of joint control, each party has a right to veto the relationship to a standstill. In eg Aghion and Bolton (1992) the entrepreneur can always force the firm to a standstill and extract the surplus in the contract renegotiation. Thus the respective positions of entrepreneur and investor are extremely asymmetric in their model. Joint control, in effect, collapses to entrepreneur control with the entrepreneur holding all control and cash flow rights.

In this article, we define joint control, not as a right to force the firm into a standstill, but as a right to force the firm into *stochastic control*. Under stochastic control, the party in control is determined stochastically and the assets are always in use. For simplicity, we assume that in case of disagreement each party obtains control with a probability of 1/2. A consequence of this assumption is that the investor's disagreement payoff in renegotiations is always positive. A straightforward interpretation of the right to veto the firm into stochastic control is that in case of disagreement the party in control is chosen by tossing a coin. However, there are other arrangements that can implement the same outcome. Consider, for example, a board of directors where the decision is made by majority rule, where entrepreneur and investor have an equal number of votes (but somewhat less than 50%) and where the rest of the votes are held by a 'non-partisan' third party[3]. If entrepreneur and investor disagree on the decision, then the vote of the third party is decisive. Ex ante, the votes of the third party may be regarded as stochastic.

One may wonder why the entrepreneur, who has all the bargaining power ex ante and ex post in our model, would ever relinquish any

[2] Joint control, though, is quite usual in practice. Among the best-known examples of joint control are joint ventures, where parties typically share control rights 50:50. Other control structures which resemble joint control are partnerships and some venture capital financings. Partnerships differ from joint ventures in that decisions are typically made by majority rule, which means that no fixed subset of parties has a veto. Also some venture capital financings resemble joint control, in that neither the founders of the firm nor the venture capitalists have full voting control. In Kaplan's and Strrömberg's (2000) data, the share of such financings was over 20%.

[3] In venture capital financings, for example, there are typically various types of board members that are neither venture capitalists nor the insiders of the firm. The boards typically include, for instance, academics, executives from other firms, retired executives, lawyers, consultants, investment bankers, former managers of the firm, relatives etc (Gompers and Lerner 1999, ch. 8).

control rights to the investor. As in Aghion and Bolton (1992), our explanation is the *financing constraint*. *Entrepreneur control* is not always feasible, as the entrepreneur's choice of action may not generate sufficient monetary returns (in expected value) to satisfy the investor's ex ante participation constraint. In that case, the entrepreneur must relinquish some or all of his control rights to the investor to induce him to provide finance in the first place. Under *investor control*, the entrepreneur relinquishes all control rights to the investor. Joint control and signal-contingent control are more intermediate forms of control. In what follows we study the feasibility and optimality properties of all of these alternatives, and show that the optimal form of control crucially depends on the amount of needed finance (or, equivalently, on the degree of conflict of interest between the parties).

Our main result is the following. If the cost of the project, K, is at an 'intermediate' level, entrepreneur control contracts are not feasible, while under mild conditions the three-layered signal-contingent control dominates other forms of control. This result is consistent with the empirical findings of Kaplan and Strömberg (2000). In addition, we show that investor control is optimal for a wider range of parameter values than argued by Aghion and Bolton (1992) (see also essay 4 of this thesis).

The intuition of the optimality of the three-layered signal-contingent control allocation is the following. When the amount of needed finance is sufficiently large, entrepreneur control is not feasible. Full investor control, in turn, is unattractive for the entrepreneur, as the investor ignores the entrepreneur's private benefits when choosing the interim action. Under signal-contingent control allocation, the expected[4] share of control rights allocated to each party lies between these two extremes. This division of control rights provides both parties with some protection from expropriation by the other party. It protects the investor, as the entrepreneur cannot always choose his preferred action, which would yield high private benefits but low monetary returns. Simultaneously, it protects the entrepreneur from the investor, who would always choose an action that yields high monetary returns but low private benefits.

Besides being consistent with contingent and divisible control rights, our model is consistent with the 'pecking order theory of control' (Aghion and Bolton 1992). If the amount of needed finance is small, the investor does not need much protection against

[4] The actual division of control rights depends on the realisation of the signal.

entrepreneurial expropriation. In that case, the entrepreneur can retain all control rights. When the amount of needed finance is larger, the investor needs some control rights to guarantee a sufficient return on his investment. In that case, the three-layered signal-contingent control allocation is the optimal mode of control. When the amount of needed finance is very large, the entrepreneur must relinquish all control rights to the investor to induce her to finance the project.

Besides the articles mentioned above, this essay is related to Aghion, Dewatripont and Rey (1994) and Nöldeke and Schmidt (1995), who also consider the consequences of assuming that the renegotiation point is not exogenously set at (0, 0). Bolton and Scharfstein (1990), Diamond (1991), Hart and Moore (1994), and Hart and Moore (1998) are similar to this essay in that they focus on how the allocation of control rights affects the tradeoff between cash flows and private benefits. Another branch of related literature examines the optimal allocation of control and cash-flow rights in venture capital finance. Probably closest to this paper are Chan, Siegel and Thakor (1990), Berglöf (1994), Hellmann (1998), who study how convertible securities allocate control rights to the right persons (entrepreneur and venture capitalist) in different states of the world.

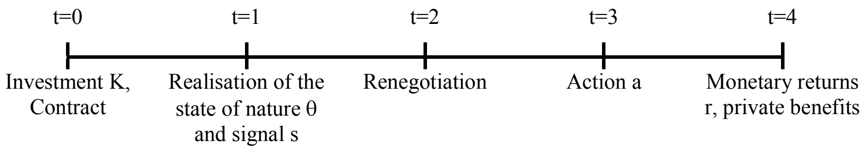
The outline of the essay is the following. In section 2, we present the model. Section 3 highlights our major results in a simple numerical example. In sections 4–7, we examine the feasibility and optimality of different types of contracts. Sections 4 and 5 examine entrepreneur control and investor control contracts, respectively. Joint control contracts are studied in section 6 and signal-contingent contracts in section 7. Section 8 concludes.

2 The model

We extend the model of Aghion and Bolton (1992) in two ways. First, to examine the optimality properties of the three-layered signal-contingent control allocation, we extend their model – with two actions, two signals and two states of nature – into a model with three actions, three signals and three states of nature. Second, we model joint control differently. Otherwise, the models are identical.

Consider a risk-neutral entrepreneur who has an opportunity to undertake an investment project but lacks funds to finance it. The funds for the investment, K, must come from a risk-neutral wealthy investor. There is a competitive market for finance. Thus, the entrepreneur reaps all the surplus of the project by making a take-it-or-leave-it offer to the investor. The investor, in turn, accepts the offered contract only if his expected monetary payoff is at least K.

The time structure of the model is the following.



The contract determines how the project's *cash flow rights* and *control rights* are divided between entrepreneur and investor. Cash flow rights determine how the project's monetary returns, r(a;θ), are divided between a non-negative transfer to the entrepreneur, t(s,r(a;θ)), and a residual allocation to the investor, r(a;θ)–t(s,r(a;θ)). Monetary returns depend on the realisation of the state of nature θ and the interim action, a. The transfer t(s,r(.)) can be directly contingent on s and r only but not of a or θ, because contracts are incomplete.

Control rights refer to the right to choose the interim action, a. Under unilateral forms of control (entrepreneur and investor control), the party in control has the exclusive right to choose the interim action. Under signal-contingent control, the party in control depends on the realisation of the signal. Under joint control, the action must be chosen unanimously.

This essay provides a novel interpretation of joint control.

Definition 1. Under joint control, the entrepreneur first proposes some action. Then the investor either accepts or rejects the proposed action.

If the parties fail to reach agreement, the entrepreneur or investor obtains control, each with a probability 1/2.

According to the standard definition of joint control, each party has the right to force the firm to a standstill in case of disagreement. As discussed in the introduction, this assumption, together with the assumption that the entrepreneur has all the bargaining power in renegotiations, implies that joint control in effect collapses to entrepreneur control. We depart from the literature by assuming that each party has the right to force the firm into stochastic control. Under stochastic control, each party obtains control with a given probability. Without loss of generality, we set this probability at 1/2.

Besides observable and verifiable monetary returns, the project yields to the entrepreneur some non-transferable, non-verifiable and non-monetary private benefits, $l(a;\theta)$. Although private benefits are non-monetary, we assume that they can be measured in monetary terms. Examples of private benefits are personal satisfaction in running the project, reputation, entrepreneur's desire to keep a family business in operation even if it may not be very profitable, and so on.

The fact that only the entrepreneur enjoys these private benefits creates a potential conflict of interest between the parties over the choice of action. The conflict of interest arises because the investor is only interested in cash flows, whereas the entrepreneur is interested in both cash flows and private benefits. The potential conflict of interest can be easily seen by comparing the parties' von Neumann – Morgenstern utility functions, $U_E(a;s,\theta)$ and $U_I(a;s,\theta)$. It is assumed that the utility functions are linear and take the following forms

$$U_E(a;\, s,\theta) = E\big[t(s, r(a;\theta) + l(a;\theta))\big] \tag{2.1}$$

$$U_I(a;\, s,\theta) = E\big[r(a;\theta) - t(s, r(a;\theta))\big] \tag{2.2}$$

It is obvious that in some state of nature, θ, and for some arbitrary transfer schedule, $t(s,r(a;\theta)$ the action that maximises the entrepreneur's utility, $U_E(.)$, may differ from the action that maximises the investor's utility, $U_I(.)$. Therefore, it matters who has the right to choose the action. In fact, disagreement over action choice can be so severe that the entrepreneur's preferred action schedule[5] may not

[5] The entrepreneur's preferred action in state θ for a given transfer schedule, $t(s,r(.))$, is given by $a_E(s,\theta) = \arg\max_a \{E[t(s, r(a;\theta)) + l(a;\theta)]\}$.

compensate (in expected value) the investor for his initial investment, K, even if he gets all the cash flow rights (ie if $t(.) = 0$). That is, for some parameter values, $E(r(a(.), \theta)) < K$. In that case, the feasibility of financing requires that the entrepreneur relinquishes at least some control rights to the investor, to ensure that the latter's participation constraint is satisfied.

Contracts are incomplete in two ways. First, the realisation of the state of nature is unverifiable for third parties. Therefore, contracts cannot be contingent on θ. The entrepreneur and investor, however, observe the realisation of θ ex post. This provides a rationale for the ex post renegotiation. The variable θ can be interpreted eg as the quality of the project. As the project progresses, both parties are likely to learn this quality. Although observable ex post, the quality may not be easily measured and described. Therefore, it may be impossible to write contracts that are contingent on it. However, it may be possible to write a contract that is contingent on some publicly verifiable signal s, which correlates with θ. For example, the firm's short-run profits are likely to correlate with the quality of the project. If the correlation between signal and state is sufficiently high, it may be useful to design contracts that are contingent on signals. Second, the action is too complex or too difficult to describe in the contract. As a consequence, contracts cannot be contingent on actions.[6]

After the realisation of θ, the initial contract can be renegotiated. As is typical in incomplete contracting environments, renegotiation may be socially useful and actually take place in equilibrium (see eg Salanie 1997). We assume that the entrepreneur has all the bargaining power in renegotiations.[7] Thus, the entrepreneur can make a take-it-or-leave-it offer to the investor after θ realises. In renegotiations, the entrepreneur proposes a new monetary transfer schedule for the investor. If the investor accepts the new contract, the old one is torn up. Obviously, the investor accepts the new contract if and only if his payoff is at least as high as under the old contract.

In Aghion and Bolton (1992), there are only two states of nature, two actions in the action set, and two possible outcomes of the signal. Their model is designed to examine the optimality of 'all-or-nothing' shifts of control. However, to study smoother shifts in control right allocations we need a larger number or a continuum of possible states

[6] We rule out contracts which are contingent on agents' announcements of the state of nature (so called Maskin schemes), since, as shown by Aghion and Bolton (1992, App. 1), they do not achieve first-best efficiency in this framework.

[7] Our main results remain valid even if this assumption is relaxed. See the arguments in Aghion and Bolton (1992, p. 479, ftn. 7).

and signals. We examine the simplest extension with three actions, three states, and three signals. Thus, we assume that the sets of actions, states of nature, and signals are, respectively, $A = \{a_g, a_m, a_b\}$, $\Theta = \{\theta^g, \theta^m, \theta^b\}$, $S = \{s^g, s^m, s^b\}$.[8]

The first-best action $a^*(\theta^i)$ in state θ^i, $i = g, m, b$, maximises the sum of monetary returns and private benefits. In other words $a^*(\theta^i) = \arg\max_{a_j \in A}\{E(r(a_j;\theta^i)) + l(a_j;\theta^i)\}; i, j = g, m, b$. This formulation shows that the first-best action may be different in different states of the world. We assume that the parameters of the model are such that $a_g = a^*(\theta^g)$ is the first-best action in state θ^g, $a_m = a^*(\theta^m)$ in state θ^m, and $a_b = a^*(\theta^b)$ in state θ^b.

The signals are imperfectly correlated with the states of the world. Denote

$$\beta^{ki} \equiv \text{Prob}(s = s^k \mid \theta = \theta^i) \quad (i, k = g, m, b). \tag{2.3}$$

We assume that the signals satisfy

$$\beta^{gg}, \beta^{mm}, \beta^{bb} > 1/2 \tag{2.4}$$

We also assume that the project return $r \in \{0,1\}$. Given this set of possible returns, the expected monetary return of the project in state θ^i when action a_j is chosen can be expressed as

$$y_j^i = E\left(r \mid \theta = \theta^i, a = a_j\right) \equiv \Pr\left(r = 1 \mid \theta = \theta^i, a = a_j\right) \tag{2.5}$$

We assume that each state of nature θ^i occurs with a probability of 1/3. Thus, if the first-best action is chosen in each state of the world, the expected monetary return is $(1/3)(y_g^g + y_m^m + y_b^b)$. In what follows, we label this return as the *first-best monetary payoff*.

Private benefits in different states and with different actions are denoted in the same way as the monetary returns. In other words, the level of private benefits in state θ^i when the action is a_j is denoted by l_j^i.

[8] Throughout the essay, we follow the convention that subscripts denote actions and superscripts denote either signals or states of the world, depending on the context.

There is a conflict of interest between investor and entrepreneur only if the same action does not maximise both monetary returns and private benefits in a given state of nature. The next assumption guarantees that the potential conflict of interest is as stark as possible.

Assumption 2. Private benefits, l_j^i, and expected monetary returns, y_j^i, satisfy $(i)\, l_g^i > l_m^i > l_b^i$ for $i = g, m, b$ and $(ii)\, y_g^i < y_m^i < y_b^i$ for $i = g, m, b$.

According to (i), in each state of nature, action a_g yields a larger private benefit than action a_m, which in turn yields a larger private benefit than action a_b. According to (ii), in each state of nature, action a_b yields a larger monetary return than action a_m, which in turn yields a larger monetary return than action a_g.

In the next section, we highlight our main results in a simple numerical example. In subsequent sections, we generalise the insights of that example.

3 Numerical example

For a moment, assume that the initial contract allocates all monetary returns to the investor and that the initial contract can be contingent on the state of the world. In later sections, these assumptions are relaxed.

Suppose that the monetary return y_j^i and private benefit l_j^i of an investment project depend on actions and states of the world in the following way.

		Action		
		a_g	a_m	a_b
	return	$y_g^g = 100$	$y_m^g = 150$	$y_b^g = 200$
State θ^g	private benefit	$l_g^g = 150$	$l_m^g = 80$	$l_b^g = 0$
	total surplus	250	230	200
	return	$y_g^m = 0$	$y_m^m = 60$	$y_b^m = 90$
State θ^m	private benefit	$l_g^m = 90$	$l_m^m = 50$	$l_b^m = 0$
	total surplus	90	110	90
	return	$y_g^b = 0$	$y_m^b = 30$	$y_b^b = 60$
State θ^b	private benefit	$l_g^b = 30$	$l_m^b = 20$	$l_b^b = 0$
	total surplus	30	50	60

Now, consider the entrepreneur's maximisation problem. The entrepreneur, who has all the bargaining power, allocates control rights with the aim of maximising his expected payoffs while satisfying the investor's participation constraint. We show below that the way the entrepreneur allocates control rights depends on the cost of the project, K (or, equivalently, on the severity of the conflict of interest between the parties).

For a moment, assume that renegotiation is not possible. Suppose first that $K \le (1/3)(y_g^g + y_g^m + y_g^b)$ or $K \le 100/3$. In this case, *entrepreneur control* is feasible and implements the first-best action schedule. To see this, consider the entrepreneur's problem of maximising his private benefits. The action that maximises the private benefit is a_g in all three states of nature. When the entrepreneur chooses a_g in all three states, the investor's expected monetary return is $(1/3)(y_g^g + y_g^m + y_g^b)$.[9] However, note that renegotiation will actually take place in states θ^m and θ^b. In state θ^m, the entrepreneur offers to choose the first-best action a_m in exchange for a payment of $y_m^m - y_g^m = 60$ from the investor. Similarly, in state θ^b, the entrepreneur offers to choose the first-best action a_b in exchange for a payment of $y_b^b - y_g^b = 60$. Thus, whenever feasible, entrepreneur control implements the first-best action schedule. Entrepreneur control is feasible whenever the investor's expected pre-renegotiation return $(1/3)(y_g^g + y_g^m + y_g^b)$ (which is equal to her post-renegotiation return, as the entrepreneur has all the bargaining power) are at least as large as K.

The more interesting case is $(1/3)(y_g^g + y_g^m + y_g^b) < K$, where entrepreneur control is not feasible. In that case the entrepreneur must relinquish some or all of the control rights to the investor, to guarantee that the latter's participation constraint is satisfied. Suppose first that $(1/3)(y_g^g + y_g^m + y_g^b) < K \le (1/3)(y_g^g + y_m^m + y_b^b)$ or $100/3 < K \le 220/3$. For these values of K, the following *three-layered state-contingent control allocation* is feasible and implements the first-best action schedule. If the state is θ^g, the entrepreneur retains control. If the state is θ^m, the parties share control. If the state is θ^b, the investor obtains control.[10]

To show this, consider which actions are implemented in each state. As shown above, entrepreneur control implements the first-best action, a_g, in state θ^g. It is also clear that investor control implements the first-best action, a_b, in state θ^b, since the investor always chooses the action that maximises his monetary payoff. What is less obvious is that joint control implements the first-best action, a_m, in state θ^m. To see this, suppose that the entrepreneur proposes that action a_m be taken. If the investor agrees, then the investor's and entrepreneur's payoffs are y_m^m and l_m^m, respectively. If the investor disagrees, then, by assumption 1, he forces the firm into stochastic control. Under

[9] Since the entrepreneur has all the bargaining power, the investor makes an initial lump-sum payment of $(1/3)(y_g^g + y_g^m + y_g^b) - K$ to the entrepreneur if $(1/3)(y_g^g + y_g^m + y_g^b)$ is strictly greater than K.

[10] Of course, it would be possible to set the numerical values of our example in such a way that the optimal state-contingent control allocation would be different. For example, it is easy to think of real world cases where investor control is optimal in the good state of the world and entrepreneur control in the bad state of the world.

stochastic control, the entrepreneur chooses his preferred action, a_g, with probability 1/2 and the investor his preferred action a_b with probability 1/2. In that case, the investor's and entrepreneur's expected payoffs are $(1/2)(y_g^m + y_b^m)$ and $(1/2)(l_g^m + l_b^m)$, respectively.

Now it is clear that joint control implements the first-best action, a_m, in state θ^m as the parameters in the example satisfy

$$y_m^m > (1/2)(y_g^m + y_b^m)$$

and

$$l_m^m > (1/2)(l_g^m + l_b^m)$$

To summarise, the state-contingent control allocation where the entrepreneur obtains control in the good state of the world, both (joint control) in the medium state of the world and the investor in the bad state of the world directly implements the first-best actions – a_g, a_m and a_b – in states θ^g, θ^m, and θ^b, respectively. Given these choices of actions, the investor's expected monetary payoff under the above state-contingent control allocation is $(1/3)(y_g^g + y_m^m + y_b^b)$. Thus, when $(1/3)(y_g^g + y_g^m + y_g^b) < K \leq (1/3)(y_g^g + y_m^m + y_b^b)$ or when $100/3 < K \leq 220/3$, the state-contingent control allocation is feasible and implements the first-best action schedule, whereas entrepreneur control is not feasible. In what follows we also show that under mild conditions, the three-layered state-contingent control dominates other forms of control for intermediate values of K.

For very high values of K, only the investor control contracts that allocate control to the investor in all states of the world are feasible. When K is close to $(1/3)(y_b^g + y_b^m + y_b^b)$ or 350/3, the entrepreneur obtains finance only by relinquishing all cash flow and control rights to the investor.

In what follows, we generalise the numerical example in two ways. First, we assume that state-contingent contracts are not possible because of contractual incompleteness. However, we show that signal-contingent contracts approximate state-contingent contracts if the signals are sufficiently well correlated with the states of the world. Second, we assume that the entrepreneur is interested not only in private benefits but also in monetary returns.

In the subsequent sections, we examine the conditions under which entrepreneur control, investor control, and joint control are feasible. We then derive the conditions under which the three-layered signal-contingent control allocation dominates these other control allocations.

4 Entrepreneur control

This section is a straigtforward extension of section III.A of Aghion and Bolton (1992) into the three-action, three-signal and three-state case.

Under entrepreneur control, the entrepreneur has the right to decide which action to choose at date 3. In this section we show that, whenever feasible, entrepreneur control implements the first-best plan of actions. Unfortunately, as shown below, some socially profitable projects cannot be implemented under entrepreneur control.

The entrepreneur's problem at date 0 is to design a transfer schedule t(s,r) such that the investor, anticipating future actions and outcomes of possible future renegotiations, is willing to provide the funds at date 0. Following Aghion and Bolton (1992), we concentrate on the linear transfer schedules

$$t(s, r) = t^s r \text{ where } 0 \leq t^s \leq 1 \text{ for s = g, m, b}$$

Thus, the variable t^s denotes the entrepreneur's share of the final monetary returns, which depends on the signal s.

Let us examine the case where entrepreneur control is feasible and implements the first-best action plan. As shown in our example, the initial contract may implement the first-best actions either directly or indirectly through renegotiation. Recall that in our example, where $t^s = 0$ for all s, the entrepreneur's preferred action was a_g in all three possible states of the world. In consequence, the first-best action, a_g, was directly implemented in state θ^g. In fact, entrepreneur control directly implements the first-best action, a_g, in state θ^g for all admissible transfer schedules.

Proposition 1. Under entrepreneur control, any transfer t^s, $0 \leq t^s \leq 1$, directly implements the first-best action, a_g, in state θ^g.

Proof. For a given t^s, the entrepreneur strictly prefers action a_g to actions a_m and a_b, if $t^s y_g^g + l_g^g > \max[t^s y_m^g + l_m^g,\ t^s y_b^g + l_b^g]$. By the definition of first-best action, $y_g^g + l_g^g > \max[y_m^g + l_m^g,\ y_b^g + l_b^g]$ and, by assumption 2(i), the above inequality is satisfied for all t^s, $0 \le t^s \le 1$. QED

In contrast to state θ^g, not all transfers t^s, $0 \le t^s \le 1$ not directly implement the first-best actions in states θ^m and θ^b. To see this, consider the entrepreneur's problem of choosing the action in state θ^i with some arbitrary transfer schedule (t^g, t^m, t^b). When the signal is s, the entrepreneur's preferred action in state θ^i is given by

$$a_E(s, \theta^i) = \arg\max_{a_j \in A} \left\{ t^s y_j^i + l_j^i \right\};\ i, j = g, m, b \tag{4.1}$$

It is easy to see that when the value of t^s is close to zero, the entrepreneur prefers the inefficient action, a_g, which provides him high private benefits, to an efficient action, θ^m or θ^b. In that case, the first-best action is implemented only if the investor bribes the entrepreneur to choose the efficient action in contract renegotiations.

For illustration, suppose that in state θ^m (a similar analysis applies to state θ^b), t^s is so low that the entrepreneur prefers action a_g. Thus, the entrepreneur's and investor's pre-renegotiation payoffs are $t^s y_g^m + l_g^m$ and $(1 - t^s) y_g^m$, respectively. In renegotiations, the investor bribes the entrepreneur to choose the first-best action, a_m. As the entrepreneur has all the bargaining power in renegotiations, the entrepreneur's and investor's post-renegotiation payoffs are $y_m^m + l_m^m - (1 - t^s) y_g^m$ and $(1 - t^s) y_g^m$, respectively. Analogously, we can show that in state θ^b the first-best action a_b is implemented in renegotiations in a similar fashion. Therefore, whenever feasible, entrepreneur control always implements the first-best action schedule.

Unfortunately, as illustrated in our example, some efficient projects are not feasible under entrepreneur control since the entrepreneur cannot always guarantee to the investor sufficient payoffs to satisfy his ex ante participation constraint. The general result is presented in proposition 2 below. Before stating the proposition, we introduce three definitions.

Contracts are *renegotiation-proof* if the transfer schedule (t^g, t^m, t^b) induces the entrepreneur to choose the first-best action in all states of the world for all possible signals, ie if the transfer schedule is such that $a(s,\theta^i) = a^*(s,\theta^i)$ for all s and i.

Contracts are *full renegotiation* contracts if the initial transfers (t^g, t^m, t^b) are so low that the initial contract is always renegotiated in states θ^m and θ^b regardless of the signal.

Contracts are *partial renegotiation* contracts if the initial contract is renegotiated in at least one of the states θ^m and θ^b with at least one signal but not in both states regardless of signal. Thus, partial renegotiation contracts include all contracts that are neither renegotiation-proof contracts nor full renegotiation contracts.

We also introduce the following auxiliary definitions

$$t_{rp}^m \equiv (l_g^m - l_m^m)/(y_m^m - y_g^m),\ t_{rp}^b \equiv \max\left[\frac{l_g^b - l_b^b}{y_b^b - y_g^b}, \frac{l_m^b - l_b^b}{y_b^b - y_m^b}\right], \tag{4.2}$$

and $t_{rp}^E \equiv \max[t_{rp}^m, t_{rp}^b]$

$$\pi_{rp} \equiv \frac{1}{3}(1 - t_{rp}^E)(y_g^g + y_m^m + y_b^b) \tag{4.3}$$

$$\pi_{fr} \equiv \frac{1}{3}(y_g^g + y_g^m + y_g^b) \tag{4.4}$$

$$\begin{aligned}\pi_{pr} \equiv\ & (1/3)\left[(\beta^{gg} y_g^g) + (\beta^{mg} \cdot (1 - t_{rp}^m) y_g^g) + (\beta^{bg} \cdot (1 - t_{rp}^b) y_g^g)\right] \\ & + (1/3)\left[(\beta^{gm} y_g^m) + (\beta^{mm} \cdot (1 - t_{rp}^m) y_m^m) + (\beta^{bm} \cdot (1 - t_{rp}^b) y_g^m)\right] \\ & + (1/3)\left[(\beta^{gb} y_g^b) + (\beta^{mb} \cdot (1 - t_{rp}^m) y_b^b) + (\beta^{bb} \cdot (1 - t_{rp}^b) y_b^b)\right]\end{aligned} \tag{4.5}$$

where π_{rp}, π_{fr} and π_{pr} denote the entrepreneur's highest feasible monetary payoffs with renegotiation-proof, full renegotiation, and partial renegotiation contracts, respectively.

Proposition 2. Entrepreneur control is feasible and implements the first-best action plan if and only if $\max(\pi_{rp}, \pi_{fr}, \pi_{pr}) \geq K$. If K belongs to the non-empty interval $\left(\max(\pi_{rp}, \pi_{fr}, \pi_{pr}), (1/3)(y_g^g + y_m^m + y_b^b)\right]$, entrepreneur control is not feasible.

Proof. See appendix.

The intutition underlying proposition 2 is that not all efficient projects are feasible under entrepreneur control, since the entrepreneur must get a sufficient share of the project's monetary returns (either directly or indirectly through renegotiation) in states θ^g and θ^m in order to choose the first-best actions a_g and a_m, respectively, instead of the action a_b, which maximises his private benefits. For high values of K, this requirement conflicts with the investor's participation constraint.

For illustration of this result, let us insert the numerical values of our example into the formulae of π_{rp}, π_{fr} and π_{pr}. We get

$$\pi_{rp} = 115/9,$$

$$\pi_{fr} = 100/3,$$

$$\pi_{pr} = \frac{1}{3}\left[100\left(\beta^{gg} + \frac{1}{5}\beta^{mg} + \frac{1}{3}\beta^{bg}\right) + 70 \cdot \frac{1}{5}\beta^{mm} + 60\left(\frac{1}{5}\beta^{mb} + \frac{1}{3}\beta^{bb}\right)\right]$$

When β^{gg}, β^{mm}, and β^{bb} converge to one, π_{pr} converges to 202/3. Thus, when signals are very informative, partial renegotiation contracts are feasible for higher values of K than renegotiation-proof or full-renegotiation contracts. However, even partial-renegotiation contracts fail to implement the first-best action schedule when K is sufficiently close to the first-best monetary return, 220/3.

Note that the result that the partial-renegotiation contracts dominate full-renegotiation contracts for some values of K is somewhat surprising, as the full renegotiation contracts allocate all cash flow rights to the investor. The reason for this surprising result is that, as the entrepreneur has all the bargaining power in the renegotiation phase, he may extract too high a surplus when there is maximum renegotiation (for details, see Aghion and Bolton 1992, p. 483).

5 Investor controls

In this section we study the feasibility of investor control contracts. We show that investor control contracts dominate entrepreneur control contracts for intermediate values of K. More specifically, we show that investor control contracts implement the first-best action schedule even when $K \in \left(\max(\pi_{rp}, \pi_{fr}, \pi_{pr}), (1/3)(y_g^g + y_m^m + y_b^b)\right]$, ie in the range of where entrepreneur contracts are not feasible.

Let us start our analysis of investor control contracts by examining which transfers induce the investor to choose the first-best action in each state of nature. Note first that for any transfer t^s, $0 \le t^s < 1$, the investor's preferred action is a_b in all states of the world, since, by assumption 2 (ii), $a_I(s, \theta^i) = \arg\max_{a_j \in A}((1 - t^s) y_j^i) = a_b$ for all i and t^s, $0 \le t^s < 1$. The next proposition directly follows from that observation.

Proposition 3. Given any t^s, $0 \le t^s < 1$, investor control directly implements the first-best action, a_b, in state θ^b.

In states θ^g and θ^m, however, the investor's preferred action, a_b, differs from the first-best actions, a_g and a_m. Thus, in those states the first-best actions are implemented only if the entrepreneur offers to renegotiate his share of the monetary return to bribe the investor to choose the first-best action.

On the basis of the renegotiation process, investor control contracts can be divided into two categories: full-renegotiation contracts and partial renegotiation contracts.

Full renegotiation contracts

Full renegotiation contracts are always renegotiated in states θ^g and θ^m and implement the first-best actions with all realisations of the signal. First, consider the entrepreneur's problem of inducing the investor to choose the first-best action, a_g, in state θ^g. The investor chooses a_g only if the entrepreneur offers to lower his initial share of the monetary return from t^s to $\hat{t}^s$, such that

$$(1 - \hat{t}^s) y_g^g \ge (1 - t^s) y_b^g \tag{5.1}$$

By setting $\hat{t}^s = 0$, we get the lowest initial transfer t^s that satisfies this inequality. Denote that transfer by t^g_{fr}.

$$t^g_{fr} \equiv 1 - y^g_g / y^g_b \tag{5.2}$$

which, by assumption 2, is greater than zero.

Analogously, the lowest initial transfer t^m_{fr} that induces the investor to choose the first-best action, a_m, in state θ^m is

$$t^m_{fr} \equiv 1 - y^m_m / y^m_b \tag{5.3}$$

which, by assumption 2, is also greater than zero.

Let us combine (5.2) and (5.3) to find the lowest transfer t^I_{fr} that induces the investor to choose the first-best action in *all* states of the world and for all signals

$$t^I_{fr} \equiv \max\left[t^g_{fr}, t^m_{fr}\right] \tag{5.4}$$

Now, the investor's highest expected payoff under full-renegotiation investor control contracts is

$$\pi^I_{fr} \equiv \frac{1}{3}(1 - t^I_{fr})(y^g_b + y^m_b + y^b_b) \tag{5.5}$$

Thus, the full-renegotiation investor control contracts are feasible if and only if $\pi^I_{fr} \geq K$. If K belongs to the non-empty interval $\left(\pi^I_{fr}, (1/3)(y^g_g + y^m_m + y^b_b)\right]$, full-renegotiation investor control contracts are not feasible. In the numerical example, $\pi^I_{fr} = 125/3$. If $K \in (125/3, 220/3]$, full renegotiation contracts are not feasible and do not implement the first-best action schedule.

Aghion and Bolton (1992) limit their analysis of investor control contracts to full-renegotiation contracts. Therefore, they conclude that investor control is feasible only if $\pi^I_{fr} \geq K$. However, as shown in Vauhkonen (2002, the chapter 4 of this thesis) their reasoning is not valid, as they overlook the *partial-renegotiation investor control contracts*.

Next, we show that partial renegotiation investor control contracts implement the first-best action schedule for all $K \in [0,(1/3)(y_g^g + y_m^m + y_b^b)]$, and thus strictly dominate entrepreneur control contracts for some intermediate values of K.

Partial renegotiation contracts

As mentioned above, partial renegotiation investor control contracts are contracts that are renegotiated in at least one of the states θ^g and θ^m for at least one of the possible signals but not in both of the states for all signals.

In the next proposition we show that, if the signals are sufficiently strongly positively correlated with the states of nature, the investor's expected payoff can converge to the first-best monetary payoff under investor control contracts.

Proposition 4. When β^{gg}, β^{mm} and β^{bb} converge to 1 and the transfer schedule is $(t_{fr}^g, t_{fr}^m, 0)$, the investor's expected monetary payoff π_{pr}^I converges to the first-best monetary payoff, $(1/3)(y_g^g + y_m^m + y_b^b)$.

Proof. By design, t_{fr}^g is defined as the entrepreneur's initial share of the monetary returns that he offers to cut to zero to bribe the investor to choose the first-best action, a_g, in state θ^g. The transfer t_{fr}^m is designed analogously in state θ^m. In state θ^b, the investor chooses the first-best action a_b with any transfer $0 \le t^s < 1$. This implies that when $(t^g, t^m, t^b) = (t_{fr}^g, t_{fr}^m, 0)$ and β^{gg}, β^{mm} and β^{bb} converge to 1, the investor's expected post-renegotiation payoffs in states θ^g, θ^m and θ^b converge, respectively, to y_g^g, y_m^m and y_b^b. This in turn implies that the investor's expected total monetary payoff converges to the first-best monetary payoff $(1/3)(y_g^g + y_m^m + y_b^b)$. QED

It may be worth elaborating this result. Given the transfer schedule $(t_{fr}^g, t_{fr}^m, 0)$ and assuming as above that $t_{fr}^I = t_{fr}^g \ge t_{fr}^m$, the expression for the investor's expected payoff π_{pr}^I can be written as

$$\begin{aligned}\pi^{I}_{pr} = (1/3)\left[(\beta^{gg} y^{g}_{g}) + (\beta^{mg} \cdot (1 - t^{m}_{fr}) y^{g}_{b}) + (\beta^{bg} y^{g}_{b})\right] \\ + (1/3)\left[(\beta^{gm} \cdot (1 - t^{g}_{fr}) y^{m}_{b}) + (\beta^{mm} y^{m}_{m}) + (\beta^{bm} y^{m}_{b})\right] \\ + (1/3)\left[(\beta^{gb} \cdot (1 - t^{g}_{fr}) y^{b}_{b}) + (\beta^{mb} \cdot (1 - t^{m}_{fr}) y^{b}_{b}) + (\beta^{bb} y^{b}_{b})\right]\end{aligned} \tag{5.6}$$

We immediately see that when β^{gg}, β^{mm} and β^{bb} converge to 1, π^{I}_{fr} converges to the first-best monetary payoff $(1/3)(y^{g}_{g} + y^{m}_{m} + y^{b}_{b})$.

To summarise this section, we showed that investor control contracts dominate entrepreneur control contracts when $K \in \left(\max(\pi_{rp}, \pi_{fr}, \pi_{pr}), (1/3)(y^{g}_{g} + y^{m}_{m} + y^{b}_{b})\right]$. The reason is that the investor's preferred action plan yields higher expected monetary returns than the entrepreneur's preferred action plan. That allows the financing of some high-cost projects which are not feasible under entrepreneur control.

6 Joint control

Under joint control, the parties must make a unanimous choice of action. In this section, we show, first, that a renegotiation-proof joint control contract that allocates all monetary returns to the investor implements the first-best action in state θ^{m} under mild conditions. This is an important auxiliary result, which is utilised in section 7. Second, we show that joint control contracts never strictly dominate all other control allocations.

We consider two kinds of joint control contracts. Under renegotiation-proof contracts the initial transfer schedule directly induces a unanimous choice of action. The second possibility is that parties reach agreement in the renegotiation. Before examining these contracts, we need to examine what happens under joint control if the parties disagree on the choice of action.

If the parties disagree on the choice of action and if the renegotiations fail, then, by assumption 1, each party obtains control with a probability of 1/2. The party in control then chooses his most preferred action. As shown in section 5, the investor's preferred action in any state of the world for any realisation of the transfer t^{s}, $0 \le t^{s} < 1$ is a_b. The entrepreneur's preferred action in state θ^{i} for some t^{s} in turn is given by $\arg\max_{a_j \in A} (t^{s} y^{i}_{j} + l^{i}_{j}) \equiv a_E(s, \theta^{i})$. These action choices in combination with the initial transfer schedule (t^g, t^m, t^b) determine the parties' disagreement payoffs, which are the starting points for possible future renegotiations.

Consider first the parties' disagreement payoffs in state θ^m. The entrepreneur's disagreement action is a_m if $t^s \geq t^m_{rp}$ and a_g if $t^s < t^m_{rp}$, where t^m_{rp} is defined in (4.2). Thus, the investor's expected disagreement payoff $\pi_{dis}(s, \theta^m) = \frac{1}{2}(1 - t^s)(y^m_m + y^m_b)$, if $t^s \geq t^m_{rp}$ and $\pi_{dis}(s, \theta^m) = \frac{1}{2}(1 - t^s)(y^m_g + y^m_b)$, if $t^s < t^m_{rp}$. Note that, when $t^s = 0$, $\pi_{dis}(s, \theta^m) = \frac{1}{2}(y^m_g + y^m_b)$.

This result is utilised in the next proposition, which shows that joint control contract with $t^s = 0$ for all s directly implements the first-best action a_m in state θ^m under mild conditions.

Proposition 5. When the parameters of the model satisfy $y^m_m \geq (1/2)(y^m_g + y^m_b)$ and $l^m_m \geq (1/2)(l^m_g + l^m_b)$, the transfer schedule $(t^g, t^m, t^b) = (0,0,0)$ directly implements the first-best action, a_m, in state θ^m.

Proof. Suppose first that the investor and entrepreneur unanimously agree on action a_m. In that case, given that $(t^g, t^m, t^b) = (0,0,0)$, their payoffs are y^m_m and l^m_m, respectively. Suppose, alternatively, that the parties disagree on the choice of action. Then, given that $(t^g, t^m, t^b) = (0,0,0)$, and by assumption 1, their expected payoffs are $(1/2)(y^m_g + y^m_b)$ and $(1/2)(l^m_g + l^m_b)$, respectively. Thus, the first-best action a_m in state θ^m is chosen unanimously when the parameters of the model satisfy $y^m_m \geq (1/2)(y^m_g + y^m_b)$ and $l^m_m \geq (1/2)(l^m_g + l^m_b)$. QED

In the next proposition we show that joint control is not feasible when K is sufficiently high. The proposition follows directly from the following lemma.

Lemma 1. The first-best action, a_b, is always implemented in state θ^b if and only if $t^s \geq t^b_{rp}$, where $t^b_{rp} \equiv \left[\frac{l^b_g - l^b_b}{y^b_b - y^b_g}, \frac{l^b_m - l^b_b}{y^b_b - y^b_m}\right]$.

Proof. The entrepreneur proposes that action a_b is taken in state θ^b only if t^s is such that

$$t^s y_b^b + l_b^b \geq \max\left\{\frac{1}{2}\left[t^s(y_g^b + y_b^b) + (l_g^b + l_b^b)\right], \frac{1}{2}\left[t^s(y_m^b + y_b^b) + (l_m^b + l_b^b)\right]\right\}$$

i.e. if $t^s \geq \max\left[\frac{l_g^b - l_b^b}{y_b^b - y_g^b}, \frac{l_m^b - l_b^b}{y_b^b - y_m^b}\right] \equiv t_{rp}^b$. QED

Thus, if $t^s \geq t_{rp}^b$, a_b is always implemented. If $t^s < t_{rp}^b$, the parties disagree on the choice of action. In that case, a_b is implemented only with a probability of 1/2.

Proposition 6. There are values of K such that joint control contracts do not implement the first-best plan of actions and thus are dominated by investor control contracts.

Proof. By lemma 1, joint control implements the first-best action a_b in state θ^b only if the entrepreneur obtains a positive share of the monetary return. Therefore, the investor's largest expected monetary payoff under joint control is necessarily less than the first-best expected monetary payoffs, $(1/3)(y_g^g + y_m^m + y_b^b)$. Thus, there are values of K close to the first-best expected monetary payoff such that joint control contracts are not feasible. The investor control contracts in turn implement the first-best action schedule for all $K \in \left(0, (1/3)(y_g^g + y_m^m + y_b^b)\right]$. Therefore, investor control contracts strictly dominate joint control contracts for some values of K close to $(1/3)(y_g^g + y_m^m + y_b^b)$. QED

By propositions 4 and 6, joint control never strictly dominates other forms of control in our model. This is a standard result in the literature (see Hart 1995). In the next section we show, however, that joint control can be a part of the optimal signal-contingent control allocation.

7 Signal-contingent control

The control allocations examined in previous sections are not contingent on realisations of s. In this section, we examine signal-contingent control allocations, where the party in control depends on the realisation of s.

By propositions 1, 3 and 5, an obvious candidate for efficiency is a control allocation rule which allocates control to the entrepreneur when s = g, to the investor when s = b, or to both (joint control) when s = m. The next corollary follows straightforwardly from propositions 1, 3, and 5.

Corollary 1. When the parameters of the model satisfy $y_m^m \geq (1/2)(y_g^m + y_b^m)$ and $l_m^m \geq (1/2)(l_g^m + l_b^m)$, the investor's expected payoff converges to the first-best monetary payoff when the initial contract with a transfer schedule $(t^g, t^m, t^b) = (0,0,0)$ allocates control to the entrepreneur when s = g, to the investor when s = b or to both when s = m.

Proof. By propositions 1, 3 and 5, the above control allocation directly implements the first-best actions in each state of the world when the signals correspond to the state. Therefore, when $(t^g, t^m, t^b) = (0,0,0)$ and when β^{gg}, β^{mm} and β^{bb} converge to 1, the investor's expected monetary payoff converges to the first-best monetary payoff. QED

For illustration, note that the investor's expected payoff, π_S, with the signal-contingent contract specified in corollary 1 is

$$\begin{aligned}\pi_S = (1/3)&\left[\beta^{gg} y_g^g + \frac{1}{2}\beta^{mg}(y_g^g + y_b^g) + \beta^{bg} y_b^g\right] \\ &+ (1/3)\left[\beta^{gm} y_g^m + \beta^{mm} y_m^m + \beta^{bm} y_b^m\right] \\ &+ (1/3)\left[\beta^{gb} y_g^b + \frac{1}{2}\beta^{mb}(y_g^b + y_b^b) + \beta^{bb} y_b^b\right]\end{aligned} \tag{7.1}$$

As β^{gg}, β^{mm}, β^{bb} converge to 1, π_S converges to the first-best monetary payoff $(1/3)(y_g^g + y_m^m + y_b^b)$.

By propositions 2 and 6, neither entrepreneur nor joint control is feasible when K is sufficiently close to the first-best monetary return. Therefore, signal-contingent control dominates entrepreneur control and joint control when K is sufficiently close to $(1/3)(y_g^g + y_m^m + y_b^b)$. This argument, however, is not adequate to establish that signal-contingent control dominates investor control as, by proposition 4, π_{pr}^I, determined in condition (5.6), also converges to the first-best monetary payoff. However, it can be shown that there exist parameter values such that the difference $\pi_S - \pi_{pr}^I$ is positive. For example, if we set the value of y_g^g to a sufficiently high level compared with other y_j^i, then $\pi_S - \pi_{pr}^I > 0$. When $\pi_S - \pi_{pr}^I > 0$, then, for some parameter values, signal-contingent control strictly dominates investor control. By combining these findings, we can establish the main result of this essay.

Proposition 8. There are values of K such that (i) entrepreneur and joint control are not feasible and (ii) signal-contingent control dominates investor control.

Proof. See above.

We interpret the signal-contingent control allocation examined above as a control allocation associated with many venture capital financings. The benefit of the signal-contingent control allocation is close to the benefit of debt in Aghion and Bolton (1992). When the amount of needed finance is sufficiently large, the entrepreneur must relinquish some control rights to the investor to obtain finance. The signal-contingent control allocation allows the entrepreneur to keep some control rights and to reap some private benefits while allowing adequate protection to the investor.

8 Conclusions

The principal objective of this paper was to try to explain the smooth shifts in control observed by Kaplan and Strömberg (2000). In an incomplete contracting environment, we used a signal-contingent contract as a proxy for smooth control contracts and showed that such a signal-contingent contract may dominate other control allocations under mild parameter restrictions. On the basis of this result, we regard our model to be in line with the key empirical findings of Kaplan and Strömberg (2000).

The reader may wonder how such signal-contingent control allocation can be implemented using standard financial securities. As discussed in Kaplan and Strömberg (2000), in real world venture capital financings there are many combinations of preferred equity, convertible securities, and multiple classes of common stock that implement any desired control allocation. One simple possibility is that the entrepreneur finances the project by issuing multiple classes of common stock. Initially the investor has all the control rights. Then, if the signal of the firm's performance is intermediate, some of the investor's equity with superior control rights is converted into common stock such that the parties share the voting rights. If the signal is good, most or all of the investor's equity with superior control rights converts into common stock such that the entrepreneur obtains voting control.

We regard our model as a first step towards explaining continuous, contingent and divisible control rights. In this area, much remains to be explored in future studies. Another direction worth pursuing might be to try to build venture capital-specific models that are more consistent with the empirical findings of Kaplan and Strömberg (2000) than the existing venture capital-specific models (see Kaplan and Strömberg 2000, p. 30–32). Our general model lacks many features that are prevalent in the theoretical literature of venture capital financings, such as both parties' effort choices. Ideally, one would want to incorporate such venture capital-specific characteristics into the theoretical models which attempt to explain empirical observations from venture capital contracts.

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Appendix

Proof fo proposition 2

Note that this proposition and its proof are very similar to proposition 2 of Aghion and Bolton (1992) and its proof. The minor differences between the two propositions stem from the fact that we model the case with three actions, three signals and three states whereas Aghion and Bolton (1992) made the two-action, two-signal, and two-state case.

We consider one-by-one the feasibility conditions of the three different types of entrepreneur control contracts: renegotiation-proof contracts, full renegotiation contracts and partial renegotiation contracts. Recall that contracts are feasible if the investor's expected monetary payoffs are at least as high as the cost of investment, K. To study the feasibility, we derive below the investor's highest possible expected monetary payoffs under different types of contracts.

Renegotiation-proof contracts:

First, we must derive the conditions for contracts being renegotiation-proof. Contracts are renegotiation-proof if the initial transfers (t^g, t^m, t^b) are sufficiently large to induce the entrepreneur to choose the first-best action in all states of the world for all possible signals. Consider state-by-state which transfers induce the entrepreneur to choose the first-best actions.

First, consider the state θ^g. By proposition 1, all t^s, $0 \leq t^s \leq 1$, directly implement the first-best action, a_g, in state θ^g.

Next, consider the state θ^m. The entrepreneur control directly implements the first-best action, a_m, if and only if

$$t^s y_m^m + l_m^m \geq \max\left[t^s y_g^m + l_g^m,\ t^s y_b^m + l_b^m\right] \tag{A1.1}$$

which, by the definition of first-best and assumption 2 reduces to

$$t^s \geq (l_g^m - l_m^m)/(y_m^m - y_g^m) \equiv t_{rp}^m \tag{A1.2}$$

where t_{rp}^{m} is defined as the lowest t that directly induces the entrepreneur to choose the first-best action, a_m, in state θ_m.

Finally, consider the state θ^b. The analysis is similar to that in state θ^m. Thus, the entrepreneur directly chooses the first-best action, a_b, in state θ_b if and only if

$$t^s \geq \max\left[\frac{l_g^b - l_b^b}{y_b^b - y_g^b}, \frac{l_m^b - l_b^b}{y_b^b - y_m^b}\right] \equiv t_{rp}^{b} \tag{A1.3}$$

where t_{rp}^{b} is defined similarly to t_{rp}^{m}.

Combining the results, we see that contracts are renegotiation-proof, if and only if the following condition is satisfied for all s

$$t^s \geq \max\left[t_{rp}^{m}, t_{rp}^{b}\right] \equiv t_{rp}^{E}. \tag{A1.4}$$

Thus t_{rp}^{E} is the lowest transfer that induces the entrepreneur to choose directly the first-best action in all states of the world. Therefore, the investor's highest possible expected payoff with renegotiation-proof entrepreneur-control contracts is

$$\pi_{rp} = \frac{1}{3}(1 - t_{rp}^{E})(y_g^g + y_m^m + y_b^b) \tag{A1.5}$$

and thus the renegotiation-proof contracts are feasible if and only if $\pi_{rp} \geq K$.

Full renegotiation contracts

This is the case we studied in our numerical example. We define full renegotiation contracts as contracts which are always renegotiated in states θ^m and θ^b. Among these contracts, the investor's expected payoff is maximised when $t^s = 0$ for all s. Given this transfer schedule, the entrepreneur's preferred action is a_g in each state of the world. Thus, the investor's pre-renegotiation expected return (which is the same as the post-renegotiation expected return) is

$$\pi_{fr} = \frac{1}{3}(y_g^g + y_g^m + y_g^b)$$

Thus, the full-renegotiation contracts are feasible if and only if $\pi_{fr} \geq K$.

Partial-renegotiation contracts

With partial renegotiation contracts, transfers are defined in such a way that the initial contract is renegotiated in some states of the world for some signals. Thus, the family of partial renegotiation contracts consists of all contracts that are neither renegotiation-proof nor full renegotiation contracts.

The transfer schedule that maximises the investor's expected monetary payoff for this type of contracts is $(t^g, t^m, t^b) = (0, t^m_{rp}, t^b_{rp})$. Suppose, without loss of generality and similarly as in our numerical example, that $t^m_{rp} > t^b_{rp}$. Then the investor's expected monetary payoffs π_{pr} can be written

$$\begin{aligned}\pi_{pr} = (1/3)&\left[(\beta^{gg} y^g_g) + (\beta^{mg} \cdot (1 - t^m_{rp}) y^g_g) + (\beta^{bg} \cdot (1 - t^b_{rp}) y^g_g)\right] \\ + (1/3)&\left[(\beta^{gm} y^m_g) + (\beta^{mm} \cdot (1 - t^m_{rp}) y^m_m) + (\beta^{bm} \cdot (1 - t^b_{rp}) y^m_g)\right] \quad \text{(A1.6)} \\ + (1/3)&\left[(\beta^{gb} y^b_g) + (\beta^{mb} \cdot (1 - t^m_{rp}) y^b_b) + (\beta^{bb} \cdot (1 - t^b_{rp}) y^b_b)\right]\end{aligned}$$

Thus, the partial renegotiation contracts are feasible if and only if $\pi_{pr} \geq K$.

Combining the above results, we see that entrepreneur control contracts are feasible if and only if $\max(\pi_{rp}, \pi_{fr}, \pi_{pr}) \geq K$. QED

Essay 4

An incomplete contracts approach to financial contracting: a comment*

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Abstract

We show that the main result of Aghion and Bolton (1992) related to the optimality properties of contingent control allocations under incomplete contracting environment holds only if an additional condition is satisfied.

1 Introduction

In their seminal paper, Aghion and Bolton (1992) (hereafter AB) examine a long-term financial contracting problem between a wealth-constrained entrepreneur and a wealthy investor in an incomplete contracting environment. At date 0, the entrepreneur, who has no funds, seeks funding from the investor to cover the set-up cost, K, of an investment project. At date 2, the project yields monetary returns and unobservable and unverifiable private benefits to the entrepreneur. The sizes of the monetary returns and private benefits depend on the date 1 realization of the state of the world and the action taken at date 3/2. As the agents have potentially conflicting interests, they may prefer different actions. The potential conflict over the choice of action cannot always be solved by ex ante contracts since, by assumption, contracts can be contingent only on publicly verifiable signals but not on the true state of the world or the action. Then, the right to decide what action to choose (control) becomes important. In this framework, AB show that different control allocations are efficient for different values of monetary returns and private benefits.

In proposition 5(iii) of their paper, AB argue that for some sufficiently high values of the setup cost, K, a contingent control allocation where control is allocated to the investor when the signal realisation $s = 0$ and to the entrepreneur when $s = 1$ dominates unilateral control allocations (entrepreneur control and investor control). The purpose of this comment is to show that the contingent control allocation stated in their proposition 5 dominates *investor control* only if the values of the monetary returns satisfy an additional condition. Furthermore, we show that this additional condition is not satisfied in their numerical example.

The model and notation are described in section II of AB. For further usage, we write out AB's expression for the investor's expected return under contingent control (AB's equation 6) and their proposition 4. The investor's expected return π_c under contingent control allocation $(\alpha_0 = 0; \alpha_1 = 1)$ with a transfer schedule $t(s,r) = 0$ for all s and r is

$$\pi_c = q\left[\beta^g y_g^g + (1-\beta^g) y_b^g\right] + (1-q)\left[\beta^b y_g^b + (1-\beta^b) y_b^b\right] \tag{1.1}$$

Their proposition 4 reads as follows

Proposition 1. When monetary benefits are not comonotonic with total returns, a necessary and sufficient condition for the first-best action plan to be feasible under investor control is $\pi_4 \equiv (qy_b^g + (1-q)y_b^b)y_g^g / y_b^g \geq K$.

It is important to note that one assumption underlying the definition of π_4 is that the entrepreneur's share of the final monetary returns, determined in the initial contract, is set as a *constant* $\bar{t} = 1 - y_g^g / y_b^g$.

AB state that contingent control dominates investor control when the investor's expected returns under contingent control and investor control are determined by equation (1) and proposition 1, respectively. More specifically, AB claim that if the set-up cost, K, belongs to the non-empty interval $\left(\pi_4, qy_g^g + (1-q)y_b^b\right]$, a contingent control allocation $(\alpha_0 = 0, \alpha_1 = 1)$ strictly dominates investor control when $(\beta^g, \beta^b) \rightarrow (1,0)$.

Their reasoning goes as follows (see their p. 485). By proposition 4, the first-best action plan is not implemented under investor control when $K > \pi_4$, since investor control implements the inefficient action a_b in state θ_g. As a result, the aggregate payoffs under investor control are bounded away from the first-best aggregate payoffs. On the other hand, the aggregate payoffs under contingent control converge to the first-best aggregate payoffs as $(\beta^g, \beta^b) \rightarrow (1,0)$. This argumentation leads them to conclude that contingent control allocation strictly dominates investor control under the conditions stated in their proposition 5.

However, their reasoning is not valid. To see this, consider an alternative investor control contract with a *signal-contingent* transfer schedule $(t_0 = 0, t_1 = \bar{t})$, ie a contract giving the investor the right to choose the action and stipulating that the entrepreneur's share of the monetary returns $t_0 = 0$ when the signal realisation $s = 0$, and $t_1 = \bar{t} = 1 - y_g^g / y_b^g$ when the signal realization $s = 1$. Correspondingly, the investor's share of the monetary returns is 1 when $s = 0$ and y_g^g / y_b^g when $s = 1$. Given this contract, the investor's expected (post-renegotiation) return under investor control is

$$\pi_4' = q\left[\beta^g y_g^g + (1-\beta^g) y_b^g\right] + (1-q)\left[\beta^b y_b^b (y_g^g / y_b^g) + (1-\beta^b) y_b^b\right] \qquad (1.2)$$

Now, AB's reasoning is not valid, since π_4' also converges to the first-best when $(\beta^g, \beta^b) \to (1,0)$. Therefore, to show that contingent control dominates investor control, we must show that $\pi_c - \pi_4' > 0$ for some values of K. The difference $\pi_c - \pi_4'$ is positive only if the monetary returns satisfy the following condition

$$\Phi = y_g^b - y_b^b (y_g^g / y_b^g) > 0 \tag{1.3}$$

Thus, AB's proposition 5(iii) is correct if and only if the condition $\Phi > 0$ is satisfied. This condition is not necessarily satisfied in AB. For example, in their numerical example $\Phi = -25$, which implies that there are no values of K in their numerical example such that contingent control strictly dominates investor control.

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