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Résumé / Abstract

Cet article présente les impacts de la structure de capital sur l'optimalité des contrats financiers contingents. Le rôle des relations financières est non seulement de fournir des capitaux mais aussi d'offrir de l'assurance à un entrepreneur riscophobe par des transferts contingents. Comme ces relations sont de longue durée, si le financier ne peut s'engager à toujours offrir du financement dans le futur, l'assurance ne peut pas être parfaite. Dans ce cas, l'entrepreneur choisit de complémenter l'assurance externe par du financement interne. Si le financier n'a pas tous les droits de propriété sur les réserves de la firme, l'utilisation des réserves internes peut relâcher les contraintes de refinancement externe et améliorer considérablement le niveau d'assurance ainsi que l'efficacité des décisions d'investissement. Ce résultat justifie l'usage de dette convertible dans les relations de capital risque.

This paper examines the impact of capital structure on the optimality of contingent financial contracts. The role of financial relationships is not only to provide funds but also to offer insurance to a risk adverse entrepreneur through contingent financial transfers. Since such financial relationships are long term, the question is on the depth of the financier's commitment to continue to offer financing in the future. If such a commitment cannot be obtained, insurance cannot be perfect. In that case, the entrepreneur chooses to complement outside insurance with internal financing. Depending on the financier's property rights on the firm's assets, the use of reserves can relax the financing constraints and considerably improve not only the level of insurance obtained through the contract but also the efficiency of investment decisions. This rationalizes the use of convertible debt in venture capital relationships.

Mots Clés : Structure de capital, capital de risque, gestion des risques, financement de long terme

Keywords: Capital structure, venture capital, risk management, long term financial contracts

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1 Introduction

The question of capital structure has long been studied in risk neutral environments where risk management issues are ignored to the benefit of incentives and information problems. Risk and risk management considerations are important in financial decisions, however. Indeed, what venture capitalists offer to entrepreneurs with risky projects is, aside from financing, to bear a part of the risk generated by the project. Financial relationships then include a part of risk sharing.

Financial relationships between entrepreneurs and venture capitalists are close and long term. Venture capitalists may have a say in the firm's management and, depending on the cash flows realizing in the firm, they may be called to refinance the project before maturity. Hence, venture capital relationships look like contingent contracts. On the other hand, venture capitalists provide funding in exchange for convertible securities, as preferred stocks or convertible bonds. Aside from the incentives this provides to participate in a proper management of the firm, I claim here that the type of security they receive, and, in particular, the share of ownership they are entitled to, influences their incentives to refinance the firm. This has a great impact on the amount of risk they take on themselves and the amount they leave on firm owners. Hence, the value an entrepreneur receives from his/her project is related to the capital structure embodied in contingent financial contracts. I show in this paper that the use of convertible debt in venture capital can be rationalized by refinancing and risk management considerations.

In the literature of corporate finance, the central topic is generally the determination of the optimal capital structure. For Modigliani and Miller (1958), with perfect capital markets, capital structure is irrelevant since the firm's value is independent on its financing. It has been shown since that, with market imperfections, capital structure matters.[1] Hence, a great part of the literature explains the use of debt by the reallocation of *property rights* implied by debt contracts in case of default. Thus, debt contracts alleviate agency problems in the firm and reduce conflicts of interest between managers and shareholders (Jensen and Meckling, 1976; Harris and Raviv, 1990). The existence of debt in the firm can also send to financial markets the signal that managers have a positive private information on their firm's value (Ross, 1977; Myers, 1984; Myers and Majluf, 1984). Or, debt can be a commitment to

[1]Harris and Raviv (1991) make a survey of the research on the subject.

a more aggressive behaviour on the commodity markets, (Brander and Lewis, 1986) or can be used to avoid takeovers (Harris and Raviv 1988).

More recently, papers have developed the idea that debt can be optimal because it allows a shift of *control rights* in some states of the world. Hart and Moore (1994, 1995, 1998) explain that when managers can have opportunistic behaviours, the verifiable payments imposed by a debt contract force the manager to transfer the firm's cash flows, instead of keeping them for himself or investing in non profitable projects. Moreover,the debt contract imposes the credible threat of transferring the firm's assets to outside investors, then depriving the manager from the power of making decisions. This forces the manager to make some transfers to the outside (the debtholder), then decreasing the amount of free cash flow available for waste expenses.

The literature on incomplete contracts uses the same arguments (Aghion and Bolton, 1992; Dewatripont and Tirole, 1994). When contracts are incomplete, financing through debt contracts is optimal because default can be made contingent on a given signal when decisions cannot. Debt financing allows to shift control, ex post, to the party that will make the first best decision. In Dewatripont and Tirole (1994), capital structure designs income streams and guarantees that control is passed to debtholders, who choose to reorganize, when it is efficient to do so after the realization of the first period return.

This paper diverges from the usual corporate finance literature in that it discusses the relevance of capital structure in a *complete* financial contract with *no asymmetric information*. The financial contract offers financing as well as insurance to the entrepreneur. Since the decision maker in a firm can be a manager whose remuneration depends on the firm's result, or an individual entrepreneur whose remuneration is the firm's earnings, risk aversion can have a great influence on financial decisions. The introduction of risk averse behaviours in corporate finance is not widespread even though some papers, as Leland and Pyle (1977), explain the use of debt by risk averse managers having aversion for default risk, as a way to signal a high firm's value. Here, I argue that the flow of outside financing over time is regulated by the entrepreneur's risk management policy. The entrepreneur needs to smooth the firm's net income in transferring revenue from a period to another or from a state of the world into another.[2] I represent these flows with a unique risk neutral investor providing

[2]A concave utility function for the entrepreneur involves demand for both smoothing and insurance. All along the paper, I call insurance the equalization of income throughout states of nature and smoothing the

contingent transfers over time. Hence, the firm's financing is modeled with a long term contingent contract where the financier embodies the many sources of outside financing and insurance that the firm can find.

With symmetric information and describable states of nature in all periods, a complete contingent contract illustrates perfect financial markets. It can provide full insurance and smoothing to the entrepreneur, except if it is not enforceable for some reason. It seems that, with firm's income observable and verifiable, any contingent contract should be enforceable. I consider, however, that the parties may not find profitable to commit in the contract. In particular, with competition on the financial market, the financier cannot obtain more than a zero expected profit in the contract. He, then, finds no interest in committing to always refinance the firm. The long term contract is implicit, it is well known to each part that the investor agrees to refinance the firm only when it is profitable. The argument is not valid for the entrepreneur as it may be optimal for him to commit in the contract. I then consider that the entrepreneur transfers are enforceable. This is a reasonable assumption since the states of nature being verifiable, it is possible to enforce transfers in states where the entrepreneur is a debtor.

The impossibility to bind outside investors into long term contracts prevents the entrepreneur from obtaining full insurance through perfect contingent transfers. Hence, financial markets are incomplete, explaining that the Modigliani and Miller (1958) irrelevance result does not hold. When financial markets cannot provide sufficient tools for the firm's risk management policy, the entrepreneur distorts the productive decisions to cope with the future variability of operating income.

The entrepreneur can also use internal reserves as a risk management tool. Internal savings can only provide smoothing, not insurance, nevertheless, the use of reserves allows to relax the constraints imposed to contingent transfers by the absence of long term commitment by outside investors and improves insurance as well as smoothing. Reserves transform internal cash into contingent future revenue. The entrepreneur borrows in the first period and saves at the same time. In the following period, the investor may not want to refinance if the return is low. But then, the entrepreneur can refinance through reserves and limit the amount transferred from the investor, amount that is, nevertheless, contingent. Then, the

equalization of income throughout time. The use of a non separable utility function could allow to separate both behaviours, however, this separation is not crucial and makes the model unnecessarily more complex.

existence of reserves allows to circumvent the financier's inability to commit to refinance.

This representation of financial relationships as risk sharing implicit contracts borrows to the literature on dynamic self-enforcing contracts. Models of dynamic relationships with non commitment have enlightened the effect of non commitment in infinite horizon frameworks. Thomas and Worrall (1988) and Gauthier, Poitevin and González (1997) show that consumption can be only partially smoothed and insured by a risk sharing contract between a risk neutral and a risk averse agent when non commitment is bilateral. Sigouin (1999) simulates the path of investment when such a contract represents financial relationships and show that there exists distortions on investment due to imperfections in insurance and smoothing. Gobert and Poitevin (1998) and Ligon, Thomas and Worrall (2000) show that the existence of savings in contingent risk sharing contracts can help relax the non commitment problem. I use, here, a simple version of the risk sharing model. I reduce the horizon to three periods, which is sufficient to analyze the behaviour of savings and investment when transfers are not binding.

In this paper, I insist on the importance of outside opportunities in these non binding contracts. Outside opportunities are dependent on the property rights of each party on the assets at stake. Hence, I show that capital structure matters for the determination of the degree of insurance such contracts can provide, and that this has an impact on the value an entrepreneur receives from his/her firm. The main result of the paper is that the firm's internal reserves (savings) are a complement to outside imperfect financing as long as they can be kept out of the investor's ownership. A risk averse entrepreneur should then retain part of the firm's equity in her own portfolio or diversify financing in combining debt and equity. Convertible debt is an appropriate instrument because it keeps property rights out of the investor's hands as long as refinancing can be needed. It is only when the firm reaches maturity that the investor becomes an owner, at that time, the project is less risky and risk management can be dealt with more conventional instruments.

In section 2, I describe the model and the optimal dividend path for an entrepreneur who makes no use of outside financing as well as the perfect markets financial contract. Section 3 presents the three-period contingent financial contract where the investor does not commit to refinance in the future, that is, the constrained optimal financial/risk management policy. In section 4, I discuss capital structure issues and I interpret the results in the light of the observed venture capital relationships. Section 5 concludes.

2 The model

An entrepreneur runs a firm for three periods. In period 0 she has an initial wealth W. She can consume this wealth or invest all or part of it to ensure returns and consumption in period 1 and 2.

In period 0, the entrepreneur invests an amount k in a productive technology for which return in period 1 is given by the stochastic earning function $g(k, s)$.[3] The function g is strictly increasing and strictly concave in k. Let us denote g' the first order derivative of g with respect to its first argument k, and suppose that $g'(0, s) = \infty$ for all s. The state of nature s is drawn in period 1 from a finite discrete set $\mathcal{S} = \{1, 2, \cdots, S\}$ with probabilities $p^1, \cdots, p^S$, $\sum_{s\in\mathcal{S}} p^s = 1$.

In period 1, the entrepreneur consumes part of the income $g(.,.)$ and re-invests in the productive technology in order to create earnings for period 2. The choice of investment depends on the realization of the state of nature s in period 1, it is denoted $k'(s)$. The production function generating income in period 2 from $k'(s)$ is the same function g as in period 1, and states of nature in periods 1 and 2 are i.i.d. on the same set $\mathcal{S}$.

The entrepreneur can also retain part of the firm's earnings in a savings account where the firm's reserves accumulate at the risk free rate r per period. However, markets are not perfect and the entrepreneur is subject to a credit constraint that makes it impossible to borrow at rate r. Let us denote A, the stock of reserves at the end of period 0. The credit constraint imposes $A \geq 0$. The entrepreneur can use the accumulated reserves to finance the period 1 investment or can save furthermore to increase her consumption in period 2. The stock of reserves at the end of period 1 depends on the income in period 1 and is, therefore, denoted $A'(s)$. The credit constraint in period 1 imposes $A'(s) \geq 0$ for all $s \in \mathcal{S}$.

Denote d_t the firm's dividend, that is, the net income available for the entrepreneur's consumption at the end of period t.[4] The entrepreneur has an aversion for the variability of the firm's dividend. She is endowed with a strictly increasing and strictly concave periodic utility function $u(d_t)$. The entrepreneur has a preference for smoothed dividends and uses reserves to transfer income from period to period. She also has a preference for non risky returns and may not want to invest in a risky technology. However, since g and u are

[3]The function g gives the firm's net income after wages and taxes have been paid for.

[4]The dividend d_t is the productive return g net of investment, financial payments and savings.

increasing, the entrepreneur invests in the productive technology as long as the expected return on capital is higher than the return on savings.

In order to invest in production, the firm can resort to internal as well as outside financing. I show here how this choice depends on the risk sharing the entrepreneur wishes to obtain through financial arrangements. Financing may not only be used as a source of funds to undertake production but also as a risk management tool that allows the entrepreneur to smooth the income that supports her consumption. While internal financing offers no risk-sharing, it is possible to design transfers with an outsider so that final earnings are smoother, or better insured, that the original net income. This is value increasing for the entrepreneur so she would optimally rely, at least partially, on outside financing. However, when markets are not perfect, even a risk-sharing contract with a risk neutral investor may not offer perfect insurance and smoothing. I show in this paper that the distribution of property rights to outside investor is determinant for the allocation of risk between the parties.

The next subsection briefly describes what the entrepreneur can achieve through internal financing, I then describe the relationship with external financiers when markets are perfect. The relationships with external financiers on imperfect markets are described in section 3.

2.1 Internal financing

I impose Inada conditions on the utility function, in particular, $u'(0) = \infty$. Let $\beta = \frac{1}{1+r}$ be the discount factor. The entrepreneur's problem is to make the investment and reserves choices k, A, $k'(s)$ and $A'(s)$, for all s, that maximize her intertemporal utility:

$$u(d_0) + \beta \mathrm{E}_{s\in\mathcal{S}} \left(u(d_1^s) + \beta \mathrm{E}_{z\in\mathcal{S}} u(d_2^z(s)) \right). \tag{1}$$

The period 0 dividend is made of the initial wealth minus any investment or reserves made for the next period: $d_0 = W - A - k$. Period 1 dividend depends on the realization of income in period 1: $d_1^s = g(k,s) + (1+r)A - k'(s) - A'(s)$. The dividend in period 2 depends on the realization of the state of nature in period 2 (z) but also on period 1 state of nature s, since s determines the level of investment $k'(s)$ and saving $A'(s)$ conditioning period 2's income. Period 2 dividend is then denoted $d_2^z(s) = g(k'(s), z) + (1+r)A'(s)$. No investment is made in this last period.

The optimal choice of the entrepreneur who finances through internal funds is given by the Euler conditions derived from the first order conditions for the maximization of (1) subject to the credit constraints $A \geq 0$ and $A'(s) \geq 0$ for all s:

$$u'(d_0) = \beta \mathrm{E}_s u'(d_1^s) g'(k, s) = \mathrm{E}_s u'(d_1^s) + \mu, \tag{2}$$

$$u'(d_1^s) = \beta \mathrm{E}_z u'(d_2^z(s)) g'(k'(s), z) = \mathrm{E}_z u'(d_2^z(s)) + \mu^s \quad \forall s \in \mathcal{S}, \tag{3}$$

where μ and μ^s, $s \in \mathcal{S}$, are the multipliers for the credit constraints respectively in period 0 and period 1, state s.

The Inada conditions and the concavity of the utility function guarantee that the entrepreneur's consumption is never zero at the optimum. For W large enough, the borrowing constraint is not binding ($\mu = 0$) since the entrepreneur chooses to invest in productive capital until the expected marginal return on productive investment is equal to the marginal return on savings. However, if initial wealth W is not sufficient to reach that point, the entrepreneur is willing to borrow at rate r in order to invest at the first best level, what is made impossible by the credit constraints ($\mu > 0$). The same pattern happens in period 1 where the entrepreneur needs to borrow at rate r in order to invest the optimal $k'(s)$, when the realized income is low in the first period.

It is clear from conditions (2) and (3) that the entrepreneur, if she decides to rely on internal financing only, can achieve neither perfect insurance nor perfect smoothing of her dividends. The only way to obtain some insurance is to agree to a schedule of contingent transfers with a risk neutral investor. In the following subsection, I describe the perfect risk-sharing financial contract.

2.2 The perfect financial contract

A risk neutral investor can assume part of the entrepreneur's risk in exchange for a premium. I suppose here that there is competition on the financial markets, so that the maximum premium a risk neutral investor can require is an expected return of r.

The outside investor first invests the amount i in period 0. The financial contract then stipulates contingent transfers in periods 1 and 2. In period 1, the transfer represents a payment from the firm to the investor if realized earnings are high enough. However, if the earnings are too low to allow for the second period investment, the investor must refinance the firm. In that case, the transfer in period 1 goes from the investor to the entrepreneur and the investor waits until period 2 to get a positive return.

In period 0, the entrepreneur decides what part of his project is financed through outside funds and what part is provided by internal resources. Internal financing offers an additional degree of freedom and allows the entrepreneur to control the smoothing of her consumption in period 0 and 1. The entrepreneur may choose to consume part of the outside funds in period 0 and to invest part of it in the productive asset k or in the reserves A. Then, the dividend available for consumption in period 0 is $d_0 = W + i - A - k$.

External financing can be obtained through various types of contracts. In particular, a financial contract can distribute property rights on the firm's assets or not. Hence, I represent by exogenous shares the fact that the investor can receive part of the ownership of the firm. When the entrepreneur sells part of its equity in order to receive funds, the investor gets a share of the firm's assets, he is an equityholder. When the investor gets no property right, he can be interpreted as a debtholder. I also allow the investor to be a mix of equity- and debtholder. This allows us to discuss the influence of the type of outside financing and, hence, of the capital structure, on the risk sharing in financial contracts.

Let us denote α and α' respectively the share of the productive assets and the share of the reserves the outside investor is granted with the contract. I suppose that these shares are exogenous, that is, I don't let the investor's share be dependent on the part of capital he contributed. In fact, outside financing could be supplied through a mix of equity and debt, making the share of the assets in the investor's hand independent of i. On the other hand, I introduce a distinction between property rights on the productive capital and property rights on reserves. This distinction can appear improper since an equityholder is the legal owner of a share of all the firm's assets. However, I want to allow the entrepreneur to be able to hide the reserves, that is, to save on a personal account instead of in a firm's account, then having $\alpha' < \alpha$. We see in what follows that the distinction is important for the characterization of the financial relationships on imperfect markets.

The financial contract specifies contingent transfers τ_1^s and $\tau_2^z(s)$ from the entrepreneur to the investor in period 1 and 2, respectively. Transfers τ_1^s and $\tau_2^z(s)$ depend not only on the current state of nature but on the entire history of realizations of the past states of nature.

The entrepreneur's dividends are then:

$$\begin{aligned}
d_0 &= W + i - k - A, \\
d_1^s &= g(k,s) + (1+r)A - k'(s) - A'(s) - \tau_1^s \\
d_2^z(s) &= (1-\alpha)g(k'(s),z) + (1-\alpha')(1+r)A'(s) - \tau_2^z(s),
\end{aligned}$$

where $s \in \mathcal{S}$ denotes the state of nature realized in period 1 and $z \in \mathcal{S}$ the state of nature in period 2. The investor receives his share of the firm value at the liquidation date in period 2, meaning that the entrepreneur can only consume a share $1-\alpha$ of the operating income and a share $1-\alpha'$ of the retained earnings in period 2.

Suppose that the investor discounts the future at the same rate r as the entrepreneur does. The optimal perfect markets contract solves the following problem.

$$\max_{\substack{i,k,A,\{k'(s)\},\{A'(s)\}\\ \{\tau_1^s\},\{\tau_2^z(s)\}}} \quad u(W-k-A+i) + \beta \mathrm{E}_s\{u(g(k,s)+(1+r)A-k'(s)-A'(s)-\tau_1^s) \tag{4}$$

$$+\beta \mathrm{E}_z u((1-\alpha)g(k'(s),z)+(1-\alpha')(1+r)A'(s)-\tau_2^z(s))\}$$

$$\text{such that} \quad -i + \beta \mathrm{E}_s\{\tau_1^s + \beta \mathrm{E}_z\left(\tau_2^z(s) + \alpha g(k'(s),z) + \alpha'(1+r)A'(s)\right)\} \geq 0 \tag{5}$$

$$A \geq 0, \quad A'(s) \geq 0 \quad \forall s \tag{6}$$

The contract includes an individual rationality constraint, (5), for the financier in period 0. This constraint ensures that the financier's expected payoff in the contract is at least as large as what he can obtain with an alternative use of capital, that is, if he saves at rate r.

Let λ be the multiplier for the investor's individual rationality constraint (5), and μ and μ^s, $s \in \mathcal{S}$ be the multipliers for the credit constraints respectively in period 1 and in period 2 and state s. The first order conditions for the choice of transfers i, τ_1^s and $\tau_2^z(s)$ give

$$u'(d_0) = u'(d_1^s) = u'(d_2^z(s)) = \lambda \quad \forall s, z \in \mathcal{S}.$$

This implies that the entrepreneur can consume the same amount in each period and each state of nature: the contract offers perfect insurance and perfect smoothing. This contract is a perfect contingent contract where the financier is bound for three periods and information is complete. This illustrates the case where the entrepreneur has access to complete financial markets. The contract can offer perfect insurance and perfect smoothing to the entrepreneur and guarantee a return r to the investor.

First order conditions for productive investment in period 1 and 2 are such that

$$1 = \beta \mathrm{E}_s g'(k, s) = \beta \mathrm{E}_z g'(k(s), z) \quad \forall s.$$

Investment in productive capital is always made at the first best level, that is, such that the expected marginal product of investment is equal to its marginal cost. Since the entrepreneur's dividend is fully insured by the contingent transfers, she behaves as a risk neutral investor in production.

The credit constraints are never binding since first order conditions on savings in period 0 and 1 give $\mu = \mu^s = 0$ for all s. Within the financial relationship, the entrepreneur may want to save but this is irrelevant because, since her dividend is already perfectly smoothed and insured with contingent transfers, there is no need to accumulate reserves. The perfect contingent contract then takes no account of reserves.[5]

In this perfect financial environment, the distribution of property rights does not matter since any amount given to the investor through property rights is compensated by the complementary transfer τ in each period, so that the investor only gets a return of r. The distinction between possible sources of outside financing is not necessary since any kind of investor is bounded in an enforceable contract that smoothes and insures the entrepreneur at best and guarantees to the investor an expected return equal to the market return. The existence of such a perfect financial contract amounts to the assumption of perfect markets that leads to the irrelevance result of Modigliani and Miller (1958). Here, as in Modigliani and Miller (1958), the property rights that represent the firm capital structure have no impact on the firm value and the risk is optimally allocated to the risk neutral party.

Markets are not perfect, however. In this paper, I develop on the implicit character of most financial relationships. While a perfect contingent contract imposes prespecified transfers between the parties for all future periods, investors do not in general bind themselves into contracts for long periods of time. Any investor reevaluates at each transfer date, if it is worth or not continuing the relationship with the firm. When the contract prescribes a payment from the firm to the investor (a reimbursement), the latter obviously goes on

[5]Note that if r is less than the discount rate δ (that is, if $\beta(1+r) < 1$), saving is costly and the entrepreneur would like to borrow at rate r, not to save. This is made impossible by the credit constraint and the optimal savings policy is then $A = A'(s) = 0$ for all s. When $r > \delta$ the entrepreneur has incentives to save for growth motives, which is not the interest here.

with the contract. Nevertheless, at times where the firm needs refinancing, the financier can be better off forgetting the period 0 investment and renouncing to refinance further. That is, no contract prescribes that the financier should pay a transfer τ_1^s if this transfer is not profitable ex post. In such implicit relationships, each party recognizes the limits of the other's willingness to participate. The next section describes the level of risk sharing the entrepreneur can achieve in such a relationship, made imperfect by the impossibility to bind an investor in a long term contract.

3 The implicit financing contract

Since all investors refuse to commit in long term explicit contracts that may impose ex post non-profitable transfers, the relationship between the firm and its investor(s) is implicit. The entrepreneur knows that it is not possible to force the investor to refinance the firm after a bad state s in period 1, if it is not interesting for him to do so. Hence, the implicit contract specifies only feasible transfers, that is, transfers that the investor is still willing to perform after the realization of the period 1 return. To comply with the fact that institutions can enforce the payment of any amount due, I assume that the entrepreneur cannot renege on payments due to the financier. Since both parties are well aware of this situation, the determination of transfers in period 0 must take account of "refinancing constraints" that ensure that the investor is still willing to refinance after he has observed the realization of the return $g(k, s)$ in period 1.

These constraints impose limits on the feasible transfers in period 1. They depend on the financier's outside opportunities since, after the realization of the state of nature in period 1, he compares what the contingent contract promises with what he can have if he does not refinance and puts an end to his relationship with the entrepreneur. If the investor exits the relationship in period 1, he liquidates his stakes in the firm and obtains in state s, $\alpha g(k, s) + \alpha'(1+r)A$. Hence, what the investor gets if he exits the contract at the end of period 1 depends on his property rights on the firm's assets.

The absence of a binding contract is, then, represented by the introduction of refinancing constraints into the preceding problem (4). These constraints write for all possible state

$s \in \mathcal{S}$ realized in period 1:

$$\tau_1^s + \beta \mathrm{E}_z \left(\tau_2^z(s) + \alpha g(k'(s), z) + \alpha'(1+r)A'(s)\right) \geq \alpha g(k, s) + \alpha'(1+r)A \tag{7}$$

The refinancing constraints (7) ensure that, after the realization of state s, the expected payoff for the investor in the financial relationship (left-hand side member of the constraint) is at least as large as what he gets if he exits the contract and liquidates his share of the assets (right-hand side member).

I suppose that any transfer is enforceable in the last period. This allows for a solution for the contract. In a t-period relationship, we would still have to suppose commitment in the last period or the anticipation of a breach of contract in this last period would ruin the value of the relationship from period 0 on. This assumption is then to be seen as a transversality condition and does not affect the existing impact of non commitment in the inner periods on the efficiency of the contract.

Without competition on the investor's side, such a contract may not be renegotiation proof. That is, the investor could breach the contract after realization of period 1's return and propose a new schedule of contingent payments, giving no profit to the entrepreneur. With competition, this is ruled out since the entrepreneur is able to negotiate with another investor who requires an expected return of r only for refinancing. The original investor can then obtain no more than his share of the property value.

Since the investor is not bound into the contract, the relationship looks like a sequence of short term contracts where the investor reevaluates his benefits to agree to a contract after the realization of period 1's net income. However, I show in the appendix that a long term contract with constraints on refinancing dominates a sequence of short term contracts.

Let $\beta p^s \psi^s$, $s \in \mathcal{S}$, be the Lagrange multiplier for the refinancing constraints (7) in problem (4). Differentiating with respect to i, τ_1^s, $\tau_2^z(s)$, k, A, $k'(s)$ and $A'(s)$ for all s and z , we obtain the following set of first order conditions:

$$u'(d_0) = \lambda \tag{8}$$

$$u'(d_1^s) - \psi^s - \lambda = 0 \qquad \forall s \in \mathcal{S} \tag{9}$$

$$u'(d_2^z(s)) - \psi^s - \lambda = 0 \qquad \forall s, z \in \mathcal{S} \tag{10}$$

$$u'(d_0) = \beta \mathrm{E}_s g'(k, s)(u'(d_1^s) - \alpha \psi^s) = 0 \tag{11}$$

$$u'(d_0) = \mathrm{E}_s(u'(d_1^s) - \alpha'\psi^s) + \mu \tag{12}$$

$$u'(d_1^s) = \beta \mathrm{E}_z g'(k'(s), z)((1-\alpha)u'(d_2^z(s)) + \alpha\lambda + \alpha\psi^s) \qquad \forall s \in \mathcal{S} \tag{13}$$

$$u'(d_1^s) = (1-\alpha')\mathrm{E}_z u'(d_2^z(s)) + \alpha'\lambda + \alpha'\psi^s + \mu^s/\beta p^s \qquad \forall s \in \mathcal{S} \tag{14}$$

The optimal financial arrangement for the firm under the refinancing constraints is given by these conditions. The following Results describe the solution for the different variables characterizing the implicit contract.

Result 1 *The contract is such that the entrepreneur receives full insurance and perfect smoothing in the last period.*

Dividends are smoothed between period 1 and 2 since conditions (9) and (10) imply $d_2^z(s) = d_1^s$ for all $z \in \mathcal{S}$. There is also full insurance since the dividend in period 2 does not depend on the state of nature realized in that period. This results obtained in perfect markets, it is unaffected by the introduction of refinancing constraints since these constraints are effective in period 1 only. There is still perfect commitment in the last period, which leaves decisions non distorted for this period.

Result 2 *Investment and reserves for the last period are set as in the perfect markets contract.*

Conditions (13) together with conditions (9) and (10) gives $\beta \mathrm{E}_z g'(k'(s), z) = 1$. That is, for any s, $k'(s)$ is first best because the multiplier λ of the individual rationality constraint is positive (from (8)). On the other hand, condition (14) and Result 1 impose $\mu^s = 0$ for all possible s, that is, the entrepreneur is not liquidity constrained. Variables $k'(s)$ and $A'(s)$ do not have to be used to improve smoothing and insurance, since smoothing and insurance in period 2 are guaranteed by full commitment. Hence investment is set at its first best level and reserves are not necessary since smoothing is provided by the contingent transfer $\tau_2^z(s)$. This result is, as I mentioned earlier, a consequence of the assumption of full commitment in the last period. This is valid for the last period only and does not represent the main characteristic of our implicit contract.

Result 3 *Dividends in period 1 cannot be perfectly insured nor smoothed in the constrained contract.*

Condition (9) shows that, due to the refinancing constraints, dividends now depend on the state of nature in period 1:

$$u'(d_0) = u'(d_1^s) - \psi^s.$$

If the refinancing constraint binds in state s (i.e., $\psi^s > 0$), the dividend must be reduced compared to the perfect insurance one, then, $u'(d_1^s) > u'(d_0)$. If the contract would impose insurance ($u'(d_1^s) = u'(d_0)$) when $\psi^s > 0$, then the investor would refuse to refinance because this would involve a too high payment in period 1, compared to what the expected income is for period 2. The entrepreneur has, then, to accept a decrease in her dividend, and imperfect insurance, in exchange for the refinancing of her project.

This result on imperfect insurance in period 1 is linked to the characterization of investment and reserves in period 0. The next two Results explain that, while refinancing constraints affect the risk sharing, some distributions of the property rights may restore the conditions for first best decisions in the first stage.

Result 4 *(i) If the outside investor has full ownership of the firm's productive assets ($\alpha = 1$), investment is always done at first best in period 0.*

(ii) If the investor holds less that the entire equity, ($\alpha < 1$), there is over-investment in productive capital when some of the refinancing constraints bind.

The consequence on investment of imperfect insurance due to refinancing constraints is given by condition (11). Together with (8) and (9), this condition gives:

$$\mathrm{E}_s \left(g'(k, s)(1 + \frac{(1-\alpha)\psi^s}{\lambda}) \right) = 1 \tag{15}$$

There are only two ways we can obtain first best productive investment. Either no refinancing constraint is binding ($\psi^s = 0$ for all s) and, hence, markets are perfect, or the investor is the owner of the project ($\alpha = 1$). With the entire firm's equity sold to an outside financier, the contract is first best because the decision maker is now a risk-neutral investor dealing with himself.

In any other case, there is overinvestment in productive capital. Overinvestment is triggered by the possibility of some refinancing constraints binding in some states of nature in period 1. Having a binding refinancing constraint in state s means that the refinancing that the entrepreneur can obtain is limited in that state. If this state realizes in period 1, the entrepreneur will have to bear a negative consumption shock in order to finance the optimal investment in period 1. Overinvesting in period 0 alleviates the possible shock in the next period by increasing the realized income in all states. Hence, when the contract cannot force the investor to refinance, the entrepreneur has to trade off distortions in productive decisions against risk management issues. This result has been shown in Sigouin (1999) in an infinite horizon model with investment. Sigouin (1999) then simulates the path of investment in this environment.

However, as the next Result shows, the existence of a reserves account can make up for the need to overinvest in production. If the entrepreneur saves in the reserves instead, this can compensate for the need of extra funds in the next period if a binding state realizes. The mix of external and internal sources of funds provides an adequate way of avoiding decrease in future consumption as well as current overinvestment in production. Gobert and Poitevin (1998) show in a infinite horizon model that the use of saving can help relax a financier's refinancing constraints. The entrepreneur uses reserves as a collateral and maintains the firm's future value high enough to keep the investor interested in the contract. However, in their paper, the outside investor is considered having no property rights on the firm's assets, meaning that he cannot exit the contract with the reserves. If he can, accumulated reserves have a reverse effect on the investor's incentive. A sufficient amount of reserves can induce the investor into liquidating the firm after a bad realization of the project's return.[6]

Result 5 *(i) If the outside investor has full ownership of the firm's reserves ($\alpha' = 1$), then the firm is not liquidity constrained and investment can be distorted.*
(ii) If the outside investor has less than the entire ownership on reserves ($\alpha' < 1$), neither the credit constraint nor the refinancing constraints bind in period 1. Smoothing and insurance are perfect and investment is made at first best.

The first order condition (12) on first period saving is (using (8) and (9)): $\lambda = \mathrm{E}_s(\lambda + \psi^s) + \mu - \alpha' \mathrm{E}_s(\psi^s)$. That is,

$$\mu + (1 - \alpha')\mathrm{E}_s \psi^s = 0. \qquad (16)$$

[6] See also Ligon, Thomas and Worrall, 2000.

This implies that for $0 \leq \alpha' < 1$, it must be that $\mu = \psi^s = 0$ for any s. In this case, the refinancing problem is entirely relaxed by the existence of the reserve account and equation (15) expresses that investment is first best.

In the absence of a reserve account, the entrepreneur overinvests in order to increase the future expected operating income and then reduce the need to resort to external refinancing in period 1. When she can save in period 0, the entrepreneur reduces her own investment in the project and saves a certain amount instead. The amount i borrowed is then higher. The investor agrees to lend more because this decreases the amount he may be called to refinance the period after, and he is paid back anyway in the last period by an increased expected transfer in period 2. In period 1, the entrepreneur is less dependent on the investor since she has been able to transfer borrowed amounts into periods and states where the investor is unwilling to lend anymore. Hence, there is a complementarity between the use of internal funds and contractual borrowing. The entrepreneur can borrow more in period 0 if she accumulates reserves in the same time. Saving today is a way to commit the investor when both know he would not be willing to maintain the relationship tomorrow. However, since the return on reserves is not contingent on the realization of the operating return, a transfer τ_1 is always necessary to adjust for insurance. This transfer does not have to be a large refinancing, however, since internal reserves provide most of the refinancing. If the realization of the productive return is favorable and the entrepreneur needs no refinancing, then the transfer is positive and amounts to a reimbursement of the large i borrowed in period 0.

Since refinancing is not problematic when the investor has no property rights on the assets, there is no need to use overinvestment to remedy to imperfect insurance. As shown in condition (15), the slackness of refinancing constraints ($\psi^s = 0$ for all s) implies that investment is done at first best level.

The story is not the same, however, when the investor is the owner of the reserve account. Having $\alpha' = 1$ supposes that the entrepreneur sells the entire ownership of the reserves to the outside investor in order to get financing in period 0. Condition (16) with $\alpha' = 1$ implies $\mu = 0$, that is, the credit constraint is not binding. But condition (16) does not imply that multipliers ψ^s are 0 in all states. That means that the existence of reserves cannot help relaxing the investor's refinancing constraints. This is intuitive because the investor is now the owner of the entire stock of reserves. He makes his refinancing decision after comparing the liquidation and continuation values of the firm. The stock of reserves affects equally these two values and cannot help increase investor's incentives into refinancing. Savings are then ineffective to improve insurance and the entrepreneur's dividends remain dependent on the refinancing constraints.

The impact of the investor's ownership on reserves is more easily understood if we rewrite the refinancing constraints (7), replacing the transfers τ with their expressions in terms of entrepreneur's consumption d:

$$g(k,s) + (1+r)A - k'(s) + \beta \mathrm{E}_z g(k'(s),z) - (1+\beta)d_1^s \geq \alpha g(k,s) + \alpha'(1+r)A. \quad (17)$$

In this writing, I ignore $A'(s)$ since Result 2 implies that $A'(s) = 0$ is a solution and I replace $d_2^z(s)$ with d_1^s by Result 1. This writing makes it clear that the contract can be interpreted as assigning a contingent consumption d_1^s to the entrepreneur and leaving what is left of the firm's income to the investor. The left-hand side member of the constraint still represents the investor's payoff if he refinances in state s, the right-hand side member is what he gets if he quits in state s. It is clear that as long as $\alpha' < 1$, an increase in A enhances incentives to stay more than incentives to leave. When $\alpha' = 1$, however, the amount of savings cannot influence the refinancing decision.

The choice of investment k when savings do not help relaxing refinancing constraints is not affected by the existence of internal funds in the firm. This choice only depends on the investor's property rights α on the production returns $g(k,.)$. Let us suppose that the property rights on firm's assets apply on the same basis to productive returns and to reserves, that is, $\alpha = \alpha' = 1$. In this case, investment is done at the first best level. This means that the risk neutral equityholder can induce the entrepreneur (now reduced to a manager) to make all first best investment decisions at the cost of offering her an imperfectly insured and imperfectly smoothed remuneration schedule. The pressure to prevent the owner from liquidating the firm after period 1 is not put through investment distortion but through distortions on the manager's contingent wage.

If there are some liquidation costs applying to productive assets only, and such that the equityholder cannot retrieve the entire value $g(k,.)$ if he liquidates the firm ($\alpha < 1$ when $\alpha' = 1$), investment is not made at first best level. Hence, only an investor with 100% of the productive assets after liquidation, makes first best decisions on investment because he can retrieve the entire return on that investment after liquidation. If he cannot appropriate the entire return, there is a tendency to overinvest in period 0 in order to relax refinancing constraints in period 1 and improve the overall insurance obtained by the entrepreneur in the contract.

When the entrepreneur sells only part of his equity in exchange for financing in period 0, both α and α' are strictly lower than 1. The first order condition (16) on saving implies that $\mu = \psi^s = 0$ for all s with this value for α'. That is, as soon as the investor does not have property rights on the entire stock of reserves, reserves fully play their role in relaxing the financier's refinancing constraints. From the first order condition on productive investment (15), this implies that $\mathrm{E}_s g'(k, s) = 1$. Hence, if the entrepreneur can keep a part of the firm's reserves in his own portfolio, refinancing constraints never bind and the constrained optimal investment decision is first best.

4 Discussion

The use of internal funds allows the entrepreneur to relax the outside investor's constraints. However, if that investor is the residual claimant on the entire stock of reserves, reserves are inefficient to play this role and refinancing can be binding. In that case, there could be overinvestment in productive capital.

The capital structure of the firm is characterized by the distribution of property rights. Roughly, if the outside investor is a debtholder, he has no property rights on the firm's assets. The only way he could be transferred these rights, is if the entrepreneur defaults, what I ruled out. If he himself defaults, that is, if he refuses to refinance the firm after the first period realization of the return, he then loses everything. That means, he refuses to refinance in states of nature where the return on k is small and the period 2 expected return is not high enough to make a reinvestment profitable. In that case, the debtholder prefers to abandon the firm and lose his investment i rather than reinvest in $k'(s)$ and have a negative payoff.

A shareholder, on the other hand has a property right on the assets. He cannot lose this right if he refuses to refinance the firm. Hence, the equityholder compares the expected return in period 2 and the liquidation value in 1. If he does not find it interesting to refinance the firm after a bad result in period 1, he can liquidate the firm (if he has enough control of the firm) or sell his share of the equity.

The entrepreneur may use both kind of financing, that is, issue some debt and still give up a share of her ownership. This way, she can keep control of a part of the firm's equity and obtain the proper level of risk sharing. In this paper, I have to take the shares of ownership as exogenous since this model is not suitable to determine the optimal capital structure. However, the results show that selling off 100% of the equity to obtain financing is not the optimal policy for an entrepreneur who wishes to obtain risk sharing during the life of the project. A mix of equity and debt financing or a 100% debt financing is recommended if the entrepreneur want to be able to control the risk she bears. Her choice in that matter depends on the conditions prevailing on the financial markets and, presumably, on some considerations for incentives to participate in the firm management, an issue that is not taken into account in this model.

Having $\alpha \neq \alpha'$ is possible only if the entrepreneur can save part of the funds obtained for the firm's financing on a personal hidden savings account. Supposing that reserves are not observable by the investor does not change the conclusions of the model. Since the contract specifies transfers, the investor is not supposed to observe the entrepreneur's final consumption for the solution to be an equilibrium of the financing game. However, saving on a personal account would be an illegal practice from the entrepreneur.

The distinction I introduce between property rights on the productive assets (α) and property rights on the reserves (α'), however, is not a crucial assumption to obtain the results. It only helps separate the two important effects at stakes in the financial relationship. First, the complementarity between internal and external financing in the risk management depends on the property rights on reserves that may induce the investor to exit the relationship. Second, the decision to distort the investment decision depends only on the property rights on the return on productive assets. In reality, the two shares α and α' can be equal. The model then shows that it is advantageous for the entrepreneur to retain part of the firm's ownership in her portfolio.

While the distinction between productive assets and reserves is only helpful for the understanding of the inner effects of each variable in the model, it is interesting to note that an important distinction lies in the timing of the distribution of shares. The model implicitly imposes that the share of assets given out to the investor is fixed at the beginning of the relationship and valid until the last period. However, the refinancing constraint as it is written in equation (17) makes it clear that it is only the share of the assets the investor owns in period 1 that influences his incentives to refinance. This share could be different in period 2 without changing the conditions for refinancing. Convertible bonds allow to change the shares of ownership in time. Using convertible debt, the entrepreneur gives to her investor all the incentives to take care of the management of the project[7] since the investor receives ownership of the firm in the last period. However, in period 1, the security held by the venture capitalist is a debt, meaning that his share in the firm's equity is $\alpha = \alpha' = 0$. In period 1, outside opportunities for the venture capitalist are to leave the relationship with no share of the returns while remaining in the contract entitles him to a share of the return in the second period. In this case, the difference between share of the reserves' ownership and share of the capital's ownership is not central. What matters is that it is possible to take the value of the reserves (and productive assets) away from the investor's outside value in period 1.

The literature on venture capital rationalize the use of convertible debt with the needs to give incentives to both parties to undertake the proper efforts of management. This paper introduces another aspect of convertible securities. The entrepreneur has the knowledge to undertake her risky project and needs incentives to put the right amount of effort in it as long as the project has not reached maturity. She may prefer to sell the company, however, once the project reaches maturity and its value is high. At that stage, any manager could carry on with the firm. The entrepreneur's problem is to receive financing and risk sharing during the early stage, when returns are highly risky. The paper shows that convertible debt is the right security since it allows to preserve risk sharing during this early stage in awaiting period 2 to transfer ownership to the venture capitalist.

5 Conclusion

While most of the literature on capital structure is concerned with the effect of asymmetric information, taxes or bankruptcy organization to explain the choice of financing, I show here that risk management issues should be taken into account. Risk averse entrepreneurs or managers manage the firm financing so that the final dividend is not too variable in

[7] This is an aspect that is not developed in the paper but I don't deny it may be important in venture capital relationships.

time. Financing relationships are then to be studied on the long term. For a risk averse entrepreneur, there are gain to trade with a risk neutral venture capitalist and obtain some risk sharing. Their relationships, then, take the form of a contingent contract since they exchange risk. The contingent contract, however, is imperfect because investors don't bind themselves in long term enforceable contracts with risky firms.

Two main conclusions arise from the paper. First, internal and external financing are complementary in an adequate risk management policy. For this to be true, it is important that the entrepreneur can keep ownership of her firm, at least partially, under her control as long as she endures risky returns on her project.

Second, convertible securities allow to change the composition of the capital structure in time. This is of the greatest importance in our case since the entrepreneur can keep the reserves out of the investor's control as long as the project has not reached maturity and the firm can need refinancing. Convertible security help controlling the investor's outside opportunities along the life of the financial relationship. Hence, risk management considerations are important and they help rationalize the use of convertible securities in venture capital relationships.

Appendix

I show here that a sequence of short term contracts cannot offer a better insurance than a long term arrangement. Suppose that the entrepreneur can deal with any investor on the competitive market and that they arrange for short term contracts only. A contract in period $t = 0$ specifies investment outside investment i and reimbursement τ_1^s contingent on period $t = 1$ state of nature. Non commitment in period $t = 1$ imposes $\tau_1^s \geq 0$ for all s and the contract must verify an individual rationality constraint for the investor.

At the end of period $t = 1$, the entrepreneur may need refinancing for next period investment $k'(s)$. This refinancing in state s is done through another short term contingent contract (with, possibly, another investor) through which investor lends i_1^s and entrepreneur reimburses $\tau_2^z(s)$ at the end of period $t = 2$. Since there is full commitment in period $t = 2$, $\tau_2^z(s)$ can be anything.

Notice that if the entrepreneur cannot commit to pay his due at the end of period

$t = 1$, the first short term contract is never executed. Then, non commitment involves the impossibility of contracting in period $t = 0$. This is strong enough to show that the entrepreneur prefers long term relationship with his financier.

However, even if the entrepreneur can commit to always execute transfers τ_1^s, the constraint set for the short term problem is included in the set for long term problem. The sequence of short term contract is then more restrictive than the long term relationship. Insurance through long term contracts is then at least as good in long term relationships as I show in what follows.

The optimal contract in period zero is then solution to:

$$\max \quad u(W-k+i-A)+\beta \mathrm{E}_s[u(g(k,s)+(1+r)A-k'(s)-A'(s)-\tau_1^s+i_1^s)+ \beta \mathrm{E}_z u(g(k'(s),z)+(1+r)A'(s)-\tau_2^z(s))$$

such that

$$\tau_1^s \geq 0 \quad \forall s \in \mathcal{S} \tag{18}$$

$$-i+\beta \mathrm{E}_s \tau_1^s \geq 0 \tag{19}$$

$$-i_1^s+\beta \mathrm{E}_z \tau_2^z \geq 0 \quad \forall s \in \mathcal{S} \tag{20}$$

Whereas the constraints for the long term relationship are:

$$-i+\beta \mathrm{E}_s[\tau_1^s-i_1^s+\beta \mathrm{E}_z \tau_2^z(s)] \geq 0 \tag{21}$$

$$\tau_1^s-i_1^s+\beta \mathrm{E}_z \tau_2^z \geq 0 \quad \forall s \in \mathcal{S} \tag{22}$$

The individual rationality constraint (20) for period $t = 1$ contract is more binding than the refinancing constraint (22). It is easy to show that any vector, $(\tau_1^s, \tau_2^z(s))$ that satisfies the constraints for the short term problem, satisfies the constraints for the long term problem also.

Constraints (18) and (20) in the short term problem directly imply that constraint (22) in the long term problem is verified. Then constraints (20) for all s imply $\mathrm{E}_s[-i_1^s+\beta \mathrm{E}_z \tau_2^z] \geq 0$ and, together with (19) give (21). QED.

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