A Portfolio Approach to Venture Capital Financing*

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Abstract

This paper studies the contracting choices between an entrepreneur and venture capital investors in a portfolio context. We rely on the mean-variance framework and derive the optimal choices for an entrepreneur with and without the presence of different kinds of venture capitalists. In particular, we show that the entrepreneur always has the incentive to share the risk and benefits of the venture whenever possible. On the basis of their objectives and characteristics, we distinguish the situations of the corporate, independent, and bank-sponsored venture capital funds. Our framework enables us to derive the optimal contract design for the entrepreneur, featuring the choice of investor, the entrepreneur's investment in the venture, and her dilution in the project's equity as a function of her bargaining power. This result allows us to characterize the choice of the investor depending on her cost of equity and debt capital. In addition to project size and risk, entrepreneur's risk aversion turns out to be a critical determinant of VC investor choice – a finding which is strongly supported by a panel analysis of VC fund flows for 5 European countries over the 2002–2009 period.

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1 Introduction

To date, financial research devoted to the determination of the entrepreneur's cost of capital in the context of portfolio choice has preferably applied principles based on the integration of illiquid assets in the CAPM framework (see in particular Meulbroeck, 2001; Kerins et al., 2004). The specificity of the entrepreneurial project, and the impossibility to partition it into transferable financial securities make it difficult to precisely assess the relevant risk premium. Still, within the context of the CAPM, it is possible to move forward to address a mean-variance formulation of the cost of capital. Garvey (2001) introduces an entrepreneur-specific project into the classical framework, and relates the venture's cost of capital to the entrepreneur's risk aversion coefficient. But he further goes in the direction of identifying the cost of capital in a pure portfolio context with only financial assets. So far, the examination of the entrepreneur's problem within the portfolio theory framework has not dealt with the explicit intervention of an outside investor such as a venture capitalist, in spite of the relevance of this scenario.

At another level, the vast majority of the literature addressing the initial investment relationship between entrepreneurs and venture capitalists focuses on information asymmetries, liquidity, and the value-added of the venture.[1] Upstream from this approach, several issues are still unresolved and can be directly considered within the CAPM equilibrium framework. Amongst the most important ones, the entrepreneur's choice to resort to a venture capitalist raises two questions that directly relate to a portfolio problem: (i) would the availability of a venture capital contract induce the entrepreneur to undertake a profitable venture if she did not otherwise? and (ii) could the characteristics of such a contract enhance the risk-return properties of the entrepreneur's global portfolio? To the best of our knowledge, despite their importance, these questions have not been addressed in the financial literature.

In a dispassionate context where economic agents are rational risk averters with homogeneous in-

[1] See Schwienbacher (2007) for a review.

formation, our paper studies the determinants of the contracting preferences between the entrepreneur and the investor in a pure portfolio choice context, where allocation decisions are taken on basis of risk and return characteristics. These preferences feature the choice of the investor type and the characteristics of the contract between the entrepreneur and the selected investor. We deliberately leave aside considerations regarding the positive externalities brought by the investor on the intrinsic value of the venture (i.e. reduction of risk and/or enhancement of expected returns), and concentrate on the pure portfolio issues. As a major outcome of this analysis, we get that the entrepreneur always has a rational incentive to seek for an outside investor in the venture, even if she would have undertaken the project anyway and despite the fact that the investor would not bring any added value to the project. Bringing an analogy to insurance policies, the reason for this positive result has to be found by the risk sharing property of the contract, whereby the entrepreneur is better off by giving up some project return in excess of financial asset in exchange of a more-than proportional reduction in her global risk exposure through the venture capital contract.

The literature devoted to the determinants of venture capital investor choice is abundant. Besides their usual categorization based on their level of involvement in the venture, potential investors can be discriminated in various ways, such as level of private information (Ueda, 2004; Chemmanur and Chen, 2006), availability of internal resources (Katila et al., 2008; Subramaniam, 2009), experience (Sørensen, 2007), presence of complementarities (Hellmann et al., 2008) or project innovativeness (Hirsch and Walz, 2006). Consistent with the context of portfolio theory, we adopt a partitioning of investors similar to Hirsch and Walz (2006) and Hellmann *et al.* (2008), based on the distinction between independent, corporate or bank-sponsored venture capital investors. Such a classification enables us to analyze investor characteristics from the point of view of their cost of capital, which would be their major source of difference in a risk-return framework. We derive that the optimal choice of investor depends on her cost of capital components, on the risk aversion level of the entrepreneur and on the characteristics of the project, but is independent of the design of the contract itself. In particular, investor selection is not contingent on the bargaining power of the entrepreneur.

Starting from the same neutral point of view, in the absence of synergy or asymmetric information effects, we endogenize important contractual elements such as the proportion of capital invested and the entrepreneur's equity ownership from the point of view of the relative strength of the contracting agents. Regarding the entrepreneur, our major finding is the separation between the decision of how much to invest in the venture, which only depends on cost, risk level and risk tolerance characteristics, and the arrangement of the share of equity held in the project, after dilution, which depends on the bargaining power of the contractors. Our findings that, whatever the contractual arrangements, the entrepreneur's stake in the project decreases with project risk and increases with his wealth endowment, holds firmly in our framework with symmetric information. We do not have to resort to signaling (Leland and Pyle, 1977) or agency theory (Bitler et al., 2005) to make such a derivation.

The portfolio approach to venture capital has the potential to fill an important gap in the economic motivations of venture investments. We show that, whenever possible, the entrepreneur has always a rational incentive to enter a contract with a venture capitalist. By partitioning venture capital investor groups into corporate, independent, and bank-sponsored funds, we identify the discriminating factors that drive the choices of contractors and contracts in a pure context, i.e. in the absence of externalities induced by the relationship. Our framework enables us to derive the optimal contract design for the entrepreneur, featuring the choice of investor, the entrepreneur's share in the venture, and her dilution in the project's equity as a function of her bargaining power. This result allows us to link the optimal investor choice to her cost of equity and debt capital. Combined with our numerical analysis, the results derived in this study shed new light on the fundamental choices underlying the entrepreneur-investor relationships.

A panel data analysis of venture capital fund flows in 5 European countries over the 2002-2009 period provides strong support for one of the main predictions of our model, namely the relation between entrepreneur's risk aversion and the choice of venture capital investor type.

The paper is structured as follows. Section 2 presents the model setup. In sections 3 and 4, we characterize the preferences and contracts between the entrepreneur and the venture capital investors. The fifth section presents the results of the numerical analysis. In section 6, we report our empirical analysis. Section 7 concludes. Proofs are gathered in the Appendix.

2 Setup

Consider a financial market where a set of risky securities and a risk-free asset are traded in the absence of arbitrage. There are two agents: a potential entrepreneur (e) and a financial investor. Both have full access to all traded securities, but may differ in their risk aversion. The entrepreneur, whose endowment is normalized to 1, has proprietary access to a non-marketed venture investment π yielding a rate of return r_π. This venture is not accessible to the investor. We assume that the venture initial outlay is $K > 1$ so that the entrepreneur needs additional financing to undertake it.

All portfolio rates of return $\tilde{r}_j$ are entirely characterized by their expectation $r_j \equiv E(\tilde{r}_j)$, their standard deviation $\sigma_j \equiv \sigma(\tilde{r}_j)$ and their beta β_{jm} with respect to the market portfolio m. The return on the riskless asset is denoted r_f. For any given portfolio j, each agent a assigns a utility score $E(U_a(j)) \equiv U_j^a = r_j - \frac{1}{2}\gamma^a\sigma_j^2$, where U_j^a is a shortcut for the expected utility operator and γ^a represents the agent's constant relative risk aversion coefficient.[2]

The CAPM with two-fund separation holds on the financial market. At equilibrium with financial assets, each investor holds her utility-maximizing portfolio ϕ by combining the risk-free asset with the market portfolio with expected return r_m.

[2] Throughout, subscripts and superscripts refer to portfolios and agents, respectively.

2.1 Absence of venture capitalist

When scaled by its relative size, the project's risk-return trade-off $(K\sigma_\pi, Kr_\pi)$ locates it above the market market CML for the entrepreneur.[3] In the absence of any financial investor, the entrepreneur has to choose between her initial financial portfolio and the investment in the venture financed through a loan.

The no-venture case If the entrepreneur does not undertake the venture, she holds a portfolio of financial assets whose expected rate of return is:

$$r_\phi^e = \frac{\sigma_\phi^e}{\sigma_m} r_m + \left(1 - \frac{\sigma_\phi^e}{\sigma_m}\right) r_f,$$

where

$$\sigma_\phi^e = \arg\max_\sigma \left(\frac{\sigma}{\sigma_m} r_m + \left(1 - \frac{\sigma}{\sigma_m}\right) r_f - \frac{1}{2}\gamma^e \sigma^2\right) = \frac{r_m - r_f}{\gamma^e \sigma_m}.$$

The entrepreneur's initial utility score is

$$U_\phi^e = r_f + \frac{1}{2\gamma^e}\left(\frac{r_m - r_f}{\sigma_m}\right)^2 = r_f + \frac{1}{2\gamma^e}\left(\frac{r_\phi^e - r_f}{\sigma_\phi^e}\right)^2. \tag{1}$$

The self-financed venture case To self-finance the project, the entrepreneur must borrow $K - 1$ at the risk-free rate.[4] The expected return from her investment in the venture has expectation $r_f + K(r_\pi - r_f)$ and standard deviation $K\sigma_\pi$. The expected utility extracted from the venture project is

$$U_\pi^e = r_f + K(r_\pi - r_f) - \frac{1}{2}\gamma^e K^2 \sigma_\pi^2. \tag{2}$$

The relevant characterization of the venture is when the following two conditions are met: (C1) the investment opportunity induces a higher risk for the entrepreneur than her financial portfolio ϕ, i.e. $K\sigma_\pi > \sigma_\phi$; (C2) the venture investment lies above the CML, i.e. $\frac{r_\pi - r_f}{\sigma_\pi} > \frac{r_m - r_f}{\sigma_m}$.

[3] Because the project risk is not wholly diversifiable for the investor, the Security Market Line is not adequate for the analysis of the project risk and return. See Garvey (2001) for a discussion.

[4] Considering a higher borrowing rate would not change the qualitative insights of the model.

Proposition 1 *Under conditions (C1) and (C2), the venture is self-financed iff*

$$\gamma^e < \overline{\gamma}^e = \frac{(r_\pi - r_f) + \sqrt{(r_\pi - r_f)^2 - \sigma_\pi^2 \left(\frac{r_m - r_f}{\sigma_m}\right)^2}}{K\sigma_\pi^2}.$$

Given project and market risk-return profiles, the upper bound of entrepreneur's risk aversion for self-financing the venture is inversely related to K, which is the project size normalized by the entrepreneur's wealth. That is, all else equal, when the entrepreneur is highly financially constrained (i.e. large K), it will take a low level of risk aversion for her to accept self-financing. In other words, outside financing from venture capital is more likely to be needed when (i) entrepreneur's risk aversion is high, or (ii) entrepreneur's financial constraint is high. The result of Proposition 1 represents the starting point adopted by Garvey (2001) in his study of the cost of capital for the undiversified investor. Our paper diverges by considering the interaction between the entrepreneur and the investor, while Garvey's analysis focuses on the entrepreneur's portfolio choices and their impact on the required rate of return for the venture.

2.2 Availability of venture capital

The entrepreneur and the investor can enter a venture capital contract. Broadly speaking, such a contract is characterized with two features. First, it specifies the participations of each party. We denote $0 \leq S \leq K$ the amount invested by the entrepreneur, the remainder $(K - S)$ comes from the investor. Second, the contract determines how the expected returns generated by the venture are split between the entrepreneur and the investor. Consistent with our contract characterization, Bengtsson and Ravid (2009) report, in their empirical studies of 1,800 venture capital contracts, six types of contract terms that fundamentally serve two goals: (i) to define the contingent cash flows to be received by the investor (e.g. cumulative dividends or participation clauses) and (ii) to define the contingent cash flows that the investor commits to put on the table (e.g pay-to-play clause). Interestingly, the sharing rule of profits can differ from the initial participations and *dilution* in venture capital contracts reflect this difference. We therefore denote $d\frac{S}{K}$ the fraction of the expected project revenues that the entrepreneur is entitled to, where d is the dilution factor.

Alternatively, dilution in the venture capital contract can be captured through an interest payment. Taking dilution into account, the entrepreneur obtains an expected dSr_π from his investment on the venture and $(1-S)r_f$ from his remaining endowment. Consider instead a contract where the investor offers the entrepreneur $Sr_\pi + (1-S)\,\tau$ as a reward for the total investment, where τ denotes a riskless contractual transfer rate. The two contracts are made equivalent by setting

$$\tau = \frac{S}{1-S}\,(d-1)\,r_\pi + r_f. \tag{3}$$

If, for example $S > 1$, then the entrepreneur borrows extra money to increase her investment in the venture. The investor offers to lend this amount but proposes to charge a transfer rate $\tau > r_f$, hence from equation (3) $d < 1$. That is, the entrepreneur agrees to receive a diluted fraction of the project revenues.

With $d > 1$ (i.e. dilution is favorable to the entrepreneur), the entrepreneur enjoys favorable terms for lending ($\tau > r_f$ if $S < 1$) or for borrowing ($\tau < r_f$ if $S > 1$). With $d < 1$, the reverse is true. Therefore, there is no economic difference between defining a dilution factor d or setting a transfer rate τ. We will further characterize the venture capital contract with the pair (S, τ).

A contract between the entrepreneur and the investor is feasible if each of them has an incentive to participate. Denote $U^a(S,\tau)$ the expected utility extracted by agent a from the contract. A contract is feasible iff

$$\begin{cases} U^e(S,\tau) \geq U^e_{\phi,\pi} \equiv \max\left(U^e_\phi, U^e_\pi\right) & \text{Entrepreneur's participation constraint} \\ U^i(S,\tau) \geq U^i_\phi & \text{Investor's participation constraint} \end{cases} \tag{4}$$

A participation constraint becomes binding when the other agent has all the bargaining power in the contract negotiation. If the entrepreneur's participation constraint is binding, the contract is investor-dominant. If the investor's participation constraint is binding, the contract is entrepreneur-dominant.

Whichever the investor's type, the entrepreneur's expected utility can be written as

$$U^e(S, \tau) = \tau + S(r_\pi - \tau) - \frac{1}{2}\gamma^e S^2 \sigma_\pi^2 \tag{5}$$

By contrast, the characterization of $U^i(S, \tau)$ is specific to the type of investor. The different cases are discussed below.

2.3 Investor types

Building on earlier literature that has recognized some heterogeneity among venture capitalists, we identify three archetypes of investors. First, Hellmann (2002), de Bettignies and Chemla (2003), Chemmanur and Chen (2006), or Goldfarb et al. (2009) make a distinction between independent investors (e.g. business angels) and captive venture capitalists. Independent investors' sole objective is to maximize profit. They have a significant commitment to the venture capital activity,[5] and consequently the complement portfolio to each individual venture investment is itself dominated by a number – that can be large – of other ventures. This induces that the risk-return trade-off of the independent's pool of assets cannot be proxied by a financial portfolio such as a market index.

Besides their holding in the venture, shareholders of captive VCs hold a well-diversified portfolio of financial assets. They also have access to financial markets for their leverage decision. Their involvement in the venture capital industry is primarily motivated by the search for additional diversification potential through investment vehicles showing an attractive return potential at the expense of large specific risks. Because each venture capital investment represents a tiny proportion of a large, balanced portfolio, the specific risks are considered to be diversified away. This interpretation is in line with the common explanation of the large capital inflows from US pension funds in venture capital funds following the 1979 amendment to Employee Retirement Income Security Act's (ERISA's) prudent man rule (Gompers and Lerner, 1998). Manigart et al. (2002) test and confirm the hypothesis that, on

[5] Bottazzi et al. (2008) document that independent VCs are generally display more investor activism than captive VCs.

average, captive VC funds require a rate of return from their investments that is higher than the one required by independent venture capitalists. This finding lends support to the diversification argument as a motive for setting up captive VC vehicles.

Another important distinction is made among captive venture capitalists (see e.g. Ueda, 2004, Hirsch and Walz, 2006, Bottazzi et al., 2008, Hellmann et al., 2008): corporate VCs are owned by a parent company whereas bank-dependent VCs are subsidiaries of a banking institution.[6]

The bank-dependent VC, besides its activity as a venture capitalist, is a financial intermediary and so has a significant deposit and lending activity, which leaves her with better funding and investment conditions than the rest of the market. In our setup, this funding advantage is the major difference with the angel investor and the corporate VC. Such a view is consistent with empirical evidence shown by Hellmann, Lindsey and Puri (2008) that a strategic motive for banks to invest in venture capital is to create opportunities for enhanced lending possibilities, which is close to their actual core business as financial intermediaries. Such a view also entails that the key dimension for classifying an investor as bank-sponsored is the transformation of maturities at large. Therefore, unlike traditional classifications, we associate the sponsoring activities of insurance companies (for their life insurance activities) and pension funds to the ones of financial intermediaries.

Table 1 summarizes the characteristics of each fund provider.

Insert Table 1 here

To get a better picture of the market, the market shares in total venture capital funds in Europe and in USA according to different investor types are reported in Table 2. As underlined by Mayer, Schoors and Yafeh (2005), the broad evidence reported in table 2 masks large cross-sectional geographical differences. They report larger proportions of bank VC in Germany, of corporate VC in Israel, of pension funds (assimilated to bank VC in our analysis as they act as a maturity transformation

[6] A venture capital fund can also be public, i.e. sponsored by the government. This case is specific in that the public investor motives go beyond profit maximization. Its analysis requires further assumptions related to social welfare criteria, and is left for future research.

vehicle) in United Kingdom, and of government VC in UK as well. Evidence from the US shows a greater commitment from endowments and foundations (more than 20% of the VC funding) and the virtual absence of government-sponsored venture capital (NVCA, 2004).

Insert Table 2 here

We use superscripts *ind*, *crp* and *bnk* for the Independent, Corporate or Bank-sponsored types of investors, respectively, for further analysis.

3 Characterization of preferences

For any profit-maximizing investors, the purpose of the investment is to provide the fund's shareholders the highest possible surplus over invested capital. The rationale underlying this reasoning is the fact that, from Tobin's separation theorem, financial investors dissociate their risky investment decision from their financial leverage. Therefore, the only aim of the risky vehicles they invest in is to provide the highest possible surplus over the opportunity costs of their funds. Consequently, the profit-making VC fund's utility function can be written as the expected cash flow less the dollar-cost of capital of the venture, i.e.

$$U^i(S,\tau) = CF^i = (K-S)\left(r_\pi - \mu^i\right) - (1-S)\left(\tau - \kappa^i\right),\ i = ind, crp, bnk, \tag{6}$$

where μ^i and κ^i represent the opportunity cost of equity and the opportunity cost of risk-free financing/investment, respectively, which can differ from one investor to another. The first term is the VC's net expected profit from the venture, while the second term accounts for the transfer to the entrepreneur. As this utility function is expressed in terms of net cash flow, the corresponding reservation utility U^i_ϕ is set to zero for all i.

Next, we turn to the identification of the opportunity costs applicable to each investor.

- The independent venture capital fund, with superscript *ind*, is held by a number of committed private investors. They view the fund as an actively-managed overlay to their current portfolio, whose aim is to provide a superior Sharpe ratio to a portfolio of traded assets. Hence they assess the project in light of its contribution to the whole risk and return profile of the fund. The cost of equity capital is thus $\mu^{ind} = r_f + \beta_{\pi ind}(r_{ind} - r_f)$, where r_{ind} and $\beta_{\pi ind}$ stand for the fund's expected return and the project beta with respect to the fund, respectively.

- The corporate venture capital fund, with superscript *crp*, represents a large pool of shareholders who are well-diversified. Therefore, in line with Kerins, Smith and Smith (2004), any investment opportunity is assessed according to its position relative to the security market line. The corporate venture capitalist has otherwise the possibility to borrow or lend on financial markets at the risk free rate.

- The bank-sponsored venture capital fund, with superscript *bnk*, is a subsidiary of a regulated financial institution. The bank-sponsored venture capitalist starts with no initial endowment but gets funding from its parent institution. It can count on the contractual amount $1 - S$ transferred from the entrepreneur via a deposit account at the parent bank (if $S < 1$) or via a loan contracted at the bank (if $S > 1$). Being a financial intermediary, the bank can finance loans and invest deposits at better conditions than the market risk free rate r_f.[7] We denote

$$r_{bf} = \begin{cases} r_{bl} > r_f & \text{if } S > 1 \text{ (loan)} \\ r_{bd} < r_f & \text{if } S < 1 \text{ (deposit)} \end{cases} \tag{7}$$

  Still in line with their status, we assume that both the parent and the subsidiary are subject to regulatory capital constraints. Namely, to participate in the venture, the fund has to withdraw the full investment from the parent's bank equity. As the parent institution is itself fully diversified, we get the cost of equity capital according to the CAPM similar to the one for the corporate venture fund.[8]

[7] This rate applies regardless of whether the bank-sponsored VC offers the investor to lend or borrow by the parent's office or whether it negotiates a dilution factor d that will be financed through deposits or invested in loans anyway.

[8] Alternatively, we could refer to Pillar I of the Basle II Accord to obtain that the regulatory capital that the bank has to set aside equals 100% of the equity investment in the fund.

Table 3 summarizes the inputs for the various investors' utility maximization programs.

Insert Table 3 here

We now characterize and contrast the sets of contracts between the entrepreneur and the different categories of investors.

4 Characterization of contracts

4.1 Feasible contracts

There exists a continuum of possible contracts (S, τ) between the entrepreneur and each type of investor, depending on their relative bargaining powers. We will examine the extreme conditions, when either the investor or the entrepreneur can impose the terms of the contract, to assess the scope of feasible contracts.

The entrepreneur-dominant contract with investor i, is denoted $(S^{[e,i]}, \tau^{[e,i]})$. It corresponds to the pair (S, τ) that maximizes the entrepreneur's utility while satisfying the investor's participation constraint. Oppositely, the corresponding investor-dominant contract $(S^{[i,e]}, \tau^{[i,e]})$ maximizes the investor's utility while binding the entrepreneur's participation constraint.

The following proposition[9] summarizes the characteristics of the non-degenerate contracts $(S \neq 1)$:

Proposition 2 *If $\mu^i - \kappa^i \neq \gamma^e \sigma_\pi^2$, a non-degenerate contract (S^{*i}, τ^{*i}) between the entrepreneur and the investor i is feasible when the following condition is respected:*

$$\tau^{[e,i]} > \tau^{*i} > \tau^{[i,e]} \text{ if } S^{*i} < 1 \text{ and } \tau^{[e,i]} < \tau^{*i} < \tau^{[i,e]} \text{ if } S^{*i} > 1$$

where

$$\begin{aligned} \tau^{[e,i]} &\equiv \kappa^i + \frac{K - S^{*i}}{1 - S^{*i}}(r_\pi - \mu^i) \\ \tau^{[i,e]} &\equiv \frac{U^e_{\phi,\pi} - S^{*i} r_\pi + \frac{1}{2}\gamma^e \left(S^{*i}\right)^2 \sigma_\pi^2}{1 - S^{*i}} \end{aligned}$$

[9] All proofs are gathered in the appendix.

and where the entrepreneur's optimal level of investment S^{*i} is the same for any contract and is given by

$$S^{*i} = S^{[e,i]} = S^{[i,e]} = \min\left(\frac{\mu^i - \kappa^i}{\gamma^e \sigma_\pi^2}, K\right),$$

with, for the bank-sponsored VC, the additional condition that:

$$\gamma^e \sigma_\pi^2 + r_{bl} < r_f + \beta_{\pi m}(r_m - r_f) \text{ or } \gamma^e \sigma_\pi^2 + r_{bd} > r_f + \beta_{\pi m}(r_m - r_f).$$

Proposition 2 yields a Corollary with a strong economic relevance.

Corollary 3 *If the entrepreneur self-finances the venture, then any venture capital contract is feasible in that it leaves both parties better-off.*

Before contracting, the entrepreneur has proprietary access to a project with risk-return profile (σ_π, r_π). In one extreme case where the entrepreneur has all the bargaining power (entrepreneur-dominant case), she and the venture capitalist will agree on the rate of transfer $\tau^{[e,i]}$, which allows her to shift her utility score from U_ϕ^e to $U_{\max}^e$. In the other extreme case where the venture capitalist has all the bargaining power (investor-dominant case), they will agree on the rate of transfer $\tau^{[i,e]}$, which leaves the entrepreneur to the same initial utility score U_ϕ^e (since the investor captures all the benefits of the contract). In all cases, both parties agree on the same entrepreneur's level of investment S^*.

The optimal share of the entrepreneur is constant regardless of the contract. This share only differs with the identity of the investor. Two extreme cases require some discussion: the corner solution $S = K$ and the no-transfer solution $S = 1$.

In the first situation, the entrepreneur takes over the whole project, and borrows money from the investor. Note that $U^e(K, r_f) = U_\phi^e$. As stated in Table 2, there is no investor who offers a lending rate lower than r_f, so there simply is no contract. Indeed, if the investor's risk premium $\mu^i - \kappa^i$ is too high relative to the preference-adjusted risk of the project $\gamma^e \sigma_\pi^2$, then there is no feasible contract. In this case, the venture yields an attractive risk profile for the entrepreneur (low denominator of S^{*i}), while it is costly to finance for the investor (high numerator), who then steps away.

The second situation is more insightful. The special case $\mu^i - \kappa^i = \gamma^e \sigma_\pi^2$ is the one where the marginal cost of the project is equal to its marginal benefit for the entrepreneur, and so she merely gives up the share of the project that she cannot finance herself. There is no transfer and thus no dilution in that particular case.

For the bank-sponsored VC, the additional condition implies that situations where the lending rate is very high or when the deposit rate is very low precludes the bank's financial intermediation. In those situations, any transfer would become unacceptable for the entrepreneur who would receive too little money for her deposits or would pay too much interest for her borrowing. In these cases, the only feasible contract would be the degenerate one $(1, 0)$ which is feasible if $r_\pi - \frac{1}{2}\gamma^e \sigma_\pi^2 \geq U_{\phi,\pi}^e$. Thus, this contract is much more than a curiosity, as it is likely to prevail in a wide variety of market situations.

Corollary 3 shows that the entrepreneur would prefer to contract rather than undertaking the project on her own. The rationale underlying this result is straightforward. The linear shape of the utility function of the investor enables the entrepreneur to get rid of a share of the project's risk in exchange of a proportional premium. On the other hand, the concavity of the entrepreneur's utility function provide a gain in expected utility from risk sharing which is more than proportional to the loss in returns. This implies that the presence of venture capitalists always induces the entrepreneur to seek for a risk sharing contract to get venture capital financing. Indeed, as any feasible contract satisfies the investor's participation constraint, then both the entrepreneur and the investor are better off with the contract than with their initial investment choice.

Insert Figure 1 here

Figures 1a and 1b provide a graphical representations of the feasible contracts between the entrepreneur and the venture capitalist. In Figure 1a, the utility score of the project is not sufficient to induce the entrepreneur to shift her money away from the initial financial portfolio. The availability of a VC contract is powerful enough to shift up the expected utility, leading to a portfolio whose risk is $S^{*i}\sigma_\pi$ and that intersects the straight line relating $\left(0, \tau^{[i,e]}\right)$ to $(K\sigma_\pi, r_\pi)$. In the investor-dominant case, the entrepreneur has access to a lending rate which is just high enough to make her indifferent with the initial financial portfolio. If the bargaining power of the entrepreneur increases, she can manage to raise her utility further, up to the moment when the investor's participation constraint becomes binding. This situation corresponds to the upper segment originating from point $(K\sigma_\pi, r_\pi)$ in the figure.

The idea put forward in Corollary 3 is best illustrated in Figure 1b. The project is attractive as it clearly stands above the Capital Market Line. If the entrepreneur could self-finance the project, she would increase her utility level, but in the absence of venture capital, she is financially constrained and can only obtain the utility score U^e_ϕ derived from investing on financial markets. Nevertheless, the availability of a VC contract enhances the level of expected utility, up to the maximum achievable indifference curve $U^e_{\max}$ corresponding to the entrepreneur-dominant contract, as shown by the arrow represented on the figure.

This finding sheds new light on the discussion provided by Schwienbacher (2007) about the entrepreneur's choice between the "just-do-it" versus the "wait-and-see" strategy. In our model, where access to the venture capital market is assumed to be readily available to the entrepreneur and the project is found to be good, the "just-do-it" (adventurous) strategy of immediately invest in the project and attract the complement through venture capital, is indeed always the best choice. It holds irrespective of the entrepreneur's risk aversion, which can be related to the entrepreneurship style. Individuals pursuing the "wait-and-see" strategy can only do it rationally if they do not fit into our framework. This means that their decision to wait before investing in the venture would not be driven by some reluctance to share the venture's profits with an external investor, but rather by the fact that the project is not ready for investment and they *could* not attract a venture capitalist.

We turn to the discussion of feasible contracts and the comparison of contracts with different types of investors. This analysis of existence of feasible contracts and the comparison of contracts with different types of investors is instructive about the properties of the venture capital markets in a portfolio theory approach.

4.2 Contracting preferences

We first characterize the solution of the bargaining game between the entrepreneur and the investor. Next, we study the determinants of contracting preferences between the entrepreneur and the three types of investors.

4.2.1 Optimal contract design

The project is specific to the entrepreneur, but there are three possible kinds of investors she can contract with. Thus, there are two facets that characterize the optimal contract design: the choice of the contractor and the terms of the contract.

If all the bargaining power lies within the hands of the entrepreneur, she will choose to contract with the investor that enables her to maximize expected utility while binding the investor's participation constraint. Therefore, the program to maximize is

$$U^{[e,\bar{\imath}]} = \max_{i=ind,crp,bnk} \left[U^e(S^{*i}, \tau^{[e,i]}) - U^e_{\phi,\pi} \right] \text{ s.t. } U^i(S^{*i}, \tau^{[e,i]}) = 0. \tag{8}$$

In the mirror case, the investor maximizes net cash flows while imposing a level of utility to the entrepreneur. If each investor competing for the same project is able to dictate the contract to the entrepreneur, the winner will be the one for whom the surplus extracted from the contract is highest. The resulting level of utility for the investor achieving the largest net return is given by:

$$U^{[\bar{\imath},e]} = \max_{i=ind,crp,bnk} U^i(S^{*i}, \tau^{[i,e]}) \text{ s.t. } U^e(S^{*i}, \tau^{[i,e]}) = U^e_{\phi,\pi}. \tag{9}$$

Between these two extreme cases, the entrepreneur and each type of investor enter a bargaining game.[10] We adopt the solution proposed by Fan and Sundaresan (2000) to solve for the surplus split

[10] To simplify the optimal contract derivation, we abstract from competition effects that would result from interactions between multiple investors dealing with multiple entrepreneurs.

between the entrepreneur and the investor. Specifically, denoting η as the entrepreneur's bargaining power, and $1-\eta$ as the investor's bargaining power, the Nash solution to the bargaining game between the entrepreneur and investor i is the sharing rule that maximizes the following surplus

$$G(S^{*i}, \tau^{*i}; \eta) = \left[U^e(S^{*i}, \tau^{*i}) - U^e_{\phi,\pi}\right]^\eta \left[U^i(S^{*i}, \tau^{*i})\right]^{1-\eta}. \tag{10}$$

Note that the optimal contract design involves two objectives: (i) for a given investor, finding the optimal contract terms $\left(S^{*i}(\eta), \tau^{*i}(\eta)\right)$ as a function of the bargaining power η; and (ii) determining the kind of investor for whom the game output is maximized. So the objective function is

$$\max_{i=ind,crp,bnk} \quad \max_{S^{*i},\tau^{*i}} G(S^{*i}, \tau^{*i}; \eta) \tag{11}$$

Given the optimal share of the venture determined in Proposition 2 and the range of transfer rates that corresponds to each type of investor, we can characterize the optimal contract terms and the optimal investor choice altogether, provided that there exists an interior solution for S^{*i}, through the following Proposition.

Proposition 4 *If the entrepreneur can enter a non-degenerate venture capital contract with any type of investor, the solution of the Nash bargaining game in equation (10) with* $0 \leq \eta \leq 1$ *is given by*

$$\begin{aligned} S^{*\bar{\imath}}(\eta) &= S^{*\bar{\imath}} = \frac{\mu^{\bar{\imath}} - \kappa^{\bar{\imath}}}{\gamma^e \sigma_\pi^2} \\ \tau^{*\bar{\imath}}(\eta) &= \eta \tau^{[e,\bar{\imath}]} + (1-\eta)\tau^{[\bar{\imath},e]} \\ \bar{\imath} &= \operatorname*{arg\,max}_{i=ind,crp,bnk} \left(\kappa^i - K\mu^i + \frac{\left(\mu^i - \kappa^i\right)^2}{2\gamma^e \sigma_\pi^2} \right) \text{ with } \frac{\mu^i - \kappa^i}{\gamma^e \sigma_\pi^2} < K \end{aligned}$$

In particular, $G(S^{*\bar{\imath}}, \tau^{*\bar{\imath}}; 1) = U^{[e,\bar{\imath}]}$ *and* $G(S^{*\bar{\imath}}, \tau^{*\bar{\imath}}; 0) = U^{[\bar{\imath},e]}$.

The determinants of the optimal investor choice involves a mix of investor, project and entrepreneur-related elements. The function to maximize provides the impact of the characteristics that differentiate investors, namely μ^i and κ^i, in case of an interior solution. It is straightforward to see that, *ceteris paribus,* their impact are both indeterminate on the entrepreneur's preferences, depending on the values taken by the triplet $(K, \gamma^e, \sigma_\pi^2)$. This result calls for a closer look at the possible contracts, as discussed hereafter. The situation where $\frac{\mu^i - \kappa^i}{\gamma^e \sigma_\pi^2} \geq K$ corresponds to the corner solution where $S^{*i} = K$, where we have seen that the entrepreneur would indeed be at least as well off with her financial portfolio ϕ.

Conditionally on the optimal investor choice, the optimal contract characteristics bear a simple and intuitive form. As the entrepreneur's proportion invested in the project is constant whatever the bargaining power, her relative strength in the negotiation shows up only in the transfer rate. Given the structure of the game, the equilibrium transfer rate is a weighted average of the two extreme values that bind the corresponding participation constraint. In other terms, each counterparty's share of the surplus created by the presence of a VC investor is strictly proportional to her bargaining power. Such a simple structure appears very useful in light of equation (3), that displays a linear relation between the transfer rate and the more common dilution factor in VC investment contracts. It is obvious that the level of entrepreneur's dilution in the ownership of the project is an indicator of her bargaining power. What Proposition 4 shows is that, knowing what are the maximum and minimum dilution factors acceptable by the entrepreneur and the investor, respectively, the dilution level is directly proportional to their bargaining power.

Proposition 4 can also be viewed as a separation theorem regarding the optimal contract. It shows that the proportion of wealth invested in the project, $S^{*\bar{\imath}}$, is only a function of the investor's risk premium $\mu^{\bar{\imath}} - \kappa^{\bar{\imath}}$, the entrepreneur's risk tolerance, and project risk. This proportion is independent of η. The subsequent dilution in the entrepreneur's equity stake is only reflected in the transfer rate $\tau^{*\bar{\imath}}(\eta)$, which depends on bargaining power. Such a finding holds very strongly. It entails that, whatever the bargaining power of the entrepreneur, she will invest a larger proportion in the project if its risk is lower or if her outside wealth is larger (through a concurrent reduction in the risk aversion parameter γ^e). Bitler *et al.* (2005) derive similar prediction in the context of an agency theory framework. This is also consistent with the signaling approach of Leland and Pyle (1977). But unlike both streams of research, our results are derived in a framework of symmetric and homogenous information.

Note that the expected rate of return of the venture, r_π, has strictly no impact on the contracting preferences. This does not mean, however, that this rate is not relevant as it drives the feasible character of each venture capital contract.

4.2.2 Determinants of investor selection

Proposition 4 provides a general framework to compare contracts with the three sources of venture capital and the initial portfolio. From Table 2, the corporate VC shares one characteristic with the other two types of investors: it bears the same cost of equity capital as the bank-sponsored VC, while it has access to the same riskless rate conditions as the independent VC. Thus, it is logical to perform two-by-two comparisons with the corporate venture capital fund as one branch of the alternative, the other branch being (i) the initial financial portfolio, (ii) the independent VC and (iii) the bank-sponsored VC. These comparisons are done through the following corollaries.[11]

Corollary 5 *If the entrepreneur does not self-finance the venture, she will strictly prefer to contract with the corporate venture capital investor over her initial portfolio iff*

$$\gamma^e > \underline{\gamma}^e \equiv \frac{1-\rho_{\pi m}^2}{2K(r_\pi - r_f - \beta_{\pi m}(r_m - r_f))}\left(\frac{r_m - r_f}{\sigma_m}\right)^2 .$$

This Corollary has to be interpreted together with Proposition 1 and Corollary 3. From these two results, we know that for $0 < \gamma^e \leq \overline{\gamma}^e$, the entrepreneur would self-finance the venture (Proposition 1) but would indeed even prefer to contract with a venture capitalist (Corollary 3). On the other hand, Corollary 5 tells us that for $\gamma^e > \underline{\gamma}^e$, the entrepreneur would like to contract as well. Thus there would be no feasible contract if the project is such that $\underline{\gamma}^e > \overline{\gamma}^e$.

[11] For simplicity of the exposition, we restrict the analysis to the interior solution $S^{*i} = \frac{\mu^i - \kappa^i}{\gamma^e \sigma_\pi^2}$. The case where $S^{*i} = K$ is not very interesting as, from Proposition 4, the analysis boils down to seeking the investor whose cost of funds κ^i is the lowest.

Corollary 6 *The entrepreneur will strictly prefer to contract with the corporate over the independent venture capital investor iff*

$$\begin{cases} \mu^{ind} < \mu^{crp} & \text{if} \quad \frac{1}{2}\left(\mu^{ind} + \mu^{crp}\right) > r_f + K\gamma^e\sigma_\pi^2 \\ \mu^{ind} > \mu^{crp} & \text{if} \quad \frac{1}{2}\left(\mu^{ind} + \mu^{crp}\right) < r_f + K\gamma^e\sigma_\pi^2 \end{cases}$$

Corollary 6 presents a very counter-intuitive result. To enter a contract, the entrepreneur only has to verify that her participation constraint is verified. It would be natural to expect that she would choose the investor i whose cost of equity investment μ^i is lower, so that binding the investor's participation constraint could be done at a cheaper cost and thus the return on investment would be greater. But on the other hand, a lower μ^i induces a reduced entrepreneur's optimal stake in the venture $S^{[e,i]}$ (Proposition 2). Therefore, μ^i has opposite impacts on the quantity of invested funds and the rate of return on this investment. The entrepreneur only prefers the investor with a lower cost of equity if the average risk premium for the competing venture capital investors – represented by $\frac{\left(\mu^{ind}-r_f\right)+\left(\mu^{crp}-r_f\right)}{2}$ – does not exceed a risk premium reflecting the risk- and preference-scaled size of the project (the product $K\gamma^e\sigma_\pi^2$). The average risk premium reflects the relative importance of the difference in costs of equity. If this average is high, the absolute difference in costs of equity matters less for the entrepreneur's decision. Then, she cares more about the surplus that can be reaped, represented by the size of the project K. She prefers to get a higher share $S^{[e,i]}$ that the investor proposes her in the optimal contract, even though the corresponding transfer rate $\tau^{[e,i]}$ is less attractive. The product $\gamma^e\sigma_\pi^2$ is an adjustment for the risk aversion of the entrepreneur: the higher the product, the less likely the choice of the investor with the greater value of μ^i and the more important the cost saving effect over the surplus size effect.

In a realistic setup, most projects are such that the effect of project size dominates the inequalities, so that the project risk premium exceeds the average of the investor's risk premia. In this case, the first condition holds. Furthermore, because of her disadvantage in diversification, the independent venture capital investor is likely to have a required return μ^{ind} that exceeds the one of the corporate investor. Under such circumstances, the entrepreneur has an incentive to address a corporate venture capitalist. In order to convince the entrepreneur to contract with her, the independent investor has two possibilities: (i) to reduce its cost of capital through a large diversification between the individual venture investments (i.e. reducing $\beta_{\pi ind}$), or (ii) to provide an extra rate of return that compensates for the loss in expected utility resulting from the higher cost of capital.

Corollary 7 *The entrepreneur will strictly prefer to contract with the corporate over the bank-sponsored venture capital investor iff*

$$\begin{aligned} &\text{(i)} \quad \gamma^e \sigma_\pi^2 + r_{bd} > r_f + \beta_{\pi m}(r_m - r_f) \\ \text{or } &\text{(ii)} \quad \gamma^e \sigma_\pi^2 + r_{bl} < r_f + \beta_{\pi m}(r_m - r_f) \\ \text{or } &\text{(iii)} \quad K\left(r_\pi - \beta_{\pi m}(r_m - r_f)\right) - (K-1)\, r_f + \frac{\left(\beta_{\pi m}(r_m - r_f)\right)^2}{2\gamma^e \sigma_\pi^2} > r_\pi - \frac{1}{2}\gamma^e \sigma_\pi^2 \end{aligned}$$

Corollary 7 means that if the contract with the bank-sponsored VC fund is not degenerate (cases (i) and (ii)), then the entrepreneur would *never* want to contract with the bank-sponsored VC. Only if the intermediation margin $r_{bl} - r_{bd}$ is high enough, neither of these conditions is satisfied, and the bank could be freely chosen by the entrepreneur.

Unlike the independent investor studied in Corollary 6, the bank-sponsored venture capital investor does not have the possibility to weigh on its cost of capital. Thus, if the entrepreneur is dominant in the relationship, she will probably not knock on the banker's door to impose a venture capital contract. In order to induce her to enter such a contract, the banker would have to accept less favorable conditions than with another venture capital investor. This view is consistent with a dynamic view of the banker-entrepreneur relationship proposed by Hellmann (2002) in which the banker tries to lock a durable relationship in order to foster its lending opportunities.

5 Numerical analysis

In this section we illustrate the results implied from Proposition 4 and its Corollaries 6 and 7. To this end, we need to rely on a base case parametrization that is discussed below.

5.1 Calibration

Entrepreneur's risk aversion Several contributions propose a methodology for estimating investor's attitude towards risk. But we should keep in mind that entrepreneurs should by definition be less risk averse than average individuals. Tarashev et al. (2003) show that the risk aversion coefficient implicit from S&P options varies from 0 to 2. Bliss and Panigirtzoglou (2004) obtain a range from 0 to 4.4, but the upper bound decreases to less than 1.3 after removing the 5 largest stock return volatility changes. Based on the empirical distribution of terminal payoffs from venture-capital backed projects, Hall and Woodward (2010) induce that a risk aversion coefficient of 2 makes the entrepreneur indifferent between launching the venture or not. We therefore set $\gamma^e = 1$ for the base case and take a value of 2 as an upper limit for our simulations.

Market portfolio We follow Kerins et al. (2004) who estimate an annual standard deviation of S&P500 index returns of 16.2% over the last 20 years and use a 10% market rate. Therefore, we set $r_m = 0.1$ and $\sigma_m = 0.16$.

Venture characteristics One way to proxy for K is to divide the value of the venture's assets by the book value of entrepreneurs' equity (interpreted as their historical cost of acquisition of the project). From Table II Bitler et al. (2005) (who use National Survey of Small Businesses data), this ratio is worth 2.8 if we take mean values. It remains the same if we take median values.

Gompers and Lerner (1997) study the investments of a single venture capital firm and measure an average annual return of 30.5% gross of fees from 1972 to 1997. Cochrane (2005) estimates the arithmetic average returns of his sample venture capital projects at 59%. In their study of venture capital investments across five European countries, Manigart et al. (2002) obtain estimates of required returns from early-stage VC investments that range between 36% to 45%. Accordingly, we set $r_\pi =$ 40%. Kerins *et al.* (2004) rely on the CAPM to estimate the cost of capital for an entrepreneur. They find that the average correlation between a sample of 2,623 early stage firms' equity returns and

S&P500 returns is 0.195. The standard deviation of their sample firms' equity returns is 102.4% (see their table 4). Consistent with these figures, the value of $\beta_{\pi m}$ is set equal to $0.2 \times 100/16 = 1.25$. Dividing the value of the standard deviation of equity returns by the average project size of 2.8, we finally obtain $\sigma_{\pi} = 35\%$.

Cost of intermediation Demirgüç-Kunt *et al.* (2003) report a net interest margin for G7 countries between 2.03% (Canada) and 4.34% (the U.S.), with an unweighted average of 2.94%. We use these numbers as a proxy for cost of bank intermediation, which in our model is reflected by $2|r_f - r_{bf}|$. Assuming a risk-free rate of $r_f = 4\%$, we therefore set $r_{bl} = 5.5\%$ and $r_{bd} = 2.5\%$.

Independent venture capitalist As for the entrepreneur, Kerins *et al.* (2004) obtain that her average cost of capital ranges from 31.1% to 57.5% depending on her degree of commitment in the venture. Assuming these figures also apply to the partially diversified independent VC, we set $r_f + \beta_{\pi ind} (\mu_{ind} - r_f)$ equal to 30%.

Table 4 summarizes our model calibration.

Insert Table 4 here

5.2 Feasible contracts

Figures 2 and 3 provide numerical illustrations of Proposition 2. The upper and lower bounds for the optimal transfer are plotted against project characteristics (expected return and volatility) as well as against entrepreneur's risk aversion and project's size relative to entrepreneur's wealth. Figure 2 reports the case of the corporate VC while figure 3 reports that of the independent VC (the case of the bank VC is very close to that of the corporate and is therefore not reported).

Insert Figures 2 and 3 here

As expected, the higher the project volatility or the higher the entrepreneur's financial constraint, the greater room for agreement between the VC and the entrepreneur (i.e. the wider is the band for the optimal rate of transfer). A similar result holds for entrepreneur's risk aversion. Note however, that the space for feasible contracts does not depend on project expected return (see Figures 2a and 3a). Interestingly, if project size gets a bit low (see Figure 3d), then there is no more contracting possibility between the independent VC and the entrepreneur.

5.3 Investor selection

Figure 4 illustrates the entrepreneur's contracting preferences highlighted in Proposition 4 and Corollaries 6 and 7 as far as investor selection is concerned. Parameters are those of Table 4. For various degrees of entrepreneur's risk aversion, Figure 4 reports the optimal choice of venture capitalist in the space of project characteristics (K, σ_π).

Insert Figure 4 here

Each figure produces the same type of output. Using our base-case parameterization, they show three types of tendencies: (i) corporate-backed VCs tend to be favored for the riskiest projects, especially the larger ones; (ii) independent VC funds tend to invest in the least risky projects, irrespective of their size, and in the smallest projects, irrespective of their risk; and (iii) bank-sponsored VC investors have a window of large, middle-risk projects.

Such findings are broadly in line with the empirical literature devoted to the determination of VC adequacy to project types. On a pure U.S. sample, Hellmann et al. (2008) find that bank-dependent VCs invest less often in early rounds and they engage more in larger deals than other types of VC firms. These authors posit an underlying explanation related to relationship banking. The bank-sponsored VC behavior is supposed to reflect their desire to invest in firms which are more close to a situation where the entrepreneurs may demand loans in the future. In their study on a detailed sample of German VC-backed companies, Hirsch and Walz (2006) also conclude that venture capital investors that are not backed by a bank tend to finance more innovative projects. Mayer et al. (2005) carry out an empirical investigation on four countries (Germany, Israel, Japan and United Kingdom). Using a granular classification of VC investor types on the basis of funding sources, they find robust evidence that corporate and independent VCs prefer to invest in early-stage projects, typically characterized by high risk and/or low size. By contrast, funds whose funding comes from banks, insurance companies and pension funds favor late-stage projects. Although each country's financial system widely differs in their sample, they do not find any evidence that these differences explain observed variations in funding sources in their sample. Note that all empirical predictions focus on the dichotomization between bank and non-bank sponsored investors. Beyond the large consistency of our predictions with this stream of literature, we also bring a rationale for a strong segmentation of project financing between corporate and independent VC funds.

Besides evidence on project segmentation by investor type, the comparison of the graphs in Figure 4 reflects the influence of risk aversion on VC investor choice. The effect of an increase in the entrepreneur's risk aversion on the likelihood of contracting with the independent and corporate is clear-cut. Whatever the distribution of project size and risk, and considering the pure effect of a change in the representative entrepreneur's risk aversion, a more risk averse entrepreneur (i.e. higher γ^e) ends up being more likely to contracting with a corporate VC investor, and less likely to contract with an independent VC investor. The impact on bank-sponsored VC investor is less obvious. The lower and the upper bound of the zone of bank-sponsored fund contracting preference both increase with the level of risk as risk aversion increases. Therefore, if project risk is relatively high, a greater risk aversion will lead to a greater likelihood of a bank-sponsored VC implication. The opposite holds for low levels of project risk. More risk averse investors would then tend to look for an independent VC fund rather than a bank-sponsored one.

Table 5 clarifies the relation between the likelihood of contracting with the bank-sponsored VC and the entrepreneur's risk aversion for different levels of project size and project risk. It shows the evolution of the relative market shares for the three types of investors as K and σ_π gradually increase.[12]

Insert Table 5 here

As shown in Table 5, the bank-sponsored VC market shares increase with entrepreneur's risk aversion coefficient (across all project sizes and risks) for small values of γ^e. However, this behavior is reversed for high values of γ^e.

Insert Figure 5 here

Figure 5 provides an additional illustration of Corollaries 6 and 7. It shows the difference in surplus between the corporate VC contract and the independent VC contract (Figure 5a) and between the corporate VC contract and the bank-sponsored VC contract (Figure 5b). With parameters as given as in Table 4, we obtain $\mu^{crp} = 0.115 < \mu^{ind} = 0.3$. As stated by Corollary 6, the entrepreneur will prefer contracting with the independent VC as long as

$$\frac{1}{2}\left(\mu^{ind} + \mu^{crp}\right) > r_f + K\gamma^e\sigma_\pi^2,$$

which is true for small values of K and/or small values of σ_π. But as project size and/or project risk increase, the former condition will not hold anymore and preference will be given to the corporate VC, as shown by Figure 5a.

Similarly, parameters of Table 4 induce that $S^* < 1$ and the bank will offer a deposit account at rate r_{bd}. According to Corollary 7 part (i), the entrepreneur will prefer the corporate VC contract over the bank-sponsored VC contract iff

$$\gamma^e\sigma_\pi^2 + r_{bd} > r_f + \beta_{\pi m}(r_m - r_f),$$

which translates into a lower bound condition for project risk, as shown by Figure 5b.

Note that the magnitude of surplus difference is much smaller between the corporate VC and the bank-sponsored VC (Figure 5b) than between the corporate VC and the independent VC (Figure

[12] To keep calculations simple, we assume a uniform distribution of projects across size and risk.

5a). Combined with the empirical evidence quoted above, this might indicate that the main source of reported differences between the use of financing sources arises because on the bank-sponsored vs. independent VC dichotomy. When matched with the independent VC fund, the bank and corporate investor types look very much alike. From the pure funding cost approach that we adopt, the most adequate approach to clustering venture capital types should probably be a distinction independent versus bank and corporate, while empirical papers have mostly adopted a "independent and corporate versus bank" type of approach.

5.4 Dilution factor

In this subsection we analyze the endogenous dilution factor as obtained from the optimal transfer rate from Proposition 4 and retrieved from equation (3). Figure 6 displays the dilution factor in the (K, σ) space. We see that contracting with the independent VC yields a dilution factor of one. When dealing with the bank-sponsored VC, the entrepreneur obtains a favorable (i.e. strictly greater than one) dilution factor that is convex in project size and relatively constant in project risk. Finally, with the corporate VC, the endogenous dilution factor becomes linear in both project size and project risk.

6 Empirical analysis

Even though they bring some geographical variety in their sample, Mayer et al. (2005) confess that their results remain puzzling in that "*a large proportion of variation within as well as between countries is unrelated to sources of finance. Moreover, differences in the relation between funding source and VC activity are unrelated to the country's financial systems.*" A potential solution of this puzzle is provided by the link that exists between the prevailing level of risk aversion on a given market and the partitioning of investments by VC type. For the same spectrum of projects, a country in which risk aversion is stronger witnesses greater investment opportunities seized by corporate VC investors, less by independent VC investors, and more or less by bank-sponsored funds, depending on the distribution of project size and risk as discussed in the previous section.

The aim of this section is to test one the main predictions of the model, namely the link between entrepreneur's risk aversion and VC type contracting preferences. Naturally, the causal relationship to test is whether the entrepreneur's decision to contract with a given investor type depends on his level of risk aversion. But through a multiple regression setup, we can assess the likelihood of choosing each investor type simultaneously based upon the entrepreneur's attitudes towards risk. To this end, perform a multiple linear regression of estimated risk aversion coefficients on fund flows for each type of VC.

We carry out the analysis on a panel of European countries. Thanks to the aggregation of country-specific data performed at the level of the European Venture Capital Association (EVCA), this sample benefits from a homogenous data collection methodology and classification.

The estimation of the entrepreneur's risk aversion coefficient on each market relies on an approximation using stock market data. This approach is justifiable by the fact that the representative stock market investor's risk aversion reflects the risk attitudes of an equity investor. Even though this is a biased estimator for the overall population, it may be a reasonable proxy for the risk tolerance of the actual entrepreneur. This is the population under review in our study, since we are only interested in contracting preferences for actual venture investments. Following Bliss and Panigirtzoglou (2004), yearly risk aversion coefficients of the representative agent are estimated by regressing daily stock index returns on the changes in the daily VIX (or equivalent) implied volatility index:

$$R_{ct} \simeq -\gamma_{c,T} \Delta VIX_{ct} + \varepsilon_{ct}, \tag{12}$$

where index c stands for the country under consideration, T is the calendar year of the regression, and $\gamma_{c,T}$ is the estimator for the representative agent's risk aversion coefficient.[13] Daily stock market data is collected from *Thomson Financial Datastream* for the 2001-2009. For this time period, only

[13] Adding an intercept to Bliss and Panigirtzoglou's initial specification improves the fit, even though its estimate is never significant in our sample.

seven European markets display complete and continuous series for implied volatility indices: United Kingdom, France, Germany, Switzerland, the Netherlands, Finland and Austria. We discard the latter two countries because of too little liquidity on their stock market and lack of representativity of the venture capital investments during the period under study. The panel we create features five countries.

Yearly fund flows between 2002 and 2009 are obtained from the EVCA. Consistent with previous empirical evidence by Mayer et al. (2005) on European data, but also on our interpretation of bank-sponsored investors, we consider that banks, insurance companies and pension funds constitute a homogenous group under the umbrella of "bank-sponsored" investors. Independent VC investors gather sources from individuals, family offices and capital markets. Corporate VC investors encompass all other sources except the ones coming from public authorities, namely corporations, academic institutions, endowments and foundations, funds of funds, other asset managers, and others. Because governments are not counted but represent a substantial level and variability, the sum of bank-sponsored, independent and corporate VC types is inferior to one and enjoys considerable variation over country and time.

The descriptive statistics of the sample are reported in Table 6.

Insert Table 6 here

Panel A presents the estimation results from equation (12). The results are of the same order as those of Bliss and Panigirtzoglou (2004) on U.S. data. They report a sample average of 0.40 as well. This is also in the same neighborhood, although slightly inferior, to the values obtained for United States, UK and Germany, with a different methodology, by Tarashev et al. (2003) on a 1995-2002 time window. As expected, these values are much lower than the typical risk aversion estimates obtained in studies of the whole economy (see Bliss and Panigirtzoglou (2004) for an overview).

Because we allocate a substantial fraction of funding sources to the bank-sponsored category, Panel B shows a dominance of that particular source of funds across time and countries. Nevertheless, we observe a large variability for all three independent variables, both cross-sectionally and over time. The correlations reported in Panel C indicate a large negative value between the proportion of independent invested funds, w_{ind}, and the risk aversion coefficient. The other correlations are moderate, except between bank and corporate VC funds, which appear largely substitutes. This observation is consistent with our analysis of surplus in the preceding section, that showed a relatively small dichotomization between these two types of funding sources regarding the level of economic gain to extract from the contract.

In order to enhance the significance of the regression coefficients, we perform the analysis on a two-year average risk aversion coefficient, thereby losing the first observation. This leaves us with a panel of 40 observations (8 years $\times$ 5 countries). The equation to test is

$$\gamma_{c,T} = \gamma_0 + \sum_{i=ind,crp,bnk} b_i w_{i;c,T} + controls + \eta_{c,T}$$

We run three panel regressions. The first two are basic ones without any control variable or with a single time dummy corresponding to the 2006-07 period, during which there was a significant upward jump of risk aversion across all European markets. The third panel regression accounts for potential sources of geographical heterogeneity within each investor type. We introduce interaction variables representing the product of one or several country dummies with the proportion of VC funding corresponding to each investor type: $controls = \gamma'_0 1_{\{c=c_1 \text{ or } c_2 \text{ or} \ldots\}} + \sum_{i=ind,crp,bnk} b'_i w_{i;c,T} 1_{\{c=c_1 \text{ or } c_2 \text{ or} \ldots\}}$. For each investor type, there are 30 possible combinations. Therefore, we optimize the specification by maximizing the Schwartz information criterion.

The results are reported in Table 7. The basic panel regression results return a negative and significant coefficient for the independent VC category. This is the expected sign from the comparative statics analysis of the previous section. In all countries under consideration, there is a tendency for entrepreneurs to solicitate less funding from independent VC funds than from other sources when the risk aversion level increases. This "flight to VC safety" phenomenon does not explain, however, to whom then entrepreneurs preferably turn to. The significance level achieved from this basic regression reaches a very high level, with a panel-adjusted R-squared above 57%.

Insert Table 7 here

The optimized panel regression setup enables us to account for country-specific (or zone-specific) impacts in the relation. The level and significance of the coefficient of independent VC source get stronger, and there is no country-specific effect. The coefficient corporate VC financing becomes positive, but insignificant, and with a negative country-specific adjustment for Switzerland. The most noticeable improvement comes from the bank-sponsored VC investor coefficient. We obtain a common positive and strongly significant value for France, Germany and Switzerland.[14] For these countries, we emphasize a clear substitution effect from independent to bank-sponsored funds when the market risk aversion changes. In the Netherlands and UK, i.e. more market-oriented countries, there is no clear differentiation from the corporate and bank-sponsored funding source as a response to a change in entrepreneur's risk attitudes. A positive coefficient for the bank-sponsored VC fund is also in line with a quite low average project risk but high size, which is typically the type of projects that attract venture capital investment in Europe.

The significance level of this optimized regression is above 69%, which is an outstanding figure given the fact that the independent variable itself results from a first-pass estimation. Therefore our results stand as strong evidence supporting our approach. They shed new light on the disappointment raised by the Mayer et al. (2005), because they had not specifically tested the influence of risk aversion on VC funding choices.

We view the reasons for this strong significance as being related to the parsimony of informational assumptions underlying our model. In our setup, the investor choice is only driven by funding cost considerations, which are readily observable. Explanations related to information asymmetries rest upon effort or added-value estimations, which are essentially forward looking and thus harder to

[14] From our numerical analysis in Table 5, and given the range of estimated risk aversion parameters (0.06-0.8), our model predicts a positive relation between bank-sponsored VC fund flow and entrepreneur's risk aversion.

assess. Before looking at differential effects related to these dimensions, our approach provides a background contracting framework that emphasizes core financial contracting decision criteria.

7 Conclusion

Between the fundamental risk-return trade-off analyzed in equilibrium models such as the CAPM, and the practical considerations surrounding the determination of the cost of capital for the venture capitalist and the entrepreneur, this paper has provided a theoretical building block adapted to the context of venture investments. Even though the analytical framework that we propose is relatively simple and does not require stringent assumptions, we can characterize the entrepreneurial choices and the relations with the investors in an insightful manner. We have been able to uncover a number of strong results that hold irrespective of the numerous imperfections characterizing the market for new ventures. In particular, we emphasize the desirability of the investment relation between the entrepreneur and the venture capitalist, and the link between contracting choices and design with the cost components of the investor's capital and her bargaining power with the entrepreneur.

The limitations that this study suffers from are numerous, but they are inherent to its style and scope. As we propose a theoretical model that aims at determining equilibrium relationships, the real-life imperfections that surround the venture capital are out of its scope. We are not unaware of them however. Adverse selection and agency cost considerations affect, and probably dominate, the venture capital relationship. Frictions such as liquidity constraints and investment size or stage have a very strong impact on the venturer's investment choices and, more importantly, on the hurdle rate assigned to the portfolio. We believe that these important, but different influences do not restrain the relevance of this kind of study. They simply call for a controlled empirical investigation to assess their adequacy and their practical importance.

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Appendix

Proof of Proposition 1

The indifference point for adopting the venture is $U_\pi^e = U_\phi^e$, which yields given equations (1) and (2)

$$2\gamma^e K (r_\pi - r_f) - \gamma^{e2} K^2 \sigma_\pi^2 = \left(\frac{\mu_\phi - r_f}{\sigma_\phi}\right)^2.$$

Solutions are:

$$\begin{aligned}
\gamma_1^e &= \frac{(r_\pi - r_f) - \sqrt{(r_\pi - r_f)^2 - \sigma_\pi^2 \left(\frac{\mu_\phi - r_f}{\sigma_\phi}\right)^2}}{K\sigma_\pi^2} \\
\gamma_2^e &= \frac{(r_\pi - r_f) + \sqrt{(r_\pi - r_f)^2 - \sigma_\pi^2 \left(\frac{\mu_\phi - r_f}{\sigma_\phi}\right)^2}}{K\sigma_\pi^2}
\end{aligned}$$

The venture is self-financed for $\gamma^e \in [\gamma_1^e, \gamma_2^e]$. Condition $\gamma^e > \gamma_1^e$ is satisfied under conditions (C1) and (C2). Indeed, any real positive numbers a and b such that $a > b$ verify $\sqrt{a^2 - b^2} > a - b$. Hence, using conditions (C1) and (C2),

$$\gamma_1^e < \frac{\mu_\phi - r_f}{K\sigma_\pi \sigma_\phi} < \frac{\mu_\phi - r_f}{\sigma_\phi^2} = \gamma^e.$$

Proof of Proposition 2 and Corollary 3

First we characterize the entrepreneur's share of investment in case of any contract between e and i. It can take two generic forms, depending on who has the bargaining power (and thus maximizes utility):

$$\begin{aligned}
S^{*i,k_e} &= \arg\max_S U^i(S,\tau) \text{ s.t. } U^e(S,\tau) = k_e \\
\text{or } S^{*e,k_i} &= \arg\max_S U^e(S,\tau) \text{ s.t. } U^i(S,\tau) = k_i.
\end{aligned}$$

Binding the constraint at τ^{*i,k_e} (for the first program) or τ^{*e,k_i} (for the second program) and replacing its value in the utility function to maximize yields

$$\begin{aligned}
S^{*i,k_e} &= \arg\max_S \left[-k_e + K\left(r_\pi - \mu^i\right) + (1-S)\kappa^i + S\mu^i - \frac{1}{2}\gamma^e S^2 \sigma_\pi^2\right] \\
S^{*e,k_i} &= \arg\max_S \left[-k_i + K\left(r_\pi - \mu^i\right) + (1-S)\kappa^i + S\mu^i - \frac{1}{2}\gamma^e S^2 \sigma_\pi^2\right].
\end{aligned}$$

As both programs are quadratic functions of S and only differ with a constant, applying the FOC yields the same value:

$$\arg_S \left(\frac{\partial U^i(S, \tau^{*i,k_e})}{\partial S} = 0 \right) = \arg_S \left(\frac{\partial U^e(S, \tau^{*e,k_i})}{\partial S} = 0 \right) = \frac{\mu^i - \kappa^i}{\gamma^e \sigma_\pi^2}.$$

Because $U^i(S)$ is increasing and then decreasing, and since the value of S is bounded above by K, we obtain the optimal level of entrepreneur's investment as

$$S^{*i} = S^{*i,k_e} = S^{*e,k_i} = \min \left(\frac{\mu^i - \kappa^i}{\gamma^e \sigma_\pi^2}, K \right).$$

The condition for the existence of an optimal contract simply follows from binding the participation constraint for the extreme cases. For the entrepreneur-dominant case, we set

$$k_i = 0 \Longrightarrow \tau^{[e,i]} = \kappa^i + \frac{K - S^{*i}}{1 - S^{*i}} \left[r_\pi - \mu^i \right].$$

For the investor-dominant case, we get the entrepreneur's participation constraint $k_e = U^e_{\phi,\pi} = \max \left(U^e_\phi, U^e_\pi \right)$ and

$$k_e = U^e_{\phi,\pi} \Longrightarrow \tau^{[i,e]} = \frac{U^e_{\phi,\pi} - S^{*i} r_\pi + \frac{1}{2} \gamma^e \left(S^{*i} \right)^2 \sigma_\pi^2}{(1 - S^{*i})}.$$

The determination of μ^i and κ^i for investors $i = ind$ (the independent) and $i = crp$ (the corporate) is straightforward as they can only take one value.

For investor bnk (the bank-sponsored VC), the function $U^b(S, \tau)$ is piecewise linear. So, function $U^e(S, \tau^{*bnk})$, that writes

$$U^e(S, \tau^{*bnk}) = \begin{cases} K \left(r_\pi - \mu^{bnk} \right) + (1 - S) r_{bl} + S \left(r_f + \beta_{\pi m}(r_m - r_f) \right) - \frac{1}{2} \gamma^e S^2 \sigma_\pi^2 & \text{if } S > 1 \\ K \left(r_\pi - \mu^{bnk} \right) + (1 - S) r_{bd} + S \left(r_f + \beta_{\pi m}(r_m - r_f) \right) - \frac{1}{2} \gamma^e S^2 \sigma_\pi^2 & \text{otherwise} \end{cases},$$

with $\mu^{bnk} > r_{bl} > r_{bd}$, is piecewise quadratic in S, with the same FOC as before. Three cases are to be distinguished:

(i) if $r_f + \beta_{\pi m}(r_m - r_f) - r_{bd} > r_f + \beta_{\pi m}(r_m - r_f) - r_{bl} \geq \gamma^e \sigma_\pi^2$, then $S^{[e,bnk]} \geq 1$ (lending situation) and the prevailing rate is $r_{bf} = r_{bl}$;

(ii) if $\gamma^e \sigma_\pi^2 \geq r_f + \beta_{\pi m}(r_m - r_f) - r_{bd} > r_f + \beta_{\pi m}(r_m - r_f) - r_{bl}$, then $S^{[e,bnk]} \leq 1$ (borrowing situation) and the prevailing rate is $r_{bf} = r_{bd}$;

(iii) if $r_f + \beta_{\pi m}(r_m - r_f) - r_{bd} > \gamma^e \sigma_\pi^2 > r_f + \beta_{\pi m}(r_m - r_f) - r_{bl}$, then the local optima $S_l^{[e,bnk]} = \frac{r_f+\beta_{\pi m}(r_m-r_f)-r_{bl}}{\gamma^e\sigma_\pi^2} < 1$ and $S_d^{[e,bnk]} = \frac{r_f+\beta_{\pi m}(r_m-r_f)-r_{bd}}{\gamma^e\sigma_\pi^2} > 1$, corresponding to the two quadratic segments of the utility function, are not compatible with the domain of r_{bl} and r_{bd}, respectively. In this case, as $U^e(S, \tau^{*bnk})$ is piecewise quadratic and has a negative coefficient in S^2, the global maximum of this function is $S^{[e,bnk]} = 1$ which is a degenerate case where there is no transfer between the entrepreneur and the investor.

Proof of Proposition 4

We first solve the nested objective function

$$\max_{S^{*i}(\eta),\tau^{*i}(\eta)} G(S^{*i}(\eta), \tau^{*i}(\eta); \eta)$$

for a particular investor i.

First note that, from Proposition 2, the optimal entrepreneur's share in the venture is the same for any contract with a given investor, therefore $S^{*i}(\eta) = S^{*i}$. Since we assume the contract to be non-degenerate, $S^{*i} < K$. The only variable that drives the optimal contract as a function of the bargaining power is the transfer rate τ^{*i}.

Taking the log of the nested objective function, applying the FOC and rearranging yields

$$\tau^{*i}(\eta) = \arg\left\{\eta\left[U^i(S^{*i}, \tau^{*i})\right] - (1-\eta)\left[U^e(S^{*i}, \tau^{*i}) - U^e_{\phi,\pi}\right] = 0\right\}$$

Equations (6) and (5) provide the values of U^i and U^e, respectively. This gives a linear equation in τ^{*i} whose solution is given by

$$\tau^{*i}(\eta) = \eta\left[\kappa^i + \frac{K - S^{*i}}{1 - S^{*i}}(r_\pi - \mu^i)\right] + (1-\eta)\left[\frac{U^e_{\phi,\pi} - S^{*i} r_\pi + \frac{1}{2}\gamma^e \left(S^{*i}\right)^2 \sigma_\pi^2}{1 - S^{*i}}\right],$$

where the first expression between brackets equals $\tau^{[e,i]}$ and the second one equals $\tau^{[i,e]}$ from Proposition 2. We easily check that the second order condition is satisfied.

To solve the global problem at the equilibrium transfer rate $\tau^{*i}(\eta)$

$$\max_{i=ind,crp,bnk} G(S^{*i}, \tau^{*i}(\eta)),$$

we note that, from equation (6), and noting that $U^i(S^{*i}, \tau^{[e,i]}) = 0$ by definition, we get:

$$\begin{aligned}
U^i(S^{*i}, \tau^{*i}(\eta)) &= U^i(S^{*i}, \tau^{*i}(\eta)) - U^i(S^{*i}, \tau^{[e,i]}) \\
&= \left(K - S^{*i}\right)\left(r_\pi - \mu^i\right) - \left(1 - S^{*i}\right)\left(\tau^{*i}(\eta) - \kappa^i\right) \\
&\quad - \left[\left(K - S^{*i}\right)\left(r_\pi - \mu^i\right) - \left(1 - S^{*i}\right)\left(\tau^{[e,i]} - \kappa^i\right)\right] \\
&= \left(1 - S^{*i}\right)\left(\tau^{[e,i]} - \tau^{*i}(\eta)\right) \\
&= \left(1 - S^{*i}\right)\left(\tau^{[e,i]} - \eta\tau^{[e,i]} - (1-\eta)\tau^{[i,e]}\right) \\
&= \left(1 - S^{*i}\right)(1-\eta)\left(\tau^{[e,i]} - \tau^{[i,e]}\right).
\end{aligned}$$

Similarly, applying equation (5) and using the fact that $U^e_\phi = U^e(S^{*i}, \tau^{[i,e]})$, we get

$$\begin{aligned}
U^e(S^{*i}, \tau^{*i}(\eta)) - U^e_\phi &= U^e(S^{*i}, \tau^{*i}(\eta)) - U^e(S^{*i}, \tau^{[i,e]}) \\
&= \tau^{*i}(\eta) + S^{*i}\left(r_\pi - \tau^{*i}(\eta)\right) - \frac{1}{2}\gamma^e\left(S^{*i}\right)^2\sigma_\pi^2 \\
&\quad - \left[\tau^{[i,e]} + S^{*i}\left(r_\pi - \tau^{[i,e]}\right) - \frac{1}{2}\gamma^e\left(S^{*i}\right)^2\sigma_\pi^2\right] \\
&= \left(1 - S^{*i}\right)\left(\tau^{*i}(\eta) - \tau^{[i,e]}\right) \\
&= \left(1 - S^{*i}\right)\left(\eta\tau^{[e,i]} + (1-\eta)\tau^{[i,e]} - \tau^{[i,e]}\right) \\
&= \left(1 - S^{*i}\right)\eta\left(\tau^{[e,i]} - \tau^{[i,e]}\right).
\end{aligned}$$

Hence, the global maximization problem simplifies to

$$\max_{i=ind,crp,bnk} G(S^{*i}, \tau^{*i}(\eta)) = \max_{i=ind,crp,bnk}\left(1 - S^{*i}\right)\left(\tau^{[e,i]} - \tau^{[i,e]}\right).$$

From the definitions of $\tau^{[e,i]}$ and $\tau^{[i,e]}$ provided in Proposition 2, the preferred investor type verifies

$$\bar{\imath} = \underset{i=ind,crp,bnk}{\arg\max}\left[\kappa^i\left(1 - S^{*i}\right) + \left(K - S^{*i}\right)\left(r_\pi - \mu^i\right) - \left(U^e_{\phi,\pi} - S^{*i}r_\pi + \frac{1}{2}\gamma^e\left(S^{*i}\right)^2\sigma_\pi^2\right)\right].$$

Using the fact that $S^{*i} = \frac{\mu^i - \kappa^i}{\gamma^e \sigma_\pi^2}$ if the contract is not degenerate, removing all terms that are independent of i and rearranging yields

$$\bar{\imath} = \underset{i=ind,crp,bnk}{\arg\max} \left(\kappa^i - K\mu^i + \frac{\left(\mu^i - \kappa^i\right)^2}{2\gamma^e \sigma_\pi^2} \right),$$

which completes the proof.

Proof of Corollaries 5, 6 and 7

(i) To induce a shift from the entrepreneur's initial financial portfolio ϕ to a venture capital contract, the most favorable (i.e. entrepreneur-dominant) contract with the corporate VC must exceed the entrepreneur's participation constraint, that is:

$$U^e(S^{[e,crp]}, \tau^{[e,crp]}) > U^e_{\phi,\pi}.$$

or, from Propositions 1 and 2, replacing $\mu^{crp} = r_f + \beta_{\pi m}(r_m - r_f)$ and $\kappa^{crp} = r_f$

$$K\left(r_\pi - r_f - \beta_{\pi m}(r_m - r_f)\right) + \frac{1}{2\gamma^e}\left(\frac{\beta_{\pi m}(r_m - r_f)}{\sigma_\pi}\right)^2 > \frac{1}{2\gamma^e}\left(\frac{r_m - r_f}{\sigma_m}\right)^2.$$

By the definition of beta, we get that $\frac{\beta_{\pi m}}{\sigma_\pi} = \frac{\rho_{\pi m}}{\sigma_m}$, so the expression simplifies to

$$\gamma^e > \frac{1 - \rho_{\pi m}^2}{2K(r_\pi - r_f - \beta_{\pi m}(r_m - r_f))}\left(\frac{r_m - r_f}{\sigma_m}\right)^2,$$

which proves Corollary 5.

(ii) Similarly, to induce the entrepreneur to opt for the corporate VC instead of the independent VC, the following condition must be respected:

$$U^e(S^{[e,crp]}, \tau^{[e,crp]}) > U^e(S^{[e,ind]}, \tau^{[e,ind]}),$$

i.e.

$$
\begin{aligned}
& K\left(r_\pi - \mu^{crp}\right) + r_f + \tfrac{1}{2\gamma^e}\left(\tfrac{\mu^{crp}-r_f}{\sigma_\pi}\right)^2 > K\left(r_\pi - \mu^{ind}\right) + r_f + \tfrac{1}{2\gamma^e}\left(\tfrac{\mu^{ind}-r_f}{\sigma_\pi}\right)^2 \\
\Leftrightarrow\ & K\left(\mu^{ind} - \mu^{crp}\right) - \tfrac{1}{2\gamma^e}\left[\left(\tfrac{\mu^{ind}-r_f}{\sigma_\pi}\right)^2 - \left(\tfrac{\mu^{crp}-r_f}{\sigma_\pi}\right)^2\right] > 0 \\
\Leftrightarrow\ & K\left(\mu^{ind} - \mu^{crp}\right) - \tfrac{1}{2\gamma^e\sigma_\pi^2}\left[\left(\left(\mu^{ind} - r_f\right) + \left(\mu^{crp} - r_f\right)\right)\left(\left(\mu^{ind} - r_f\right) - \left(\mu^{crp} - r_f\right)\right)\right] > 0 \\
\Leftrightarrow\ & K\left(\mu^{ind} - \mu^{crp}\right) - \tfrac{1}{2\gamma^e\sigma_\pi^2}\left[\left(\left(\mu^{ind} - r_f\right) + \left(\mu^{crp} - r_f\right)\right)\left(\mu^{ind} - \mu^{crp}\right)\right] > 0 \\
\Leftrightarrow\ & \begin{cases} r_f + K\gamma^e\sigma_\pi^2 < \frac{1}{2}\left(\mu^{ind} + \mu^{crp}\right) & \text{if } \mu^{ind} < \mu^{crp} \\ r_f + K\gamma^e\sigma_\pi^2 > \frac{1}{2}\left(\mu^{ind} + \mu^{crp}\right) & \text{if } \mu^{ind} > \mu^{crp} \end{cases}.
\end{aligned}
$$

(iii) Finally, to induce the entrepreneur to opt for the corporate VC instead of the bank-sponsored VC, the following condition must be respected:

$$U^e(S^{[e,crp]}, \tau^{[e,crp]}) > U^e(S^{[e,bnk]}, \tau^{[e,bnk]}).$$

Three cases have to be distinguished:

Case 1: $\gamma^e\sigma_\pi^2 + r_{bd} > r_f + \beta_{\pi m}(r_m - r_f)$. Then, from Proposition 2, $S^{[e,bnk]} = \frac{\mu^{bnk}-\kappa^{bnk}}{\gamma^e\sigma_\pi^2} < 1$ and $r_{bf} = r_{bd}$. The condition writes:

$$
\begin{aligned}
& K\left(r_\pi - \mu^{crp}\right) + r_f + \tfrac{1}{2\gamma^e}\left(\tfrac{\mu^{crp}-r_f}{\sigma_\pi}\right)^2 > K\left(r_\pi - \mu^{bnk}\right) + r_{bd} + \tfrac{1}{2\gamma^e}\left(\tfrac{\mu^{bnk}-r_{bd}}{\sigma_\pi}\right)^2 \\
\Leftrightarrow\ & r_f - r_{bd} - \tfrac{1}{2\gamma^e}\left[\left(\tfrac{\mu^{ind}-r_{bd}}{\sigma_\pi}\right)^2 - \left(\tfrac{\mu^{bnk}-r_f}{\sigma_\pi}\right)^2\right] > 0 \\
\Leftrightarrow\ & r_f - r_{bd} - \tfrac{1}{2\gamma^e\sigma_\pi^2}\left[\left(\left(\mu^{bnk} - r_{bd}\right) + \left(\mu^{crp} - r_f\right)\right)\left(\left(\mu^{bnk} - r_{bd}\right) - \left(\mu^{crp} - r_f\right)\right)\right] > 0 \\
\Leftrightarrow\ & r_f - r_{bd} - \tfrac{1}{2\gamma^e\sigma_\pi^2}\left[\left(\left(\mu^{bnk} - r_{bd}\right) + \left(\mu^{crp} - r_f\right)\right)\left(r_f - r_{bd}\right)\right] > 0 \\
\Leftrightarrow\ & 1 - \tfrac{1}{\gamma^e\sigma_\pi^2}\left[r_f + \beta_{\pi m}(r_m - r_f) - \tfrac{1}{2}\left(r_f + r_{bd}\right)\right] > 0. \\
\Leftrightarrow\ & 1 - \tfrac{1}{2}\left(S^{[e,bnk]} + S^{[e,crp]}\right) > 0
\end{aligned}
$$

which is always true as $S^{[e,crp]} < S^{[e,bnk]} < 1$.

Case 2: $\gamma^e\sigma_\pi^2 + r_{bl} < r_f + \beta_{\pi m}(r_m - r_f)$. Then $S^{[e,bnk]} = \frac{\mu^{bnk}-\kappa^{bnk}}{\gamma^e\sigma_\pi^2} > 1$ and $r_{bf} = r_{bl}$. The proof is similar to the one of Case 1.

Case 3: $\gamma^e\sigma_\pi^2 + r_{bd} < r_f + \beta_{\pi m}(r_m - r_f) < \gamma^e\sigma_\pi^2 + r_{bl}$. From Proposition 2, the contract with the bank-sponsored VC is degenerate with $S^{[e,bnk]} = 1$ and $U^e(S^{[e,bnk]}, \tau^{[e,bnk]}) = r_\pi - \frac{1}{2}\gamma^e\sigma_\pi^2$. The expression follows.

Tables

Table 1: Characteristics of investor types.

Type of venture capital sponsor	Independent	Corporate	Bank
Profit-maximizer	✓	✓	✓
Diversified shareholders	×	✓	✓
Financial intermediary	×	×	✓

Table 2: Shares in total funds raised by investor type in USA and Europe.

Classification	Investor type	USA (%)	Europe (%)
"Corporate"	Funds of funds		18.8
	Endowments and foundations	21.0	3.3
	Corporate Investors	2.0	5.9
	Total	**23.0**	**28.0**
"Bank-sponsored"	Banks	25.0	21.6
	Insurance companies		13.0
	Pension funds	42.0	28.8
	Total	**67.0**	**63.4**
"Independent"	Private Individuals	**10.0**	**8.6**

Source: The European Venture Capital Association (EVCA) and the National Venture Capital Association (NVCA). Funding sources coming from government agencies and unidentified sources were left out. US data are for year 2003. European data are for years 2002-2006 (average).

Table 3: Characteristics of investors' utility maximization.

	μ^i	κ^i
Corporate	$r_f + \beta_{\pi m}(r_m - r_f)$	r_f
Independent	$r_f + \beta_{\pi ind}(r_{ind} - r_f)$	r_f
Bank	$r_f + \beta_{\pi m}(r_m - r_f)$	r_{bd} or r_{bl}

Note: μ^i represents the cost of equity investment. κ^i represents the rate of lending (if $S > 1$) or borrowing (if $S < 1$) available to the investor.

Table 4: List of calibrated parameters.

	Parameter	Notation	Value
Entrepreneur	Risk aversion coefficient	γ^e	1*
Market portfolio	Expected return	r_m	0.10
	Standard deviation	σ_m	0.16
Venture	Expected return	r_π	0.40*
	Standard deviation	σ_π	0.35*
	Beta	$\beta_{\pi m}$	1.25
	Size	K	3*
Cost of intermediation	Risk-free rate	r_f	0.04
	Bank loan rate	r_{bl}	0.055
	Bank deposit rate	r_{bd}	0.025
Independent VC	Cost of capital	μ^{ind}	0.30

Table 4 summarizes the base case calibration. Risk aversion coefficient is made consistent with estimates from Tarashev et al. (2003), Bliss and Panigirtzoglou (2004) as well as Hall and Woodward (2010). Market portfolio parameters are derived from Kerins et al. (2004). Venture characteristics are obtained from Bitler et al. (2005), Gompers and Lerner (1997), Cochrane (2005), Manigart et al. (2002) as well as Kerins et al. (2004). Cost of intermediation is inferred from Demirgüç-Kunt et al. (2003). Cost of capital for the independent venture capital is obtained from Kerins et al. (2004). Parameters marked with a star are varying in our simulations analysis.

Table 5: Market share changes for the bank-sponsored VC investor.

Panel A: Risk aversion coefficient shifts from 0.1 to 1					
	$K \leq 2$	$K \leq 3$	$K \leq 4$	$K \leq 5$	$K \leq 6$
$\sigma_\pi \leq 0.1$	0	0	0	0	0
$\sigma_\pi \leq 0.2$	0	0	0	+0.013	+0.039
$\sigma_\pi \leq 0.3$	0	+0.049	+0.113	+0.167	+0.213
$\sigma_\pi \leq 0.4$	0	+0.036	+0.084	+0.125	+0.158
$\sigma_\pi \leq 0.5$	0	+0.029	+0.067	+0.099	+0.126
Panel B: Risk aversion coefficient shifts from 1 to 2					
	$K \leq 2$	$K \leq 3$	$K \leq 4$	$K \leq 5$	$K \leq 6$
$\sigma_\pi \leq 0.1$	0	0	0	0	0
$\sigma_\pi \leq 0.2$	0	+0.046	+0.112	+0.157	+0.178
$\sigma_\pi \leq 0.3$	0	−0.014	−0.033	−0.049	−0.062
$\sigma_\pi \leq 0.4$	0	−0.010	−0.024	−0.036	−0.046
$\sigma_\pi \leq 0.5$	0	−0.008	−0.019	−0.029	−0.037

This table reports the change in the number of instances where the optimal investor type is the bank-sponsored VC as entrepreneur risk aversion coefficient shifts from 0.1 to 1 (Panel A) and from 1 to 2 (Panel B). Calculations are made under the assumption of a uniform distribution across project size and risk. Parameter values are in Table 4.

Table 6: **Descriptive statistics of empirical variables.**

Panel A: Dependent Variable				
	$\gamma_{c,T}$			
c	mean	med.	s.d.	range
FR	0.57	0.65	0.17	0.30-0.80
GE	0.37	0.38	0.19	0.06-0.67
NL	0.33	0.34	0.15	0.06-0.52
SW	0.42	0.37	0.11	0.29-0.59
UK	0.33	0.33	0.13	0.07-0.47
Total	0.40	0.39	0.17	0.06-0.80

Panel B: Independent Variables												
	$w_{ind;c,T}$				$w_{crp;c,T}$				$w_{bnk;c,T}$			
c	mean	med.	s.d.	range	mean	med.	s.d.	range	mean	med.	s.d.	range
FR	0.13	0.12	0.06	0.06-0.25	0.19	0.18	0.07	0.09-0.35	0.49	0.50	0.15	0.25-0.65
GE	0.12	0.08	0.09	0.02-0.28	0.20	0.17	0.12	0.08-0.47	0.45	0.52	0.14	0.21-0.63
NL	0.07	0.06	0.06	0.00-0.21	0.25	0.30	0.13	0.06-0.43	0.61	0.58	0.18	0.29-0.84
SW	0.15	0.10	0.19	0.00-0.55	0.35	0.30	0.21	0.07-0.74	0.38	0.38	0.18	0.06-0.66
UK	0.07	0.07	0.03	0.03-0.12	0.25	0.24	0.03	0.20-0.28	0.50	0.49	0.09	0.38-0.68
Total	0.11	0.11	0.10	0.00-0.55	0.25	0.25	0.14	0.06-0.74	0.49	0.49	0.16	0.06-0.84

Panel C: Correlations			
	$\gamma_{c,T}$	$w_{ind;c,T}$	$w_{crp;c,T}$
$w_{ind;c,T}$	-0.50***	1	
$w_{crp;c,T}$	-0.33**	0.16	1
$w_{bnk;c,T}$	0.21	-0.26	-0.47***

This table reports the descriptive statistics of the dependent variable (Panel A) and independent variable (Panel B) for France (FR), Germany (GE), the Netherlands (NL), Switzerland (SW) and United Kingdom (UK) for the period 2001-2009 (Panel A) and 2002-2009 (Panel B). The yearly estimate of $\gamma_{c,T}$ is obtained by regression $R_{c,t} \simeq a - \gamma_{c,T}\Delta VIX_{ct} + \varepsilon_{ct}$ on daily data. In Panel C, superscripts *,** ,*** indicate statistically significant at the 1%, 5% and 10% confidence level, respectively.

Table 7: **Panel regression results.**

		γ_0	$w_{ind;c,T}$	$w_{crp;c,T}$	$w_{bnk;c,T}$	d_{0607}	$\bar{R}^2$
Basic Panel Regression		0.393***	−0.554**	−0.069	0.127		57.47%
		(0.126)	(0.236)	(0.197)	(0.141)		
		0.340**	−0.522**	−0.056	0.181	0.076**	59.52%
		(0.076)	(0.234)	(0.175)	(0.164)	(0.030)	
Optimized Panel Regression	Pool	0.231**	−0.559***	0.230	0.392***	0.105***	69.26%
		(0.103)	(0.117)	(0.211)	(0.115)	(0.028)	
	FR	0.410***					
		(0.097)					
	NL				0.083		
					(0.088)		
	SW			−0.212			
				(0.165)			
	UK				0.083		
					(0.088)		

This table reports the panel least squares regression coefficients for the generic equation $\gamma_{c,T} = \gamma_0 + \sum_{i=ind,crp,bnk} b_i w_{i;c,T} + controls + \eta_{c,T}$ estimated with yearly data on France (FR), Germany (GE), the Netherlands (NL), Switzerland (SW) and United Kingdom (UK) for the period 2002-2009. Standard deviations are reported between parentheses. The dummy variable d_{0607} takes value 1 if the year is 2006 or 2007 and 0 otherwise. The other control variables have the structure $controls = \gamma_0' 1_{\{c=c_1 \text{ or } c_2 \text{ or} \ldots\}} + \sum_{i=ind,crp,bnk} b_i' w_{i;c,T} 1_{\{c=c_1 \text{ or } c_2 \text{ or} \ldots\}}$. In the optimized panel regression, the specification chosen maximizes the Schwarz information criterion. For each country specific coefficient, significance is assessed on the net coefficient value $\gamma_0 + \gamma_0'$ or $b_i + b_i'$ using the Wald test. Superscripts $^{*}, ^{**}, ^{***}$ indicate statistically significant at the 1%, 5% and 10% confidence level, respectively.

Figures

Figure 1: Feasible contracts

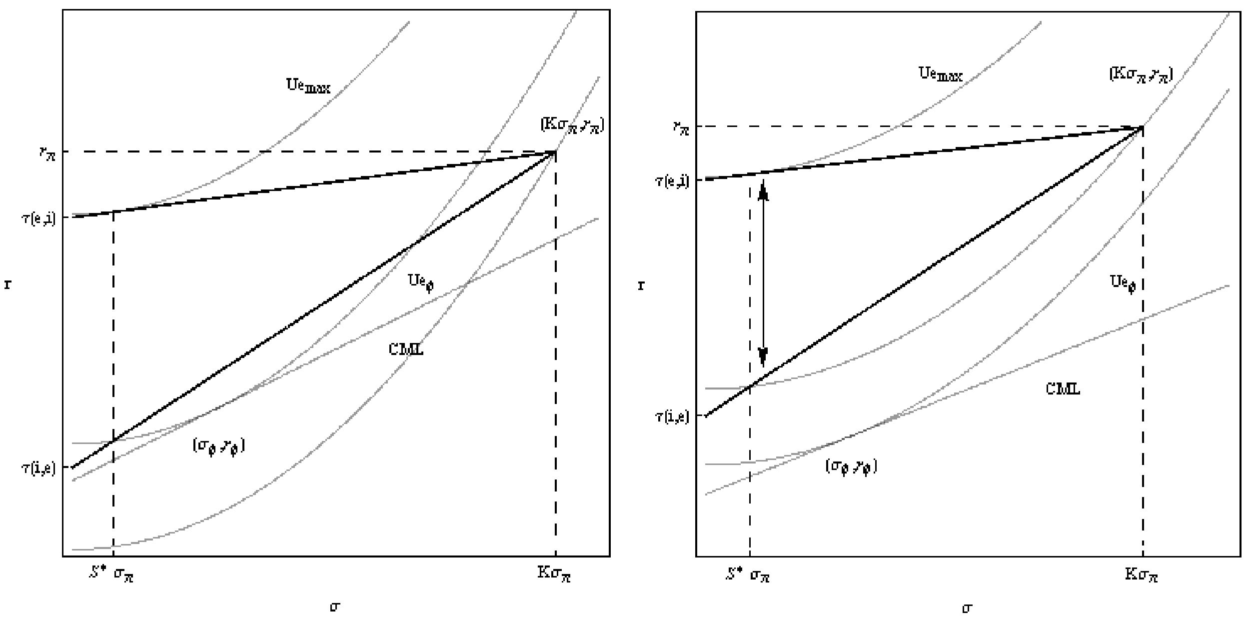
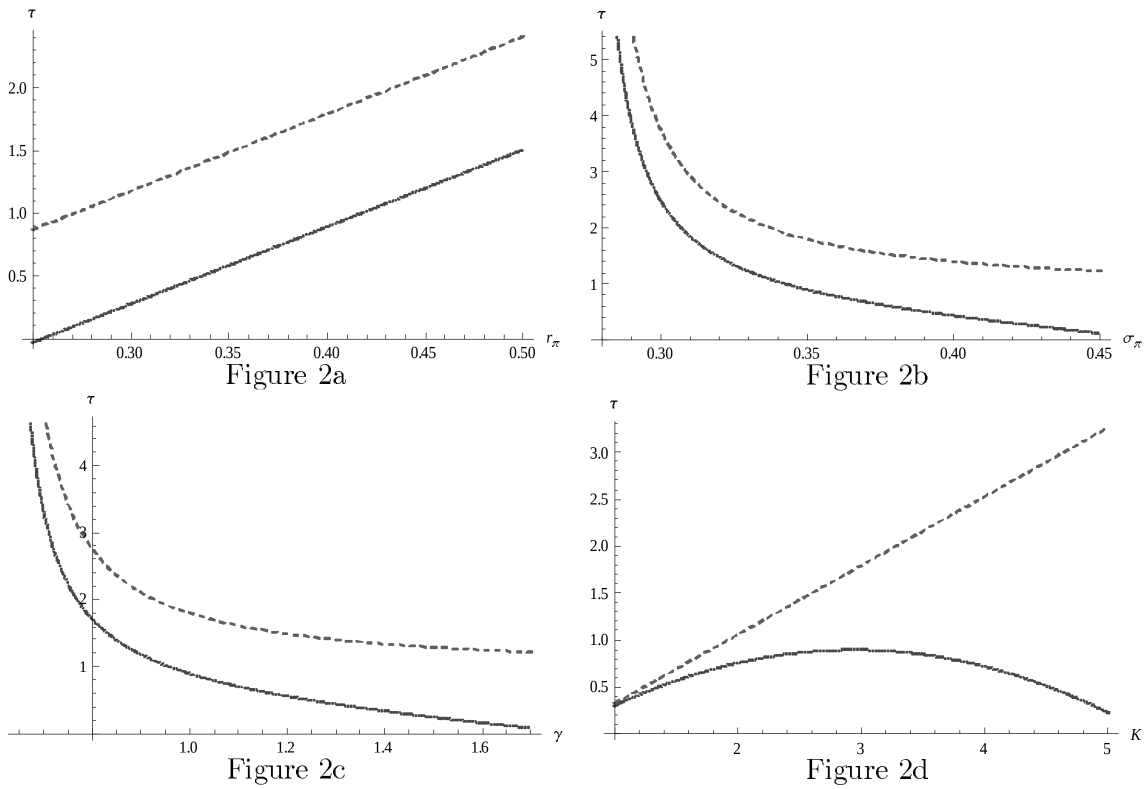


Figure 1a Figure 1b

Figures 1a and 1b illustrate the feasible contracts between the entrepreneur and the venture capitalist in the standard deviation - mean space when the entrepreneur does not (figure 1a) or does (figure 1b) finance the venture. The curve labeled U_{ϕ}^{e} is the entrepreneur's initial utility function. The straight line labeled CML is the Capital Market Line. Their tangency point is at coordinates $\left(\sigma_{\phi}, \mu_{\phi}\right)$. The bold straight lines connect the project characteristics $\left(\sigma_{\pi}, r_{\pi}\right)$ with the lower and upper bounds for the admissible rate of transfer between the entrepreneur and the venture capitalist ($\tau^{[e.i]}$ and $\tau^{[i,e]}$). The arrow in figure 1b spans the possible utility gains for the entrepreneur resulting from all feasible contracts.

Figure 2: Bounds for rate of transfer – corporate VC case



Figures 2a to 2d plot $\tau^{[i,e]}$ (straight line) and $\tau^{[e,i]}$ (dashed line) as a function of project expected return r_π (figure 2a), project return volatility σ_π (figure 2b), entrepreneur's risk aversion γ^e (figure 2c) and project's size relative to entrepreneur's wealth K (figure 2d). Base case parameter values are in Table 4. When not varying, entrepreneur's risk aversion is $\gamma^e = 1$ and project's size relative to entrepreneur's wealth is $K = 3$. The type of venture capital is corporate. In all the plotted domains, endogenous S^* is below 1, hence a contract is feasible when $\tau^{[i,e]} < \tau^{[e,i]}$.

Figure 3: Bounds for rate of transfer – independent VC case

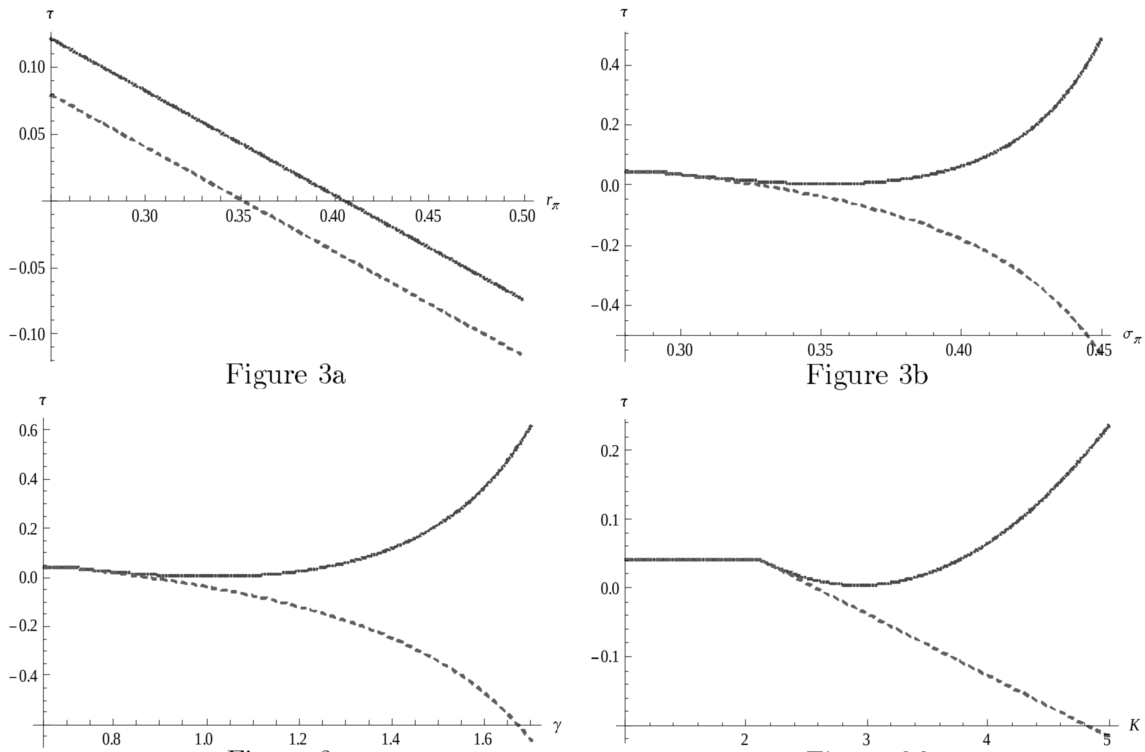


Figure 3a
Figure 3b
Figure 3c
Figure 3d

Figures 3a to 3d plot $\tau^{[i,e]}$ (straight line) and $\tau^{[e,i]}$ (dashed line) as a function of project expected return r_π (figure 2a), project return volatility σ_π (figure 2b), entrepreneur's risk aversion γ^e (figure 2c) and project's size relative to entrepreneur's wealth K (figure 2d). Base case parameter values are in Table 4. When not varying, entrepreneur's risk aversion is $\gamma^e = 1$ and project's size relative to entrepreneur's wealth is $K = 3$. The type of venture capital is independent. In all the plotted domains, endogenous S^* is above 1, hence a contract is feasible when $\tau^{[i,e]} > \tau^{[e,i]}$.

Figure 4: Optimal choice of VC type

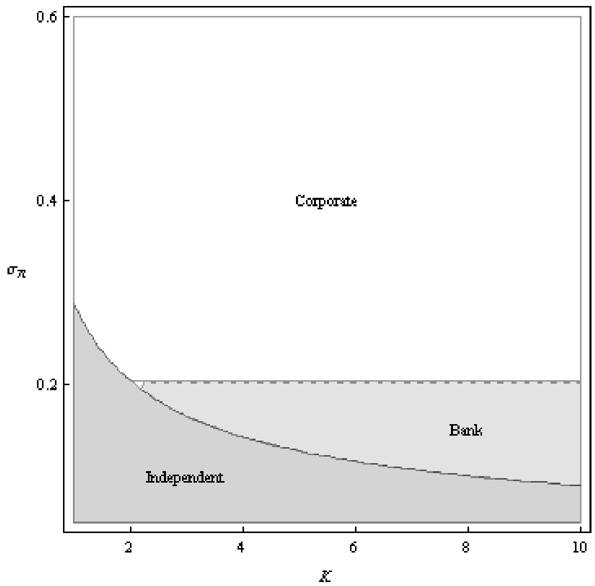


Figure 4a

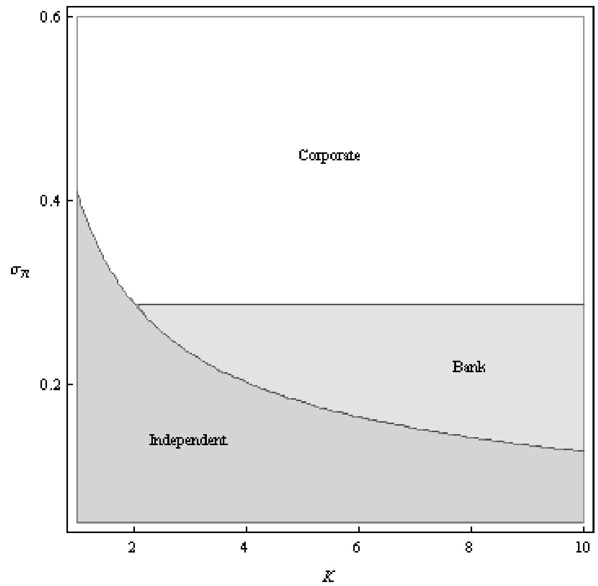


Figure 4b

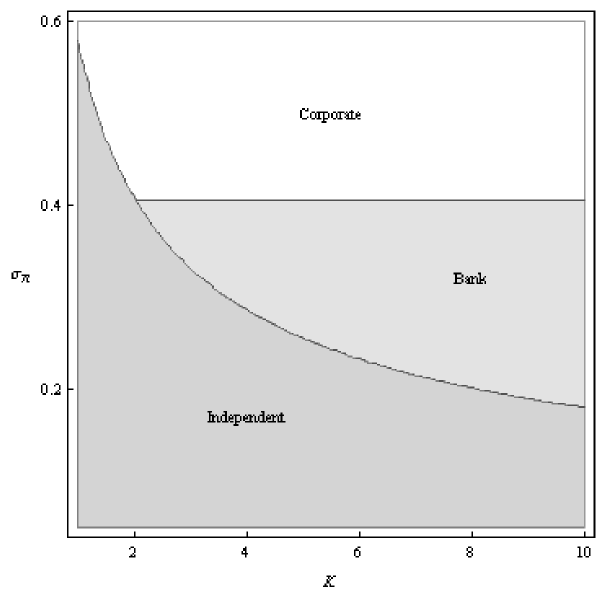


Figure 4c

Figures 4a to 4c plot, as a function of project size (K) and project risk (σ_π), the type of venture capitalist that maximizes contract surplus with the entrepreneur. Base case parameter values are in Table 4. In Figure 4a, entrepreneur's risk aversion is $\gamma^e = 2$. In Figure 4b, it is $\gamma^e = 1$. In Figure 4c, it is $\gamma^e = 0.5$.

Figure 5: Difference in contract surplus

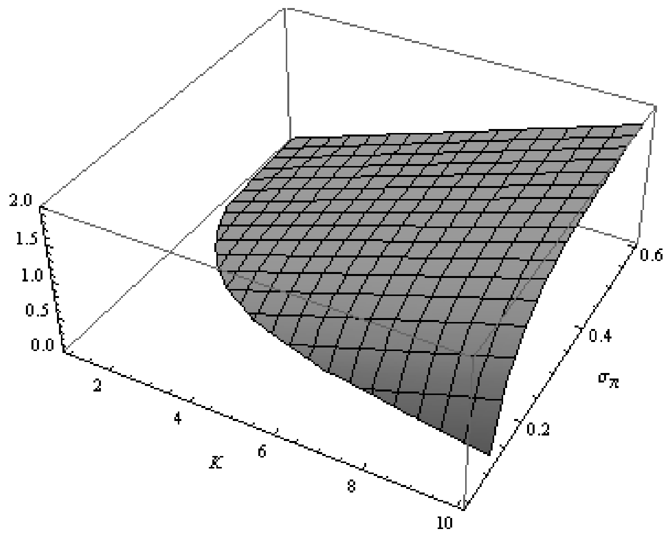


Figure 5a

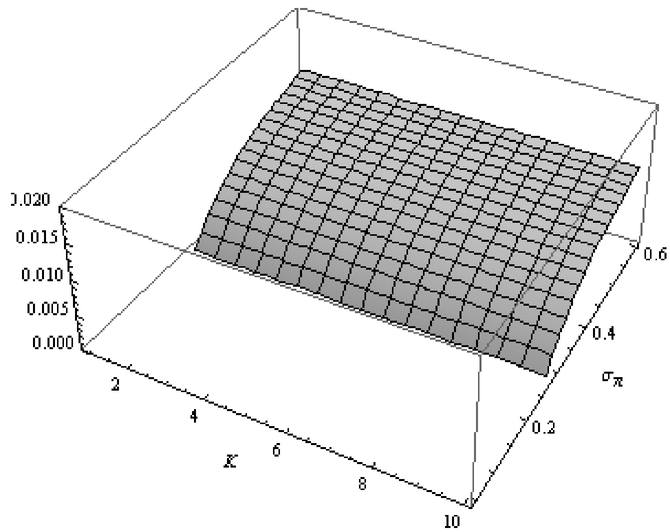


Figure 5b

Figures 5a and 5b plot, as a function of project size (K) and project risk (σ_π), the difference in contract surplus between the corporate VC and the independent VC (Figure 5a), and between de corporate VC and the bank-sponsored VC (Figure 5b). Base case parameter values are in Table 4.

Figure 6: Endogenous dilution factor

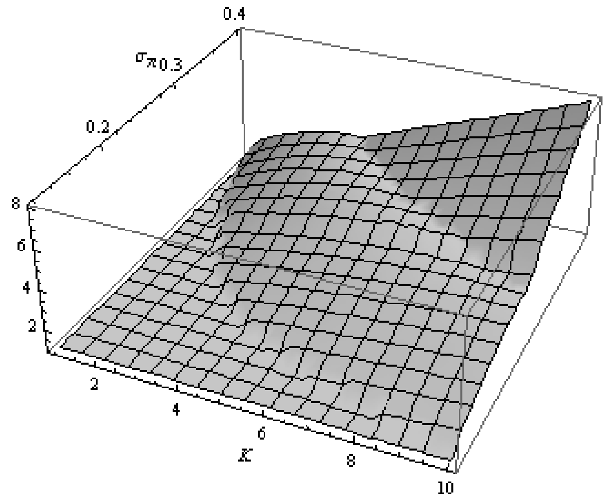


Figure 6 plots, as a function of project size (K) and project risk (σ_π), the dilution factor obtained from the optimal transfer rate. The VC type is endogenously determined. Base case parameter values are in Table 4.