INNOVATION AND VENTURE CAPITAL EXITS*

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Abstract

This paper addresses the choice between different exit routes of venture capitalists for a project yielding a quality-improving product innovation. We explicitly introduce product market characteristics into the analysis with the aim to identify their effects on the optimal exit strategy and on the financial contract. Going public can be more profitable than a trade sale (i.e., selling the venture to an existing company) when the new product is sufficiently innovative. This leads to an agency conflict if the entrepreneur enjoys private benefits from staying an independent manager in the firm after the exit of the venture capitalist. The entrepreneur has incentives to distort the innovation strategy so as to make an IPO the preferred exit. We derive the optimal financing strategy under different allocations of control rights and market power. The use of an optimal mix of debt and equity can partially mitigate such a distortion. We also discuss empirical implications and offer partial empirical evidence.

Keywords: venture capital, exit strategy, innovation, link between product market and capital market

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1 Introduction

Since most high tech start-up companies are initially unprofitable, the exit route of the venture is the primary way how the venture capitalist can realize a positive return on her investment. Exit conditions are therefore crucial for financing. The type of exit is not only an important issue for the venture capitalist, but also for the entrepreneur. The latter must understand that the venture capitalist will want to exit the venture in a not too distant future, and very often this means that the venture will be sold to another company (trade sale). If the entrepreneur nevertheless wants to keep control over the company afterwards and run it by his own, he will need to find the funds required to buy out the venture capitalist. Otherwise, the venture is sold after few years to an existing firm.

For many years, the relative lack of venture capital in Europe and Asia has been blamed on the absence of active primary equity markets and in particular the absence of high-growth and high-tech segments such as Nasdaq in the US. Conversely, the slow development of stock markets has been blamed on the small investment in venture capital funds. In the US and in Europe, the two main exit routes are trade sale and initial public offering (IPO). New stock markets that have been created recently in Europe aim to make exit easier for investors like venture capitalists. The European Venture Capital Association (EVCA (2001)) reports that, on average for the last 5 years, exits of European private equity occurred through a trade sale in almost the half of the total amount (at cost of investment); and 18% were IPOs (the rest were either write-offs or exits by "other means"). For the US, the NVCA reports a ratio trade sale over IPO of 1.1 for 1997 and 1.7 for 1998. A trade sale typically occurs after some bilateral negotiation with some existing firm, most often with one that is already present in the relevant market. In case of a trade sale, the ownership is then transferred to the acquirer. An IPO, in contrast, leads to the creation of a new independent firm and allows entrepreneurs to remain in control of their company after the venture capitalist's exit.

It has therefore been argued (e.g., by Black and Gilson (1998)) that the strong link between an active venture capital industry and a well-functioning stock market is explained by the fact that IPOs generate *implicit contracts* for entrepreneurs over future control. The possibility for an IPO is told to provide the entrepreneur with a "call option on control". In contrast to a trade sale, a public listing allows the entrepreneur to remain in the company as independent manager, for which he very often gets non-monetary private benefits. Many entrepreneurs therefore have a preference for an IPO over a trade sale.

So far, only little attention has been devoted to explain how the decision on the type of exit is made by venture capitalists. Most theoretical studies have taken either the exit value as exogenously given, or as a reduced form function of effort provided by entrepreneur and venture capitalist. But in fact, the exit route (i.e., IPO versus trade sale) can also have substantial effects on the value of the venture, and thereby the incentives of both parties during their contractual relationship.

The present paper deals with the effect of product market characteristics on the optimal exit strategy of venture capitalists. It provides a possible explanation for the choice between a trade sale and an IPO. Competition in the product market is modeled in a vertical product differentiation framework. This allows to model innovation in form of product quality improvements. We introduce explicitly product market characteristics into the analysis with the aim to identify their effects on the optimal exit strategy and on the financial contract between the venture capitalist and entrepreneur. It will be shown that highly innovative ventures do more often go public than less innovative (or imitator) projects, which are most often sold to incumbent firms. For less innovative start-up companies, competition would be so fierce in case of entry of the newcomer that the incumbent has an incentive to make an offer that is higher than what the company would get through a public listing. But when the start-up is more innovative, it differentiates itself from the incumbent so that the competition effect is weakened and the gain from a trade sale is reduced. The exit route of the venture capitalist is therefore endogenously determined on the basis of product market characteristics and the venture's depth of innovation.

In this paper, we also show that the possibility to enter into implicit contracts over control with the entrepreneur under an IPO may also have an important drawback; indeed, this also opens the door to an agency conflict that has not been studied yet. The entrepreneur might take more risk (by implementing a more innovative research path) than what the venture capitalist would like if this guarantees the entrepreneur an IPO in case the project is successful. Since the explicit analysis of product market outcome implies that more innovative companies are more likely to go public, the entrepreneur might possibly try to come up with a more innovative product to make his company more attractive for an IPO in case of successful R&D. But the opposite can also be true. The entrepreneur might be willing to take less risk if he is sure by that still to remain independent after a successful R&D stage. We show that the use of optimal debt-equity mix can reduce, in some case even eliminate, this kind of distortion. The optimal allocation of control rights also affects the outcome; an optimal allocation allows to extract additional rents from a trade sale by reducing the bargaining power of the potential buyer.

We therefore provide an alternative explanation for excessive distortion by entrepreneurs when getting outside funding for their projects. The typical claim is that entrepreneurs take too much risk because they do not bear any financial risk (another reason is excessive debt that generates hard claims for entrepreneurs). Here, excessive distortion stems from the "independence bias" implied by the private benefits under an IPO. Since most innovative ventures are more likely to go public, the distortion represents an increase in risk taking at the R&D stage.

The main focus of the paper is to explain the choice of the venture capitalist between a trade sale and an IPO and to derive empirical implications. We present them in form of hypotheses to provide (hopefully) useful material for further empirical research. One of these will be illustrated with UK data; it provides empirical evidence that the likelihood to go public is positively related to profitability. This is also confirmed by empirical studies (e.g., Cumming and MacIntosh (2000), and Gompers (1995)[1]). The model also implies that the potential distortion increases with the size of

[1] According to Gompers (1995), the annual return of venture capital in the US is 60% when exit occurs through

the entrepreneur's private benefits. Thus, the venture capitalist needs to be even more aware of the possible distortion when contracting with an entrepreneur that shows high interest in controlling the firm afterwards.

This paper also discusses issues recently raised by other authors in empirical studies (e.g., Hellmann and Puri (2000), and Kortum and Lerner (1998)) about the causality between innovation and the use of venture capital to fund projects. These studies provide evidences that the presence of venture capital fosters innovation (although the direction of this causality is not clear from their study). In this paper, we show that such a causality may exist and that the link is affected by the exit opportunities for the venture capitalist. In fact, because venture capitalists do not take into account the private benefits of entrepreneurs at the exit stage, venture-backed companies are more innovative (i.e., the entrepreneur reacts by over-distorting the depth of innovation). This bias creates an additional channel in that venture-backed companies are more innovative on average as compared to self-financed ones.

This paper is related to two different strands of literature. One is the literature on venture capital contracting and control rights allocation. Papers typically focus on agency conflicts arising from abandonment issues and from how to avoid shirking by the entrepreneur (see, e.g., Aghion and Bolton (1992), Cornelli and Yosha (1997), Bergemann and Hege (1998), and Hellmann (1998)). Among other things, they highlight the importance of adequate incentive-based rewarding schemes, the optimal allocation of control rights, and the role of stage financing to mitigate conflicts. This paper is new in that it deals with another much less studied agency conflict: one that is related to exit issues. The fact that the venture capitalist exits after the R&D stage is the source of distortion.

A paper with ideas closely related to the present paper is the one of Berglöf (1994). He argues that if the "right to sell control" (representing a veto right on a possible trade sale) belongs to the venture capitalist, the entrepreneur will be vulnerable to expropriation of his private benefits in case of a trade sale. In this case, it is optimal to give these control rights (the veto right) to the entrepreneur. It will be shown that this is also in part true in this context. But we will show that the opposite can also be true when these private benefits are very large. In the present paper, by focusing on the two main exit routes we will also provide an explanation for the question of how the venture capitalist gets out of a project. We explicitly model the product market equilibrium outcome to determine profit levels and the premium that the incumbent is willing to pay. This will allow us to derive an endogenously determined exit route based on product market and capital market equilibria.

The second literature area is the one studying the inter-connection between capital markets and product markets (see Maksimovic (1995) for a survey). It points out the disciplinary effect of the capital structure (in particular debt as hard claims) on the manager's behavior in the product market. In this paper, we add to these insights the effect of venture capital financing and innovation opportunities on both markets. The choice of exit route of the venture capitalist will be based on product market characteristics which in turn affects the financial contract between both parties.

IPOs, and only 15% when venture capitalists sell their stake to another company.

Similarly, the financial structure of the venture can also have an important impact on the exit route, since it will determine the potential outcome in the product market through its influence on the innovation strategy of the venture. This is a new channel which, we believe, has not been explored yet.

The paper is structured as follows. In the next Section, we present the model. In Section 3, we derive the optimal exit strategy for the venture capitalist. The entire model is then solved for the optimal financing strategy in Section 4. Section 5 extends the benchmark model by including reputation benefits for the venture capitalist. Section 6 deals with contingent control rights allocation. Section 7 analyzes the effect of a shift in bargaining power from the entrepreneur to the venture capitalist. It also discusses the robustness of the main assumptions. Empirical implications and some related evidences are presented in Section 8. Section 9 concludes.

2 The Model

2.1 Innovation and Venture Financing

Assume that initially a monopolist, M (also called incumbent), produces a given (indivisible) good with quality level $s > 0$.[2] Market demand is characterized by a limited number of consumers (normalized to unity) whose marginal utilities θ for quality are uniformly distributed along the segment $[\underline{\theta};\overline{\theta}]$, and each consumer's utility is $\mathrm{U}(\theta) = \theta s - P$. The variable P denotes the price for the unit purchased. Each consumer buys at most one unit of the good and the reservation value of consumers for buying that unit is set equal to zero.

Consider now an entrepreneur (E) with zero wealth who is raising funds from a venture capitalist (VC) to finance a project. The entrepreneur is the exclusive owner of the innovative idea behind the project. Both parties are assumed to be risk-neutral. The amount of funds needed is denoted by $I > 0$ and is exogenously given. The innovation offers the opportunity to improve the quality of the incumbent's product.

In case of successful innovation, the newcomer (which is the firm that might enter if the entrepreneur is successful in R&D) will be able to produce a related product but with increased quality level $s(\delta + 1)$, where $\delta \geq 0$ and[3] $\delta \leq \delta_{\max} \equiv 3\underline{\theta}/(\overline{\theta} - 2\underline{\theta})$. We assume that in case two firms are present in the market, all the consumers are served by either the incumbent or the newcomer (the so-called covered market assumption). Consumer heterogeneity (which is the difference between $\overline{\theta}$ and $\underline{\theta}$) is assumed to be large enough for two firms to coexist (which requires that $\overline{\theta} > 2\underline{\theta} > 0$).

[2] In typical vertical product differentiation models, incumbents can choose their quality levels from a segment $[\underline{s}, \overline{s}]$, where $\underline{s}$ is the lowest quality level possible, and $\overline{s}$ is the upper bound. Here, we consider the limit case in which $\underline{s} = \overline{s} \equiv s$; that is, the 'quality segment' is reduced to a single point.

[3] In fact, the analysis could be extended beyond $\delta_{\max}$ by changing the level of reservation utility of consumers, but limiting ourself to it is sufficient to get all the wanted intuitions, while keeping the analysis tractable. For the mathematical derivation of $\delta_{\max}$, cf. Part I in the Appendix. A closer look at the possible range for $\delta_{\max}$ indicates that it can take any positive value: as consumer heterogeneity increases, $\delta_{\max}$ goes to zero; when consumers' tastes are more homogeneous (i.e., $\overline{\theta}$ converging to $2\underline{\theta}$), $\delta_{\max}$ goes to infinity.

For the sake of simplicity, assume also that the production cost of the good is zero, regardless the quality level.

Innovating allows E to achieve a positive value of δ. By choosing the level of δ he wants to achieve, we assume that the entrepreneur affects the expected payoffs in two ways: by increasing δ, *(i)* the 'quality segment' will be longer in case of successful innovation (which will induce higher profits); and *(ii)* it will reduce his probability of succeeding. Both components have opposite effects on expected profits. Therefore, δ can be interpreted in two closely related ways: the depth of innovation of the venture, and the risk of its research path (the 'technological risk'). While the first interpretation stems from the fact that δ determines the quality improvement, the latter comes from the lower probability of success when the entrepreneur is selecting a higher δ. The greater this parameter, the higher the risk, but the greater the return (we will see that return increases with δ).

We therefore consider projects with high δ as being highly innovative and projects with low δ as imitators. This fits relatively well to the definition provided by Hellmann and Puri (2000). They define an innovator as a "company [that] is either creating a new market, is introducing a radical innovation in an existing market or is developing a technology that will lead to products that satisfy either of the above criteria". Imitators seek their advantage through minor differentiation, though there is still some depth of innovation in their product.

The venture's probability of success is denoted by $p(\delta)$. We assume that $p'(\delta) < 0$ and $p''(\delta) > 0$. In what follows, we will restrict ourself to the functional form $p(\delta) = 1/(\delta + d)^2$ with $d \geq 1$. We analyze situations in which R&D costs I are such that, in equilibrium, financing the project is profitable ex ante. For simplicity, we set the reservation payoff of the entrepreneur to zero and that of the venture capitalist to $I \cdot \rho$ (that is, an expected return on investment of $\rho \geq 0$).[4] In the benchmark case, we assume perfect competition between venture capitalists so that the participation constraint of VC is always binding.

2.2 Private Benefits and Competencies

As Aghion and Tirole (1994) point out, an innovative idea is very often ill-defined. It is not possible to describe it accurately ex ante, or to write enforceable contracts on it. We capture this idea by assuming that the variable δ is observable ex post, but not contractible ex ante. The idea is that it is not possible ex ante to give an exact definition of how the innovation will have to look like, which effectively gives E considerable discretionary power on the choice of δ. Typically, he is the one that manages the venture on a day-to-day basis. This contractual incompleteness is assumed throughout the paper since E has full discretion over the research path δ. Combined with the presence of private benefits for E (implied by the implicit contract over control as discussed in the introduction), this

[4]The assumption that $\Pi_{vc} \geq I\rho$ only requires a large enough value of s. The same is true for the assumption of covered market in case of entry. The parameter s can be viewed as the degree of value adding of the product. Under this view, high tech products would be characterized by relatively high values of s. This view will be used later to develop some empirical implications of the model (cf. Section 8). High quality products also characterize quite well the type of product innovations that are financed by venture capitalists.

will give rise to an agency conflict with respect to the optimal choice of δ. It will be shown later that the distortion can occur in either direction, either to a too high or too low choice of δ.

Similarly, exit issues are here assumed to be in the competencies of the venture capitalist; she will be assumed to be the only one able to negotiate efficiently with potential buyers. This is captured by assuming that VC retains the control rights (throughout this paper, these control rights refer to the right to decide on the choice of exit).

2.3 Exit Strategies and Stages of the Game

If she accepts to finance the project, VC exits after the R&D stage (ex post, it is more profitable for her to sell her shares once the R&D is over and to invest the amount in a new project). We consider the following exit routes:

(1) IPO: the company is listed on a stock market at value $\Pi(\delta)$. Assuming that E remains in the firm and is controlling it, he gets non-transferable private benefits of $b > 0$. We also assume that VC cannot credibly commit himself to fire E prior to the introduction.

(2) Trade sale (TS): the venture is sold to the incumbent M. In this case, E does not enter the product market and M retains his monopoly position. Only a proportion $0 < \gamma \leq 1$ of the technological innovation δ is transferred and successfully implemented.

(3) Liquidation: if E is unsuccessful in developing the new product, the venture will be liquidated. The liquidation value is normalized to zero.

We will assume that in an IPO the shares are sold on the stock market to a wide spectrum of investors, with none of them having a controlling stake in the firm. The entrepreneur will therefore remain in the company for sure and be free to manage it by his own.

The fact that the technological transfer is incomplete under a TS is a critical assumption. It stipulates that if M acquires the venture, he can only achieve the quality level $s(\gamma\delta+1)$. If $\gamma = 1$, the transfer is complete; if $\gamma = 0$, the transfer is impossible. In-between these two extremes, the transfer is incomplete.[5] Without this inefficiency of a TS, an IPO as the non-cooperative market outcome would always be suboptimal. Though, we will see that this does not necessarily hold anymore if $\gamma < 1$; a TS might then become too costly for M.[6]

Note that all we need to assume is a relative inefficiency of a TS compared to an IPO. Another possible interpretation for this inefficiency is related to the type of assets generated by the entrepreneur. If they are all tangible or if the product is perfectly patentable, then all the innovation

[5] Another possible source of inefficiency is the presence of switching costs for M from changing his technological level from s to $s(\delta + 1)$. Both types of inefficiency yield qualitatively similar results.

[6] A possible way to reduce such inefficiency is through a 'lock-in' contract that M could offer to E. Since control rights are retained by M, the entrepreneur will not get any private benefits (these will go to M). Still, we should expect $\gamma < 1$ due to possible replacement effects (fixed replacement cost, e.g., through scraping old equipment, or compensating former employees for firing them and hiring new ones) and the subsequent agency problems (loss of control) arising from the fact that E is now the agent of M.

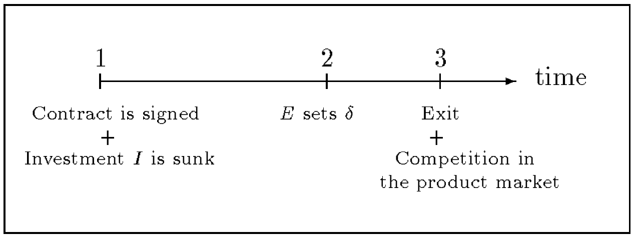

Figure 1: Time line of the game

can be used by the buyer through a TS. In this case, γ is near unity. But if the innovation involves intangible assets, like the human capital of the entrepreneur or key employees, then not all of the assets can be fully captured by the trade sale buyer. Other possible explanations for inefficiency from a trade sale are lack of clear boundaries of the firm after the acquisition (inducing difficulties in providing optimal incentive contracts to the entrepreneur and key employees), organizational inefficiencies (the negative effect for an initially losely structured firm that is being integrated into a larger, often more hierarchical (and already well-established) company) and differences in managerial culture (start-ups are often told to have their own "culture" and be based on new business models).

The game evolves over 3 stages as depicted in Figure 1. In stage 1, E offers a take-it-or-leave-it contract to VC (allocation of cash flow rights). If VC accepts the contract, the project is financed and VC invests the amount I. In stage 2, R&D takes place. E chooses δ, the depth of innovation. In the last stage, the exit decision is made. In the benchmark model, VC retains the "right to sell control" (in what follows, we will refer only to the control rights) so that she can decide on the type of exit. More specifically, she may accept or refuse any offer made by M for a TS. The profit is paid out according to the financial contract signed in stage 1. The exit value is determined on the basis of a second-price bid auction (the higher value bidder wins at the reservation value of the lower value bidder) between the incumbent M and the financial market, where the latter is perfectly competitive so that it will bid the true value $\Pi(\delta)$ for the venture. It is assumed that M is able to make a take-it-or-leave-it offer to VC in stage 3. If VC accepts it, a TS takes place; otherwise, the venture gets listed on the stock market. Therefore, M will acquire the venture before it enters the product market if he is ready to pay more than $\Pi(\delta)$ for the venture. Otherwise, the venture gets listed and enters the product market as a competitor for M.

3 First Best Outcome and Independence Bias

The purpose of this Section is twofold. First, we determine the optimal exit strategy for the venture as a function of δ; and second, we derive its optimal depth of innovation (Subsection 3.2). In both cases, we will contrast the results with the preferred choice of VC. In Subsection 3.3, we illustrate the rationale for possible distortion when E enjoys private benefits from an IPO.

3.1 Optimal Exit Decision

If there is no innovation or entry, the monopoly profit of M can be calculated as

$$\Pi_m = \frac{1}{4}\overline{\theta}^2 s \tag{1}$$

The market is then in general uncovered; i.e. not all consumers are served (this result as well as the closed-form profit levels employed later on are all derived in Part I of the Appendix). In case of a successful R&D stage and if the venture remains independent (IPO), the innovation payoff of the entrepreneur's project can be calculated as

$$\Pi(\delta) = \left[\frac{1}{9}(2\overline{\theta} - \underline{\theta})^2 s\right] \cdot \delta \equiv \mu(\overline{\theta}, \underline{\theta}, s) \cdot \delta \tag{2}$$

$\Pi(\delta)$ is the monetary value of the venture in case of entry into the product market determined as the market equilibrium outcome of the vertical product differentiation model. Note that $\Pi(\delta)$ is linear with respect to δ. The variable μ is a function of all the product market parameters and is used to make notations easier.

Let us first derive the first-best exit route. A trade sale occurs if the gain for M from acquiring the entrant (provided he is successful in innovating) is greater than the cost of this acquisition (here, the sum of $\Pi(\delta)$ and the compensation for the entrepreneur's private benefits). The following condition must therefore be satisfied:

$$\underbrace{\frac{1}{4}\overline{\theta}^2 s(\gamma\delta + 1)}_{\text{profit of } M \text{ in case of acquisition}} \quad - \quad \underbrace{\frac{1}{9}(\overline{\theta} - 2\underline{\theta})^2 s\delta}_{\text{profit of } M \text{ in case of no acquisition}} \quad > \quad \Pi(\delta) + b \tag{3}$$

The left-hand side represents the maximum offer M will make in case of innovation. It represents also the gain from acquisition (gross of costs). The right-hand side is the cost of acquisition in the price auction and thus the minimum offer that M has to make. If this condition holds, the gain for M from acquiring the potential entrant and using himself the enhanced technology will be greater than $\Pi(\delta) + b$. In this case, M will be able to acquire it by overbidding the market (which will only offer $\Pi(\delta)$ in case E goes public). Otherwise the venture is better off by opting for an IPO. Notice that if VC were the one to make the exit choice (she does this in a non-cooperative way), the cost of acquisition for the incumbent would only be $\Pi(\delta)$, since VC would not care about the benefits b.[7]

It is shown in Appendix (Part I) that, in case of a TS, M will stop producing his previous quality level s and shifts his entire production to $s(\gamma\delta + 1)$; i.e., in equilibrium, only one quality will then be produced. Thus, when buying the new entrant, he is in fact only interested in the new technology, since the best strategy is to produce at highest possible quality, which is $s(\gamma\delta + 1)$.

The condition given by equation (3) is satisfied for any δ such that

$$\delta < \delta_c' \equiv \frac{\frac{1}{4}\overline{\theta}^2 - b/s}{X - \gamma \cdot \frac{1}{4}\overline{\theta}^2} \tag{4}$$

[7]Equation (3) can also be interpreted in another way by simply shifting the second term in the left-hand side to the other side of the inequality. Then the equation says that a trade sale is optimal if monopoly profit is greater than the non-cooperative duopoly outcome (the sum of profits of M and the new entrant).

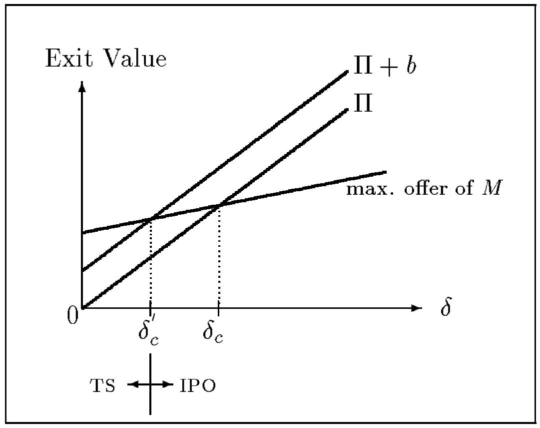

Figure 2: Threshold level of δ

with $X \equiv \frac{1}{9}(\overline{\theta}-2\underline{\theta})^2+\frac{1}{9}(2\overline{\theta}-\underline{\theta})^2$. This threshold level is always strictly positive, since the assumption $\overline{\theta} > 2\underline{\theta}$ implies that $X > \frac{1}{4}\overline{\theta}^2$. For any $\delta < \delta_c'$, M will therefore make an offer that overbids the market before any IPO occurs and compensates for b.[8] This is represented in Figure 2, and is summarized in the first Lemma:

Lemma 1 *Denote* $\delta_c' = \left[\frac{1}{4}\overline{\theta}^2 - b/s\right] / \left[X - \gamma \cdot \frac{1}{4}\overline{\theta}^2\right]$ *and* $\delta_c = \frac{1}{4}\overline{\theta}^2 / \left[X - \gamma \cdot \frac{1}{4}\overline{\theta}^2\right]$. *In a quality-improving innovation, the first-best exit route is a trade sale if* $\delta < \delta_c'$ *and an IPO if* $\delta \geq \delta_c'$. *If the venture capitalist retains the control rights on the exit choice, the threshold value is* δ_c.

If the technological transfer is complete ($\gamma = 1$), then $\delta_c > \delta_{\max}$ and therefore a TS will always be the most profitable exit route for *VC.* But as γ decreases, δ_c' shifts to the left and makes an IPO more likely to occur. Whenever $\delta > \delta_c'$, a trade sale would destroy value; for $\delta > \delta_c'$, it is the opposite.

Notice that from the point of view of the incumbent, Lemma 1 can also be seen as a choice whether to make a bid or not for the start-up. From the point of view of the venture capitalist although, the choice of the exit route depends on the options she has after the innovation stage and therefore remains a decision variable for the venture capitalist. Since in practice it is her responsibility to look for potential buyers (which is here quite trivial since there is only the incumbent), the venture capitalist faces this choice on the exit route. Furthermore, it is her strategic choice to list or to sell the venture that induces a different product market structure after her exit.

When the venture capitalist decides on exit in the way that it is optimal for her, contract incompleteness combined with the presence of private benefits for E will give rise to a distortion in the choice of δ. For instance, if δ_c is greater than the optimal δ, E might want to set the depth

[8] If $\overline{\theta} < 2\underline{\theta}$, then IPO occurs at any level of δ, since consumer heterogeneity is too small for two firms. They cannot differentiate themselves enough from each other. The inequality $\overline{\theta} < 2\underline{\theta}$ would imply a Schumpeterian 'creative destruction', independent of the depth of innovation. Notice also that $\mathrm{d}\delta_c'/\mathrm{d}\overline{\theta} < 0$ and $\mathrm{d}\delta_c'/\mathrm{d}\underline{\theta} > 0$. Thus, an increase in consumer heterogeneity (either through increase in $\overline{\theta}$ or decrease in $\underline{\theta}$) implies a lower cut-off level δ_c'.

of innovation to δ_c (thus, taking more risk than what is wanted by VC) if his benefits b are quite large. This will lower expected profits but allows E to get b in case of innovation. The same type of reasoning is true when δ_c is substantially lower than the "preferred" level of δ. In this case, E will choose a lower δ (but still greater than δ_c) than the one that only maximizes the monetary benefits of the project; this will increase the probability of a successful R&D stage, which is a prerequisite for an IPO and getting the benefits b. Thus, the distortion can occur in either direction. This intuition will be detailed in Subsection 3.3.

In the benchmark case it is assumed that VC will make the exit choice. The correct threshold level will therefore be δ_c. In this set-up, the existence of such a threshold level δ_c (but also δ_c') stems from two effects. The first one is $\gamma < 1$, and this condition is necessary in any case to get $\delta_c < \delta_{\max}$. This threshold level is decreasing in the inefficiency in the transfer of technology. The second one is the competition effect that is increasing as tastes of consumers get more similar (that is, as $\overline{\theta}$ nears $2\underline{\theta}$). δ_c decreases as consumer heterogeneity increases, since competition between M and E is reduced. Thus, for given parameters of consumer heterogeneity, there is a level of product differentiation above which competition is low enough so that the gain from acquiring the potential entrant is less than the acquisition price $\Pi(\delta)$. After a TS, when setting the price of his new product optimally, M will continue to serve consumers with high θ but now provides them with a qualitatively increased product. In contrast, when letting E enter, he specializes in serving only the consumers with low θ. A business stealing effect takes place. Consumers are therefore different for M, depending whether VC exits through a TS or an IPO. And the greater δ, the higher the product differentiation, and thus the greater $\Pi(\delta)$. Above some level (that is, for any value greater than δ_c), product differentiation is sufficiently high, and the acquisition price $\Pi(\delta)$ exceeds the gain from acquisition. An increase in δ increases product differentiation, and thus also weakens competition between firms.[9] Furthermore, when E's private benefits are taken into account, b is another factor affecting the threshold (in this case δ_c').

3.2 First-Best Depth of Innovation

Before solving this game, let us compute the first-best outcome for VC. Since VC does not get any private benefits from financing the project, the depth of innovation maximizes at the same time the purely monetary benefits of the project. In what follows next, this outcome will stand for one of the benchmark results. It is the level of δ that is not distorted by the private non-monetary benefits of the entrepreneur.

[9] The existence of such a threshold level is not unique to this model. It does also exist under Cournot quantity competition; e.g., with linear (inverse) demand $P(q_1, q_2) = a - q_1 - q_2$, the incumbent producing q_1 at constant marginal cost c and the new entrepreneur (with production level q_2) having the opportunity to enter the market at lower constant marginal cost $c \cdot (1 - \beta)$, where $0 \leq \beta \leq 1$. The depth of innovation then increases in β. Again, we need to assume some inefficiency through TS; e.g., a marginal cost of $c \cdot (1 - \gamma\beta)$ for the acquirer, where γ is defined as above. A similar result can also be derived for innovations that reduce fixed costs instead of marginal costs. Thus, this analysis is not limited to product innovation but can also be extended to so-called process innovations that affect the cost of production.

Solving the following maximization problem

$$\max_{\delta} \quad p(\delta) \cdot \Pi(\delta) - I$$

yields the following first-order condition:

$$p'(\delta) \cdot \Pi(\delta) + p(\delta) \cdot \Pi'(\delta) = 0.$$

Recall that $p(\delta) = 1/(\delta + d)^2$. Thus, denoting the level of δ that maximizes only the monetary benefits of the venture by δ_{vc}, we get $\delta_{vc} = d$. In this case, it is independent of any characteristics of the product market[10] (these characteristics are all summarized in the parameter μ, which depends on all the product market variables $\underline{\theta}$, $\overline{\theta}$ and s). But, since the parameter d determines the optimal depth of innovation, d is an indicator of the project's ex post profitability. The higher the probability parameter d, the greater the optimal innovation payoff (but also the riskier the project).

Furthermore, when taking into account the private benefits b of the entrepreneur, we have the following maximization problem:

$$\max_{\delta} \quad p(\delta) \cdot [\Pi(\delta) + b] - I.$$

This yields the first-best outcome for the venture under an IPO (the one that maximizes joint profits of VC and E), denoted by δ_e. We get

$$\delta_e = d - 2b/\mu.$$

Notice that this first-best is always achieved under an IPO when E is financially unconstrained. In fact, δ_e is the first-best that maximizes expected joint profits of VC and E. It is also achieved when VC opts for an IPO irrespective of the level of δ. When the venture capital industry is competitive, this outcome provides E with the optimal trade-off between profits and non-monetary private benefits, and thus is decreasing with the level of private benefits b and increasing in μ. Later on, we will see that even if VC is put on her participation constraint, δ_e will not always be achieved; in some cases, E will decide to distort the depth of innovation to avoid that the incumbent makes a better offer.

We summarize these results in the next Lemma.

Lemma 2 *The first-best depth of innovation is given by $\delta_e = d - 2b/\mu$; the one that maximizes the monetary benefits only is $\delta_{vc} = d$.*

While VC will prefer δ_{vc} if she had bargaining power, the entrepreneur will opt for δ_e whenever it is optimal. Their preferences with respect to δ are aligned only if either $b = 0$ or E has the incentive to choose some $\delta < \delta_c$ (since then $B(\delta) = 0$). Only in this case there will be no agency problem and the depth of innovation will be set to δ_{vc}.

[10] This is mainly due to the fact that the innovation payoff $\Pi(\delta)$ is a linear function of δ. But δ_{vc} does depend on the particular probability function.

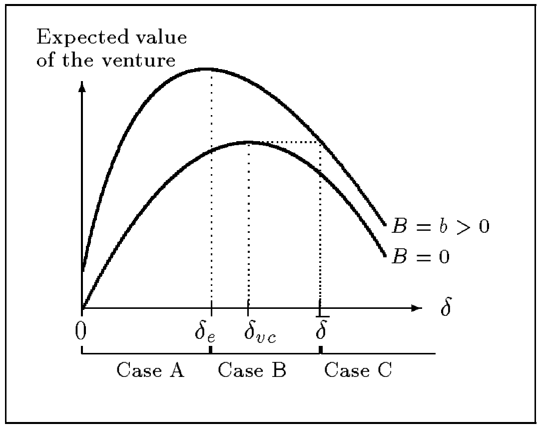

Figure 3: Expected total value of the venture with and without private benefits

3.3 Distortion in the Depth of Innovation

When the venture capitalist decides on exit, recall that E only enjoys private benefits if $\delta \geq \delta_c$. Thus, setting the depth of innovation to δ_e is only optimal if $\delta_e \geq \delta_c$. If this is not the case, the entrepreneur has incentives to distort the depth of innovation and to set it to δ_c. Figure 3 shows that three different cases need to be considered separately. The level δ_c can be situated either left to δ_e (Case A), between δ_e and $\overline{\delta}$ (Case B), or right to $\overline{\delta}$ (Case C).

In Case A, E is getting b for sure if he is successful. δ_e is therefore optimal. In Case B, it is not worth choosing δ_e, since it would not lead to an IPO anymore. Thus, E will set the depth of innovation to the corner solution δ_c; this is the lowest level of δ for which he can still remain independent in case of successful R&D. In Case C, the threshold level δ_c is so high that E will have to take too much risk to remain independent. Here the entrepreneur is ready to give up his willingness to stay independent, and chooses the level δ_{vc}, which is the one that maximizes only the monetary payoffs of the venture. Distorting the depth of innovation costs more than the expected gains from the private benefits; he will only distort if the loss in expected monetary profits from distorting is lower than the expected value of his private benefits at δ_c; that is,

$$p(\delta_{vc}) \cdot \Pi(\delta_{vc}) - p(\delta_c) \cdot \Pi(\delta_c) \geq p(\delta_c) b.$$

This is more likely to occur when b is not too important, since he will require a lower compensation. This yields the following condition:

$$\delta_c \left(\overline{\theta}, \underline{\theta}, b, s, \gamma\right) \leq \overline{\delta} \equiv d + 2\sqrt{\frac{db}{\mu\left(\overline{\theta}, \underline{\theta}, s\right)}}. \tag{5}$$

The likelihood for an IPO therefore increases with the private benefits of the entrepreneur (the amount b), the "riskiness" of the project (related to the variable d), but decreases with the degree of value-adding s. The next Proposition summarizes these findings on the depth of innovation as a function of δ_c.

Proposition 3 *The entrepreneur will choose the following levels of innovation depth which differ from the first-best values:*

$$\begin{cases} \delta_e & \text{if } \delta_c < \delta_e & \text{(Case A)} \\ \delta_c & \text{if } \delta_e \leq \delta_c \leq \overline{\delta} & \text{(Case B)} \\ \delta_{vc} & \text{if } \delta_c > \overline{\delta} & \text{(Case C)} \end{cases}$$

Proof: see discussion above. $\overline{\delta}$ is derived in a later Proposition. □

4 Analysis of the Benchmark Case

Our benchmark case is the one in which the venture capitalist retains control rights. We capture this by assuming that the entrepreneur is not competent enough to negotiate with potential buyers, and therefore exit issues are at the discretion of the venture capitalist (in the same sense as the entrepreneur's competencies on the choice of δ).[11] This will lead to δ_c as threshold value for the exit decision in stage 3. We further assume that the venture capital industry is perfectly competitive, which is captured by the assumption that E is making the take-it-or-leave-it offer to VC in stage 1 and VC's profit is driven down to the reservation rate $I\rho$. Under these circumstances, E will be able to design the contract in such a way to induce δ_e whenever it is optimal to do so. The financial contract will be such that VC just breaks even ($\Pi_{vc} = I \cdot \rho$) and, at the same time, it induces the optimal choice of δ from the point of view of the entrepreneur.

In the next Subsection, we derive the optimal financing strategy using standard debt and equity. In Subsection 4.2, we derive and discuss some optimality results in terms of security design. It is also shown that standard debt-equity contracts are optimal in this setting. As in the usual fashion, the game is solved by backward induction.

4.1 Debt and Equity Contracts

The contract between VC and E will include the allocation of cash flow rights, which are characterized by the variables α (for equity) and D (for debt payment). These are set in stage 1 of the game. As in Hellmann (1998), we separate control rights from cash flow rights. In the benchmark case, VC will hold the "right to sell control" (as part of the control rights); this determines who bargains with M (the potential buyer) and, consequently, who decides on the type of exit route if innovation is successful. This is the same definition as in Berglöf (1994). Thus, in the benchmark case VC will decide on the type of exit. Alternative allocations of control rights will be examined in a later Section. Furthermore, we exclude the possibility that contracts can be made contingent on the exit route; this will be discussed in a later section on robustness (as we will see, it will generally not be optimal to set ex post payments contingent on the type of exit; the agency conflict will not

[11] The case where E holds the control rights to decide the exit route is discussed in a later Section. It will be assumed that the entrepreneur cannot achieve the same exit value as the venture capitalist by some arbitrary amount $C > 0$.

vanish). The purpose of this later simplification is simply to make more tractable the discussion of intuitions.

Denote the private benefits of the entrepreneur by $B = b > 0$ if he is staying independent from M (i.e., in case of going public), and $B = 0$ otherwise. For standard debt and equity contracts, the expected profits of VC and E are given by

$$\Pi_{vc} = p(\delta) \cdot [(1-\alpha)(\Pi(\delta) - D) + D] - I \quad (6)$$

$$\Pi_{e} = p(\delta) \cdot [\alpha (\Pi(\delta) - D) + B(\delta)] \quad (7)$$

with $\Pi(\delta)$ representing the ex post profit of the venture (see equation (2)) in case of successful innovation. $\Pi(\delta)$ also represents the exit value of the venture. In the following, we will also refer to it as the innovation payoff. The variable D represents debt payment from the successful entrepreneur to the venture capitalist.[12] Since debt has seniority rights over equity, it is paid out first. The variable α represents the shares of the remaining profits $[\Pi - D]$ that the entrepreneur will retain for himself; VC gets the rest of this sum when exiting. By the usual limited liability assumption, we have the following additional condition: $0 \leq D \leq \Pi(\delta)$. This simply means that VC cannot expect more debt payment than the innovation payoff. Therefore, payments are also conditional on a positive result of R&D activities.

(i) The Third Stage If $\delta < \delta_c$, M will make a better offer than what VC would get through an IPO. In this case, a TS occurs and profits (gross of investment costs I for VC) are as follows

$$(1-\alpha) \cdot [\Pi(\delta) - D] + D \qquad \text{for VC} \quad (8)$$

$$\alpha \cdot [\Pi(\delta) - D] \qquad \text{for } E. \quad (9)$$

And if $\delta \geq \delta_c$, the company is introduced on the stock market, yielding

$$(1-\alpha) \cdot [\Pi(\delta) - D] + D \qquad \text{for VC} \quad (10)$$

$$\alpha \cdot [\Pi(\delta) - D] + b \qquad \text{for E} \quad (11)$$

with two firms now supplying the market; M producing at quality level s, and E at level $s(\delta + 1)$.

(ii) The Second Stage In this stage, E sets δ. To understand E's choice, assume for the moment that an IPO is the only allowed exit route. Then, for given values of α and D the entrepreneur will set δ as follows:

$$\delta^* = d - \frac{2b}{\alpha\mu} + \frac{2D}{\mu}. \quad (12)$$

[12] It can also be viewed as external debt financing. In this case, some investment funds I_D are raised from external investors which guarantee them a repayment amount of D in case of innovation. The venture capitalist then provides the rest $(I - I_D)$ for which he gets $(1-\alpha)[\Pi(\delta) - D]$ in case of success. This form of financing is equivalent to a linear payment scheme $(1-\alpha)[\Pi(\delta) - D] + D$ as proposed in the text. Thus, it is also equivalent to saying that debt financing is provided by VC which we assume here for simplicity. This idea will also apply for the model extensions in other sections.

Equation (12) is the first-order condition with respect to δ and says that including some debt increases the optimal choice of δ by generating hard claims for the entrepreneur in case of success. This shifts the distribution of profits to the right. On the other hand, issuing more equity (i.e., decreasing α) has the opposite effect on δ, since it reduces the portion of monetary benefits he will get in case of innovation; he will therefore put less weight on monetary profits. For a pure equity contract ($D = 0$), $\delta^* < \delta_e$. The reason is that a wealth constrained E will choose a depth of innovation that is lower than his first-best to increase the probability of being successful, and thus to start up his own firm. In any case, he will trade-off his monetary gains with his private benefits. The higher b, the less risky the research path he will choose. By introducing debt ($D > 0$), E is forced to put more weight on the monetary benefits of the venture. Like in Hart and Moore (1995), debt creates hard claims, which constrains E to increase monetary profits. It therefore reduces the effect of b. Equation (12) shows that a pure equity contract would result in a risk-taking behavior of E below δ_{vc} and δ_e; in contrast, pure debt financing generates a riskier R&D strategy than δ_{vc}. Too much debt may cause an overreaction by E. In this case, relying on a single security will therefore lead to a suboptimal outcome as soon as the entrepreneur gets private benefits. Furthermore, without such private benefits only pure equity contracts are optimal.

In order to make δ_e the optimal choice of E, the contract needs to be designed in such a way that $\delta^* = \delta_e$.[13] It is straightforward to check that the constraint on D and α is as follows:

$$D = b \cdot (1 - \alpha)/\alpha. \tag{13}$$

If this condition is feasible, E can achieve his first-best δ_e by issuing both securities, debt and equity. We will see later that this constraint is always implementable.

Now we solve when a TS is possible; the incumbent can then make an offer to acquire the new company. Then, the threshold value δ_c does matter. Again, three different cases need to be considered separately. The level δ_c can be situated either left to δ_e (Case A), between δ_e and $\overline{\delta}$ (Case B), or right to $\overline{\delta}$ (Case C).

In Case A, E is getting b for sure if he is successful. δ_e is therefore optimal and is achieved under the financial constraint given by equation (13). E can therefore implement his preferred outcome. In Case B, it is not worth choosing δ_e, since it would not lead to an IPO anymore. Thus, E will set the depth of innovation to the corner solution δ_c; this is the lowest level of δ for which he can still

[13] The reason for this equality can be seen when solving the first stage, which entails the following maximization problem:

$$\max_{\alpha, D} \{p(\delta^*) \cdot [\alpha\,(\Pi(\delta^*) - D) + b]\} \text{ s.t. } p(\delta^*) \cdot [(1-\alpha)\,(\Pi(\delta^*) - D) + D] = I\,(1+\rho)$$

where the expected payoffs of the entrepreneur is the same as

$$p(\delta^*) \cdot [\alpha\,(\Pi(\delta^*) - D) + b] = p(\delta^*) \cdot [\Pi(\delta^*) + b] - p(\delta^*) \cdot [(1-\alpha)\,(\Pi(\delta^*) - D) + D]$$

where the latter term is simply equal to $I(1+\rho)$. The maximization problem can therefore be rewritten as

$$\max_{\alpha, D} \{p(\delta^*) \cdot [\Pi(\delta^*) + b] - I\,(1+\rho)\} \text{ s.t. } p(\delta^*) \cdot [(1-\alpha)\,(\Pi(\delta^*) - D) + D] = I\,(1+\rho)$$

Thus, the entrepreneur will have to choose the capital structure that achieves $\delta^*(\alpha, D) = \delta_e$.

remain independent in case of successful R&D.[14] In Case C, the threshold level is again too high so that E will have to take too much risk to remain independent. He will therefore maximize monetary benefits only and choose δ_{vc}.

(iii) The First Stage In this stage, E decides on the debt level D and the equity sharing rule α that will be included in the contract. A key issue is the type of financing E will prefer (either debt or equity, or some mix). In any case the repayment amount is $I(1+\rho)/p(\delta)$. This is derived from the binding participation constraint of VC:

$$\Pi_{vc} = p(\delta) \cdot [(1-\alpha)(\Pi(\delta) - D) + D] - I = I \cdot \rho \tag{14}$$

In summary, we can conclude that it is important for the venture capitalist to take into account this possible distortion when considering her decision to finance the venture. The presence of private benefits for the entrepreneur can be an important source of distortion. The optimal contract largely depends on the value of δ_c compared to δ_e and $\overline{\delta}$.

The next Proposition summarizes the results of this Section in terms of exit strategy.

Proposition 4 *Under venture capital financing, an IPO occurs as optimal exit if* $\delta_c \leq d + 2\sqrt{db/\mu}$; *otherwise, the venture capitalist will exit through a trade sale.*

Proof: We need to consider the limit between Cases B and C; that is, an IPO occurs iff $\Pi_e(\delta_c) \geq \Pi_e(\delta_{vc})$, where $\delta_{vc} = d$ (cf. Lemma 2). This implies two roots for δ_c: $d \pm 2\sqrt{db/\mu}$. Since $\left(d - 2\sqrt{db/\mu}\right)$ does not apply for the limit between Cases B and C, we have that an IPO occurs whenever $\delta_c \leq d + 2\sqrt{db/\mu}$. □

The likelihood for an IPO therefore increases with the private benefits of the entrepreneur (b), consumer heterogeneity (difference $\overline{\theta} - \underline{\theta}$), riskiness of the project (d), but decreases with s. As discussed in the previous Section, the distortion in monetary benefits takes place only when δ_c is very large so that the additional expected profits are at least as large as the expected private benefits of E:

$$p(\delta_{vc}) \cdot \Pi(\delta_{vc}) - p(\delta_c) \cdot \Pi(\delta_c) \geq p(\delta_c) b. \tag{15}$$

This comes from the condition $\Pi_e(\delta_{vc}) \geq \Pi_e(\delta_c)$. Then, E chooses δ_{vc} and VC exits through a TS.

The right-hand side of equation (15) is increasing in b. This makes the requirement for this inequality more difficult to be met. Thus, the higher the private benefits b, the more costly the compensation for avoiding the distortion on δ. This, in turn, makes a TS less likely, since the entrepreneur might not be compensated anymore.

Proposition 4 reaffirms the result stated earlier that significant product innovations are most likely to lead to publicly-held firms, while imitator projects (those with low δ due to a low value of d) tend to be sold by VC to an existing firm as the gain from acquisition outweighs the value of the

[14] In principle, some debt can be issued, since E will choose δ_c in this configuration. But there is an upper bound for the debt level which is given by the condition $\delta^* = \delta_c$. This allows the entrepreneur to issue debt up to the following upper limit: $D \leq b - \frac{1}{2}\alpha\mu(d - \delta_c)$. Otherwise, E will overreact and choose a depth of innovation that is above δ_c.

venture as soon as the degree of product differentiation chosen by E is by far below δ_c. The term $2\sqrt{db/\mu}$ represents the effect of the distortion from an ex ante point of view.

Interestingly, the presence of a positive b can generate a shift in δ either in the one or the other direction. If $\delta_e > \delta_c$, then an increase in b induces a reduction in δ away from δ_{vc}. And if $\delta_e < \delta_c$, the presence of such benefits can generate a shift from δ_{vc} to δ_c if the entrepreneur is not compensated for his private benefits.

Furthermore, an increase in b has two different effects on expected profits: *(i)* a direct effect for E in case of an IPO; and *(ii)* an indirect effect (if δ_e is optimal) through the lower α offered to VC, which is induced by the decrease in the depth of innovation. E is gaining from an increase in b in all the cases, either directly or indirectly (or both).

Recall that δ_c' is also what a financially unconstrained entrepreneur would choose.[15] Thus, we can compare equilibrium outcome of venture-backed and non-venture-backed companies in terms of exit and distortion. Compared to self-financed projects, venture-backed companies are more innovative. This provides further explanations for the discussion on the link between depth of innovation and the use of venture capital to finance investments in R&D (Hellmann and Puri (2000), and Kortum and Lerner (1998)). In these papers, the reason for greater innovation by venture-backed companies was explained by the active involvement of the venture capitalist and the greater flexibility of venture capital. Here, the greater innovation stems from the greater distortion that arises when the company is venture-backed in order to secure private benefits for the entrepreneur. Thus,

Proposition 5 *Venture-backed companies are more innovative on average as compared to companies fully self-financed by entrepreneurs. A trade sale is more likely for venture-backed companies than for self-financed companies if* $b > 4ds^2\left(X - \gamma \cdot \frac{1}{4}\overline{\theta}^2\right)^2/\mu$*; otherwise, self-financed companies are more likely to be sold.*

Proof: For the depth of innovation, recall than self-financing entrepreneurs always choose δ_e, while venture-backed companies yields projects as determined in Proposition 3. Notice also that self-financing entrepreneurs favor a TS if $\delta_c' > d$, while the exit rule of VC is $\delta_c > d + 2\sqrt{db/\mu}$ for a TS. Thus (when subtracting one inequality with the other), a trade sale is more likely for venture-backed companies whenever $\delta_c - \delta_c' > d + 2\sqrt{db/\mu} - d$. This yields the condition presented in the above Proposition. □

4.2 Optimality of Debt and Equity

Before stating some results on contract optimality, let us cite again some definitions and intermediate results in order to better understand what makes the choice of debt and equity. In case of innovation, the total repayment of the entrepreneur to VC is the sum of debt payment D and private equity issuance $(1-\alpha)\cdot[\Pi - D]$. In the benchmark case, the venture capitalist is always put on her participation constraint. Recall also that the entrepreneur's aim is to achieve $\delta_e = d - 2b/\mu$ whenever

[15] This changes if the entrepreneur finances his project with pure debt only. Here, we assume that he has enough wealth to finance it by his own.

it is optimal for him; and for a given financial structure, for $\delta_e \geq \delta_c$ his decision rule is $\delta^* = d - 2(b - \alpha D)/\alpha\mu$. Thus, $\delta^* = \delta_e$ iff $D = b \cdot (1-\alpha)/\alpha$. Combined with the participation constraint of *VC*, this yields a unique financial structure (Proposition 6). Recall that δ_c is small when consumer heterogeneity is large or the inefficiency from the transfer of technology is important.

The following Proposition states an optimal security design for Case-A projects (leading to highly innovative projects compared to δ_c):

Proposition 6 *For $\delta_e \geq \delta_c$ (no distortion takes place), there exists a unique optimal financial contract which is a combination of debt (D_e) and equity (α_e):*

$$
\begin{aligned}
D_e &= \frac{b}{p(\delta_e) \cdot [b + \Pi(\delta_e)] - I(1+\rho)} \cdot I(1+\rho) \\
\alpha_e &= 1 - \frac{I(1+\rho)}{p(\delta_e) \cdot [b + \Pi(\delta_e)]}
\end{aligned}
$$

The first equation of the Proposition says that the proportion $b/[p(b+\Pi) - I(1+\rho)]$ of repayments will be debt. Since financial markets are perfectly competitive, equity is the rest; that is, the following condition must hold: $(1-\alpha) \cdot \Pi = \left[1 - \frac{b}{p(b+\Pi) - I(1+\rho)}\right] \cdot I(1+\rho)$. This yields α_e as presented in Proposition 6. Imposing a proportion $\left[\frac{b}{p(b+\Pi) - I(1+\rho)}\right]$ of debt ensures that E will want to choose δ_e in stage 2 and, in the same time, α_e is set in such a way that *VC*'s participation constraint is binding.

Since *VC* is put on her participation constraint at any time, standard debt-equity contracts described in this Proposition are always optimal. In any other case (i.e., whenever $\delta_e < \delta_c$), the financial structure is not unique (but, as mentioned in a previous footnote, there is an upper limit in the amount of debt that should be contracted). Notice although that the financial structure is not always irrelevant in the absence of private benefits for the entrepreneur. Whenever $\delta_e \geq \delta_c$, the issuance of debt always provides incentives to take more risk (cf. equation (12)).

Berglöf (1994) shows how control rights can be allocated using standard securities such as pure equity, convertible preferred equity, debt and convertible debt. Here, we have shown that the use of a particular type of securities is also driven by the aim to provide optimal incentives to the entrepreneur and that it can affect the equilibrium level of innovation. A first way to allocate control rights is by writing explicitly in the contract which party has the power to decide alone on exit issues. This was in fact how its allocation has been modelled here; it provides an explicit intervention right to the venture capitalist. In practice, this can be implemented through explicit veto rights combined with "go along (or tag along)" or "piggyback" rights (cf. e.g., Sahlman (1990)) and along with convertible securities (Kaplan and Strömberg (1999) show that such securities are widely used in venture capital financing). In addition, venture capitalists often include a "liquidity clause (call options)" in the contract that allows them to buy from the entrepreneur a significant amount of his shares; this allows them to increase the equity stake and thus to increase the chance to do a trade sale (which is more difficult to do if the venture capitalist only holds a very small equity stake, since acquirers typically want to buy a large stake to be sure to take control over the company).[16]

5 Reputation Benefits for the Venture Capitalist

In this Section, we extend the model by including reputation gains for VC from a successful IPO and see how it affects the outcome. We show that the distortion is similar as for the private benefits of the entrepreneur. This reputation benefit may stem from the popularity/publicity that the venture capitalist enjoys through a successful public listing.

In the following, assume the venture capitalist enjoys reputation benefits from an IPO; let us denote by $R \geq 0$ the reputation gain for VC. We also assume that $I\rho \geq p(\delta) \cdot R$ to ensure that monetary benefits are still positive ex post.[17] We also assume that the incumbent can make side payments to VC to compensate for the non-monetary benefits. Thus, he needs to pay the total amount of $\Pi(\delta) + R$ to acquire all the shares.

Kaplan and Strömberg (1999) show that most securities hold by venture capitalists are convertibles, either convertible debt or equity. Berglöf (1994) illustrated the use and implementability of such securities in the presence of private benefits for either party. Here we reach the same results but extend by showing its effect on the optimal depth of innovation and the exit route.

When $R > 0$, VC's preferred depth of innovation under an IPO is:

$$d - \frac{2R}{\mu}. \tag{16}$$

To achieve this depth of innovation, the financial contract would need to satisfy the following condition: $d - \frac{2R}{\mu} = \delta^*$. This is the case whenever:[18]

$$D = R(1-\alpha)/\alpha. \tag{17}$$

Thus, whenever $R > 0$, the amount of debt issued needs to be lower in order to induce this lower depth of innovation.

Notice that the existence of reputation gain for VC also affects the threshold level for which VC will be indifferent between an IPO and a TS; this level is now equal to

$$\frac{\frac{1}{4}\overline{\theta}^2 - R/s}{X - \gamma \cdot \frac{1}{4}\overline{\theta}^2}$$

Proposition 7 *In terms of exit choice and optimal depth of innovation, the effect of reputation gains for the venture capitalist under an IPO is similar to the presence of independence benefits for the entrepreneur under an IPO.*

[16] Cf. Bartlett (1999) for a detailed presentation of these financial clauses.

[17] This simply says that the required monetary gain must be greater that the expected reputation gain for VC so that shareholders of the venture capital fund (the external investors) still gets a positive expected profit from the fund.

[18] The first-best depth of innovation is: $d - \frac{2(b+R)}{\mu}$. This could be achieved iff $D = b(1-\alpha)/\alpha - R$.

Proof: see above discussion. □

The reason is the following. There is no real certification effect, but rather the reputation effect plays the same role as private benefits for the entrepreneur. When $R > 0$, it is aligned with the entrepreneur's incentives induced by his private benefits b.

Though, the first-best is not achieved; the first-best threshold level is equal to

$$\frac{\frac{1}{4}\overline{\theta}^2 - (b + R)/s}{X - \gamma \cdot \frac{1}{4}\overline{\theta}^2}$$

that is, each party only internalizes his own non-monetary benefits and not the ones of the other. This leads to a too high depth of innovation. VC does not take into account b when choosing the exit route in stage 3 and E does not internalize R when setting the depth of innovation in stage 2.

6 Contingent Control Rights Allocation

In this Section, we analyze what happens when both parties include the "right to sell control" as additional degree of freedom into the contract. Recall that this right determines who is allowed to decide on exit issues. In the previous Sections, it was retained by the venture capitalist and it was assumed that she is the most competent person for this choice. As we will see, giving this right to the entrepreneur will allow to extract a premium from the buyer under a TS that compensates for his private benefits. Here, we analyze the conditions under which it is more efficient to allocate these rights to the entrepreneur. This will allow him to bargain with M in stage 3. In other words, M will be making the take-it-or-leave-it offer to E (instead of to VC) who, in turn, may accept it or refuse it. Again, if the offer is accepted, a TS takes place; otherwise, the venture goes public with exit value $\Pi(\delta)$.

If E is retaining the control rights to decide on exit, a TS will only take place if M is ready to pay $\Pi + b$ for acquiring the innovative entrant. This guarantees E a payoff of $\alpha(\Pi - D) + b$, just as in the alternative exit route; VC then gets $(1 - \alpha) \cdot [\Pi - D] + D$. Compared with the previous Section, M now needs to pay a "premium" equal to b. If the entrepreneur had no private benefits, M would not have to pay this premium. Therefore, the implicit contracts for control implied by an IPO also positively affects the outcome of the negotiation with potential acquirers.

Since the venture capitalist is the most competent in making deals (her competencies in financial engineering), there is a cost for the entrepreneur if he decides to retain control rights on the exit route; the discount will be denoted by $C \geq 0$ and assumed a fixed amount. This cost should be understood as relative disadvantage compared to the competency of VC.[19] Thus, the new threshold

[19] Notice that costs C only occurs for the exit of VC; otherwise, E can hold his shares if he funds his own project (which increases his outside option in case of TS). These costs can also be seen as underpricing due to recognition of outside investors of the passivity of VC (underpricing is avoided when VC holds control rights because of her reputation/certification). Thus, this Section can also be seen as an analysis of active vs. passive VCs. Active involvement of VC adds value by avoiding costs C (this Section shows the impact of her active involvement).

level of δ that determines the optimal type of exit is

$$\delta_c'' \equiv \frac{\frac{9}{4}\overline{\theta}^2 - (b - C)/s}{X - \gamma \cdot \frac{9}{4}\overline{\theta}^2}. \tag{18}$$

The following Proposition summarizes the results in terms of optimal allocation of control rights.

Proposition 8 *(i) Let $b > C$. Then, giving the control rights to the entrepreneur lowers the threshold level to δ_c''. It is optimal to give him control rights if $\delta \leq \delta_c''$. For any δ between δ_c'' and δ_c, the entrepreneur opts for an IPO, while the venture capitalist wants to sell the venture to the incumbent. For any $\delta \geq \delta_c''$, control rights should be allocated to the venture capitalist. (ii) If $b \leq C$, it is always optimal to allocate control rights to the venture capitalist.*

Within the critical interval $[\delta_c''; \delta_c]$, unanimity on the exit route cannot be achieved. If E retained the control rights, exit would occur through an IPO; in case VC retained these rights, exit would also be through an IPO but at depth of innovation of δ_c. Thus, allocating the right to sell control to the entrepreneur would lead to the same exit route but at different levels of innovation. It is higher when the venture capitalist retained this right.

It provides a possible explanation for the observation of Hellmann and Puri (2000) that more innovative firms (assume δ exogenously given) are more likely to get venture capital. Since entrepreneurs of less innovative companies retain control rights, the role of venture capitalist is passive, while the latter can add value for more innovative projects by bringing in their competencies in doing deals (i.e., by holding these control rights on exit).

7 Robustness of the Model

7.1 Market Power of Venture Capitalist

In contrast to a lot of other projects that need to be funded, venture-backed projects typically exhibit high information asymmetry so that entrepreneurs usually face an imperfectly competitive venture capital supply, since the latter need themselves to be highly specialized (either in few industries and/or financing stages) to get a comparative advantage over other types of financial intermediaries. This provides in reality the venture capitalists with important bargaining power. Only if the supply of venture capital funds continues to increase in the same way as in the last few years that we could expect in the near future a complete shift in bargaining power in favor of entrepreneurs.

In this Subsection, we investigate to which extent the previous results relied on the imposed assumptions of bargaining power. In particular, in reality the venture capitalist still has important bargaining power vis-à-vis the entrepreneur. Here, we assume that she has all the bargaining power. This opposite assumption might also be rather exaggerated; the reality probably lies somewhere between these two extremes.

Consider first the case where VC gives no monetary payoff to E. If VC decided to set $\alpha = 0$ and $D = 0$, E's best strategy is to choose δ_c. This gives the minimum expected profit of E in any case.

In this way, he may still get benefits of b in case of successful innovation. To avoid this, VC has to set α and D in such a way that the entrepreneur is at least compensated for his deviation payoff equal to $p(\delta_c) \cdot b$. In what follows, we will refer to this minimum expected payoff as the 'deviation payoff' of the entrepreneur. Whenever VC is making a take-it-or-leave-it offer to E in stage 1, she will have to compensate the entrepreneur for this amount if she wants to induce another level of innovation. Otherwise, he will choose δ_c for sure.

Under these circumstances, the outcome of the third stage is as described in Lemma 1 with δ_c as threshold level. In stage 2, VC will try to induce $\delta_{vc} = d$, which does not take into account the non-monetary benefits of E. Recall that the optimal choice of δ for given values of D and α are determined by E in stage 2 and, for $\delta \geq \delta_c$, according to the rule provided by equation (12).

For standard debt and equity contracts, we establish the following optimal financing strategy with the corresponding exit route:

Proposition 9 *For $\delta_{vc} > \delta_c$, the optimal exit route is an IPO with the following contract:*

$$D_{vc} = b/\alpha_{vc}$$
$$\alpha_{vc} = \frac{p(\delta_c)b}{p(\delta_{vc}) \cdot \Pi(\delta_{vc})}.$$

For $\delta_{vc} \leq \delta_c$, exit occurs through a trade sale whenever $\delta_c > \widetilde{\delta}$; i.e., the entrepreneur is compensated for giving up the firm. Otherwise (i.e., for $\delta_c \leq \widetilde{\delta}$), an IPO takes place with $\alpha = D = 0$; where

$$\widetilde{\delta} \quad s.th. \quad \Pi_{vc}(\delta_{vc}, \alpha_o) = \Pi_{vc}(\widetilde{\delta}, 0)$$

$$and \quad \alpha_o = \frac{p(\delta_c)b}{p(\delta_{vc})\Pi(\delta_{vc}) - p(\delta_c)\Pi(\delta_c)}.$$

Again, the moral hazard problem increases with the size of b. An increase in b again has two different effects on expected profits: *(i)* a direct effect for E in case of an IPO; and *(ii)* if $\delta \geq \delta_c$, an indirect effect through α offered by VC, which then affects both parties. It is possible to show that E is gaining from an increase in b in all the cases, either directly or indirectly (or both). On the other hand, VC is indifferent with respect to a marginal change in b in case of an IPO. In case of a TS, VC is worse off, since she needs to give E more shares ($\mathrm{d}\alpha_o/\mathrm{d}b > 0$) while the depth of innovation is not affected (remains at δ_{vc}). But in contrast to the setting in Section 4, VC now has a control device from her market power. Whenever $\delta_{vc} > \delta_c$, she is able to induce δ_{vc} by using a specific combination of debt and equity as described in Proposition 9.

A consequence of a shift in bargaining power in favor of E (as in the previous Sections) is that the first-best level of innovation (δ_e) is expected to be implemented more often for highly innovative projects. This is because VC loses the power to control the choice of δ through the optimal setting of α and D. VC has virtually no control anymore to affect the R&D strategy of E. But as long as this shift in bargaining power has not yet occurred, VC can influence the entrepreneur's decision through the variables D and α, whenever $\delta_{vc} \geq \delta_c$. For $\delta_{vc} < \delta_c$, VC must accept either a distortion in δ or a monetary incentive payment. Only in the latter case does exit occur through a TS.

The next Proposition states the optimal financing strategy using a more general class of contracts:

Proposition 10 *For $\delta_{vc} > \delta_c$, from the point of view of the venture capitalist, the standard debt-equity contract described in Proposition 9 is optimal. For $\delta_{vc} \leq \delta_c$, the optimal contract is a non-linear equity contract with*

$$\alpha(\Pi) = \begin{cases} \alpha_p & \text{for } \Pi = \Pi(\delta_{vc}) \\ 0 & \text{otherwise} \end{cases}$$

$$\text{and} \qquad \alpha_p = \frac{p(\delta_c) \cdot b}{p(\delta_{vc}) \cdot \Pi(\delta_{vc})}.$$

Furthermore, the value of δ_c for which VC is indifferent between a TS and an IPO is as in Proposition 4; that is, M will make an offer to buy the newcomer's technology if $\delta_c > d + 2\sqrt{db/\mu}$ and let E enter the market otherwise.[20] This does not alter the previous analysis, though in the optimal contract α_o is replaced by α_p. This will benefit VC, while E will lose.

The suboptimality of linear contracts may get very large as δ_c is near δ_{vc}. Denote the ratio (α_o/α_p) by Ψ. Then (recall that this is only valid when $\delta_c \geq d$):

$$\Psi = \frac{(\delta_c + d)^2}{(\delta_c - d)^2}$$

with Ψ decreasing in δ_c and increasing in d. Thus, VC is more likely to compensate E for his private benefit and avoiding the distortion in δ, when she contracts on Π. Furthermore, the difference between α_o and α_p is more likely to be great for more innovative projects (high d). But E is in overall worse off, since his expected compensation is lower.

Finally, when the entrepreneur retains control rights, an important difference is that the expected "deviation payoff" of the entrepreneur is now $p(0)b$; i.e., E will set $\delta = 0$ if he is expecting no monetary benefit from a successful innovation but retaining the right to sell. In equilibrium, a TS occurs whenever the entrepreneur sets the depth of innovation below δ_c''.

7.2 Contracts Conditioned on Exit Route

One could claim that it is possible to achieve the first-best outcome by imposing in the contract an IPO as unique exit route; for example, by mandating that if a trade sale were chosen, VC would get no monetary compensation. In this case, E would expect private benefits for sure so that he chooses δ_e as in the first-best. This reasoning is misleading as the venture capitalist can fix share prices to $\Pi(\delta_e) + \varepsilon$ (consider some $\varepsilon > 0$ but very small), so that only the incumbent buys shares (we assume that shares are widely dispersed only if the issuance value is $\Pi(\delta)$ so that not only M but also a lot of other investors bid for the shares). In this case, E does not get his private benefits anymore although the company is publicly listed. Thus, there is no use to condition cash flow rights (monetary payments) on exit route.[21] On the other hand, the venture capitalist cannot expect a higher price than $\Pi(\delta_e) + \varepsilon$, since otherwise M will not buy to force VC to reduce share price down to $\Pi(\delta_e) + \varepsilon$. The premium ε must therefore be very small to assure a successful IPO.

[20] In Proposition 9, this critical value was denoted by a. For standard debt-equity contracts, $a > d + 2\sqrt{bd/\mu}$.

[21] In principle, it is sufficient that there is a positive probability that the incumbent acquires control so that the entrepreneur will again distort the depth of innovation. Then, we do not achieve the first-best anymore.

Furthermore, it is not sensible to condition payments on some realized exit value $\Pi(\delta_e)$ (or some lower bound), since (once the contract signed) the entrepreneur has incentives to deviate and choose some depth of innovation sufficiently lower to make an IPO at that price impossible; E would then be able to retain all the monetary gains, and VC would get nothing. Thus, no venture capitalist will accept a contract conditioned on some exit value. The same argument applies when the venture capitalist's compensation is contingent on a TS with price $\Pi(\delta_e) + b$; the entrepreneur again has incentives to deviate by choosing a slightly lower depth of innovation than the one implied by the predetermined price. We therefore conclude that it is not useful to condition payments of the venture capitalist on exit routes and/or exit price if δ is non-contractible.

8 Empirical Implications

Some topics on exit of venture capitalists have already been studied empirically, like issues on IPO underpricing (e.g., Barry, Muscarella et al. (1990)) and the certification effect for venture-backed IPOs (e.g., Megginson and Weiss (1991)).[22] Kaplan and Strömberg (1999) studied the importance of ownership for explaining the observed interaction between a venture capitalist and an entrepreneur. They provide empirical evidence that venture capitalists retain important intervention rights to protect herself against possible opportunistic behavior of entrepreneurs.

The choice of the venture capitalist between a trade sale and an IPO has not gained much attention yet. This is also true for the effect of product market characteristics on venture capital financing. One interesting empirical paper that aimed to create such a link is the one by Hellmann and Puri (2000). They find that more innovative firms are more likely to be financed by venture capital,[23] and that the effect of this type of financing on "time-to-market" is strongest for innovative firms. In other words, venture-backed companies tend to go faster to market than others, particularly if they are innovators. The speed of innovation is particularly important for high tech start-ups.

In this Section, we state empirical implications arising out of the independence bias studies in this paper. We present them in form of hypotheses that could possibly be tested; this Section is therefore intended to provide material for further empirical research. We present some hypotheses on innovation depth and product market structure as well as on other issues derived from the studies framework. One of these hypotheses will be illustrated using UK data.

H1: *The depth of innovation of a venture is positively correlated with its likelihood to go public.*

This hypothesis is summarized in Lemma 1 and can be observed as ex post outcome. It must be recognized that there is no exact measure for the depth of innovation. But Hellmann and Puri (2000) used an interview-based method to approximate this variable. Based on answers by their respondents, they classified all their ventures in either innovator or imitator. **H1** would then imply

[22] A more detailed survey of empirical findings on exit issues is provided by Gompers and Lerner (1999).

[23] The present model provides a possible rationale for this choice. A high degree of innovation means high profits and a greater chance to go public. Thus, if venture capitalists build their reputation from IPOs, they will prefer to finance more innovative venture.

that innovative ventures are more likely to go public than for imitator projects. But still, problems of finding a fully reliable proxy for the depth of innovation remain, since it is hardly quantifiable.

A possible way to test Lemma 1 is to relate the depth of innovation to profitability:

H2: *The return on venture capital investments is positively correlated with the decision to go public.*

This hypothesis stems from the fact that in our model, the value of the venture is also innovation driven. Greater innovation implies higher profits (cf. equation (2)). Profits can therefore be used as a proxy for innovation depth.

The company's price-to-earnings ratio should be broadly consistent with profitability in the sense used in our framework. In this case, we would expect the likelihood to go public to be positively affected by an increase in the price-to-earnings ratio.[24] In the next table, we present results from logit and OLS regressions on a UK data set[25] for the period 1996-1999 (this should not be viewed as a test of **H2** but simply an illustration that fits with this hypothesis). The dependent variable is a dummy variable that is equal to 1 if exit occurred through an IPO and 0 in case of a trade sale. The data set contains 105 IPO cases and 207 cases of trade sale. Therefore, the total number of observation for the regressions is 312.

Explanatory variable	Logit-coefficients	OLS-coefficients	Sample distribution
price-to-earnings ratio	0.034**	0.001*	–
dummy (information technology)	(not significant)	0.41**	30%
dummy (business service)	−1.67**	0.21**	24%
dummy (entertainment)	−0.95**	0.32**	20%
dummy (communication)	−1.65**	0.21**	26%

Note: Significance levels for coefficient estimation are indicated by * for 5%, and ** for 1%.

This is consistent with **H2**. Furthermore, since the estimated coefficients for the IT dummy is not significantly different from zero for the logit regression, this indicates that for a given price-to-earnings ratio an IPO is more likely for ventures in this particular industry than in the sectors of business service, entertainment and communication. Similar results are obtained by an OLS regression. The last column of the table shows the sample distribution based on the different industries. Only these four were represented in the data set that we have obtained.

Cumming and MacIntosh (2000) used the market-to-book value to test a qualitatively similar hypothesis (although based on an adverse selection argument) on a data set of US and Canadian ventures. They also come to the same conclusion; that is, an IPO is the preferred exit route for venture capitalists for their most profitable companies. Gompers (1995) also report that US venture capitalists earn an average annual rate of return of 60% when they exit through an IPO, as compared to 15% for trade sales.

[24] Alternatively, this also means that we would expect more innovative ventures to have a higher Tobin's Q.

[25] These data have been collected by and obtained from Suzan van Lieshout. She kindly accepted to put these data at our disposal for further econometric tests. Data on trade sales stem from the magazine *Acquisitions Monthly*; the data source on IPOs is *Bloomberg* for the Alternative Investment Market in the UK. Notice although that we do not have any information whether all these companies were venture-backed at the time of IPO or trade sale.

H3: *Distortions in the innovation strategy are less likely in high tech industries than "low tech" industries.*

This hypothesis is related to the parameter s. Note that this hypothesis is not implied by **H1** and **H2**, which were related to the parameter δ. It determines the initial quality level and therefore may be a proxy to the value-adding, since it increases the product market profits. Thus, high tech industries should be characterized by high values of s. The fact that it reduces the distortion stems from the fact that high tech industries imply higher profits, which in turn makes the entrepreneur put more weight on monetary incentive returns than his private benefits.

The size of distortion can be proxied by the likelihood to go public (since a greater distortion implies a higher likelihood for an IPO). Another possibility is to relate excessive distortion with the relative volatility of projects, which is then expected to be higher for "low tech".

H4: *The likelihood to go public increases with the number of incumbents in the product market.*

This is shown in the Appendix (Part II). For a given depth of innovation, the gain from a trade sale between the incumbent and the newly created company stems from the fact that the incumbent benefits from the acquisition by remaining a monopolist instead of being in a duopoly situation. Under price competition like in our framework, if there are more than two incumbents already in the market the acquirer cannot gain anymore from the reduced competition implied by the acquisition. In fact, acquiring the new entrant does not allow to weaken the competitive effect so that entry of the new firm (the venture) is more likely. Therefore, no incumbent will have the incentive to overbid the market (i.e., to offer more than Π). This also applies for markets in which firms are free to enter at the incumbent's quality level s. In the Appendix, it is also shown that this also holds in presence of the exit-related agency problem as discussed previously in this paper. Thus, empirical work should take into account the effect of ex ante product market concentration.[26]

H5: *The likelihood to go public increases with private benefits of the entrepreneur and reputation benefits of the venture capitalist.*

An increase in private benefits for the entrepreneur increases the gain in monetary profits that must be achieved through a trade sale; this makes an IPO more likely (the condition for an IPO was given in Proposition 4). As argued in Section 5, the existence of reputation benefits for the venture capitalist has similar effects to the entrepreneur's private benefits.

H6: *The likelihood to go public increases with the degree of asset intangibility of the innovation.*

It should be recalled the meaning of the asset intangibility. Here, intangibility implies inefficiency in the transfer of technology (i.e., it lowers γ) and thus represents a loss for the acquirer. It therefore

[26] Notice although that under these assumptions, we would expect an IPO for sure when the innovative product also leads to a new market ($n = 0$). Cf. Appendix. This should be particularly important for the analysis of "high tech" product like in **H3**, since these products are probably more likely to create new markets (though this is an empirical issue and can therefore not be considered here).

is arising from the inalienability of the entrepreneurial team and not from the possible diffusion of information under an IPO (which requires more openness of the companies' plans vis-à-vis outside investors and competitors).

9 Conclusion

The aim of this paper was to incorporate product market characteristics and the depth of innovation into the analysis of exit decision, and take them into account in the financial contracting between the venture capitalist and the entrepreneur. It is first shown that an IPO can be more profitable than a trade sale when the new product is sufficiently innovative. This implies that highly innovative and profitable ventures are more likely to go public than for imitator projects. The model presented in this paper therefore provides a possible explanation for why in reality we find both types of exit route. Furthermore, a greater consumer heterogeneity lowers the threshold level of innovation for an IPO to occur. This provides theoretical support to the more general observations of Hellmann and Puri (2000) that product market characteristics do matter in venture capital contracting.

The decision about the exit route can induce an agency problem when the entrepreneur is getting non-transferable private benefits from staying independent after the R&D stage. This agency problem stems from the implicit contracts inherent in the venture capitalist's option to list the company. In this analysis, this induced the entrepreneur to try to differentiate more his product from the existing competitor than what would be optimal from a pure profit maximizing point of view. Reputation gains for venture capitalists from an IPO have qualitatively similar effects. Furthermore, transferring the "right to sell control" to the entrepreneur can increase the exit value of the venture if exit occurs through a trade sale. This effect is increased with the level of private benefits. Finally, the model allows to state different empirical implications to provide material for further empirical research.

Finally, this paper contributes to the literature that links product market and capital market together. It analyses some particularities of the venture capital market (namely the exit of the venture capitalist and its financing). The fact that the venture capitalist wants to sell her shares after the R&D stage may generate a distortion and thus affects the optimal product market structure.

A Appendix

Part I: Product Market Outcomes

We compute three different outcomes: (1) profit of M prior to innovation (or if R&D is unsuccessful); (2) profit of M in case of a TS; and (3) profits of M and E in case of an IPO. Solving the two last cases allows to derive the exit condition expressed by equation (3).

(1) Prior to any innovation (or if R&D is unsuccessful), the incumbent M faces the following maximization problem:

$$\max_P \qquad P \cdot [\overline{\theta} - \theta_c(P)]$$

with $\theta_c = P/s$ and, by construction, $\theta_c \geq \underline{\theta}$. This yields $\Pi_m = \frac{1}{4}\overline{\theta}^2 s$, which is also the profit level of M if no innovation takes place. θ_c is derived from the following condition: $U(\theta_c) \geq 0$; that is, it represents the marginal utility of the consumer that is indifferent between buying one unit from M and not buying at all. All the consumers with higher marginal utility buy for sure, while consumers with $\theta < \theta_c$ do not buy (therefore, demand equals $\overline{\theta} - \theta_c$).

(2) In case of a TS, the aggregated profit of the incumbent (we do not impose here the covered market assumption) is (Π^a denotes this level of profit for M)

$$\Pi^a = P_2[\overline{\theta} - \widetilde{\theta}] + P_1[\widetilde{\theta} - \theta_c]$$

with

$$\widetilde{\theta} = \frac{P_2 - P_1}{s\gamma\delta} \qquad (19)$$

$$\theta_c = P_1/s. \qquad (20)$$

The subscript 1 denotes the existing product with quality level s; the innovative product with quality level $s(\delta + 1)$ is labeled with subscript 2. Equation (19) gives the marginal utility of the indifferent consumer (that is, the one that is indifferent between buying from M and the innovative entrant);[27] equation (20) defines the critical level of θ below which consumers with lower marginal utility do not buy, since utility falls below their reservation value of zero. Deriving the first-order conditions for both prices yield:

$$P_1 = \frac{P_2}{\gamma\delta + 1}$$

$$\text{and} \qquad P_2 = P_1 + \frac{1}{2}\overline{\theta} s\gamma\delta.$$

Thus, the equilibrium prices are:

$$P_1^* = \frac{1}{2}\overline{\theta} s$$

$$P_2^* = \frac{1}{2}\overline{\theta} s(\gamma\delta + 1)$$

[27] It is derived by solving the following condition: $U(s(\gamma\delta + 1), P_2) = U(s, P_1)$.

with demands $D_1 = 0$ and $D_2 = \frac{1}{2}\overline{\theta}$ respectively. M will therefore stop producing his old (existing) product.

Increasing P_1 is worthless, since demand for this product is already zero for P_1^*; and decreasing it reduces aggregate profit, since it only shifts demand to product 1 (thus increasing $\widetilde{\theta}$). To compensate, M will have to lower P_2. Profit maximization occurs if M only produces the innovative product and sells it at P_2^*. Thus, at equilibrium: $\Pi^a = \frac{1}{4}\overline{\theta}^2 s(\gamma\delta + 1)$.

(3) In case of entry, let us denote by index 1 the incumbent and by index 2 the entrant. Thus, P_2 denotes the price for the innovative (quality-improved) product of the newcomer; P_1 is the price of the existing product in case both qualities are offered. Demand for product 1 and 2 are $D_1 = \widetilde{\theta} - \underline{\theta}$ and $D_2 = \overline{\theta} - \widetilde{\theta}$, respectively. Their maximization problems are the following:

$$\max_{P_1} \quad P_1 \cdot (\widetilde{\theta} - \underline{\theta}) \qquad \text{for } M$$

$$\max_{P_2} \quad P_2 \cdot (\overline{\theta} - \widetilde{\theta}) \qquad \text{for the entrant.}$$

with now

$$\widetilde{\theta} = \frac{P_2 - P_1}{s\delta}.$$

This yields (Π^{na} denotes the profit of M under an IPO; Π is the profit level of the newcomer):

$$\Pi(\delta) = \frac{1}{9}(2\overline{\theta} - \underline{\theta})^2 s\delta \quad \text{and} \quad \Pi^{na}(\delta) = \frac{1}{9}(\overline{\theta} - 2\underline{\theta})^2 s\delta.$$

We now have all the profit levels at equilibrium needed for equation (3). Since the reservation value of consumers was normalized to zero, we limit ourself to $\delta_{\max}$ so that, in case of entry, at equilibrium all consumers buy either from M (so that the consumer with $\underline{\theta}$ also buys; i.e., $U(\underline{\theta}) = \underline{\theta}s - P_1 \geq 0$) or E (so that $U(\widetilde{\theta}) = \widetilde{\theta}s(\delta + 1) - P_2 \geq 0$). This is required from the covered market assumption, and defines $\delta_{\max} \equiv 3\underline{\theta}/[\overline{\theta} - 2\underline{\theta}]$.

Part II: Proof of Hypothesis H4

In this appendix, we show the positive relationship between the number of incumbents and the likelihood for the venture to go public (hypothesis **H4** in Section 8.1). Let us denote by n the number of incumbents in the product market prior to the potential entry of E and the threshold level of innovation by δ_c^n (now as a function of the number of incumbents). Thus, we need to show that $\delta_c^1 > \delta_c^2 > \delta_c^3$ (under Bertrand competition, the results are identical for any $n \geq 3$). Assume that all incumbents produce at quality level s. The innovation is identical to the one described in Section (2); that is, E comes up with the quality $s \cdot (\delta + 1)$ in case of innovation. The next table shows how the exit value of the venture $\Pi(\delta, n)$ and the maximum offer of any incumbent $\Pi_1(\delta, n)$ evolves with n:

n	$\Pi(\delta, n)$	$\Pi_1(\delta, n)$
0	$\frac{1}{4}\overline{\theta}^2 s(\delta + 1)$	no offer, since no incumbent
1	$\frac{1}{9}(2\overline{\theta} - \underline{\theta})^2 s\delta$	$\frac{1}{4}\overline{\theta}^2 s(\gamma\delta + 1) - \frac{1}{9}(\overline{\theta} - 2\underline{\theta})^2 s\delta$
2	$\frac{1}{4}\overline{\theta}^2 s\delta$	$\frac{1}{9}(2\overline{\theta} - \underline{\theta})^2 s\gamma\delta - \frac{1}{9}(\overline{\theta} - 2\underline{\theta})^2 s\delta$
3 or more	$\frac{1}{4}\overline{\theta}^2 s\delta$	$\frac{1}{4}\overline{\theta}^2 \gamma s\delta - 0$

Thus, if $n = 0$, exit will always occur through an IPO, since the innovation is a completely new market and therefore there is no incumbent prior to the innovation. If firms outside the relevant market suffer from the same inefficiency from the transfer of technology $\gamma < 1$ as incumbents, the best they would achieve is a profit of $\frac{1}{4}\overline{\theta}^2 s(\gamma\delta + 1)$ and therefore would never be able to overbid the IPO market. Thus, $\delta_c^0 = 0$.

Until now we have dealt with the case $n = 1$. The exit outcome was established in Lemma 1. The threshold value was denoted by δ_c (i.e., $\delta_c^1 = \delta_c$). For $n = 2$, prior to innovation the price in the product market was driven down to marginal cost so that no firm made any profit. In case of a TS (for which a bid auction again takes place), the acquirer will produce at quality level $s \cdot (\delta\gamma + 1)$, while the other will continue to produce at level s. In case of an IPO, the entrant will produce at $s \cdot (\delta + 1)$, while the two incumbents will continue to produce at level s and continue to compete à la Bertrand (price competition). For $n \geq 3$, all the firms that did not acquire the new technology still make zero profit, since they all produce an undifferentiated product; only the one that has won the auction for the venture will make some profit (though, the acquisition price will always exceed this gain if $\gamma < 1$ – see the above table). Thus, a TS will never happen if perfect competition will continue to prevail among incumbents, since the acquisition price for E will be the monopoly profit of the whole industry (the line labeled "maximum offer" starts at the origin and has positive slope). Therefore, $\delta_c^3 = 0$.

The only problem is $n = 2$. The inverse relationship under Bertrand competition only prevails in a strict sense. For $n = 2$, we have an IPO whenever $\Pi(\delta, 2) > \Pi_1(\delta, 2)$, i.e.

$$\frac{1}{4}\overline{\theta}^2 s\delta > \frac{1}{9}(2\overline{\theta} - \underline{\theta})^2 s\gamma\delta - \frac{1}{9}(\overline{\theta} - 2\underline{\theta})^2 s\delta$$

It is straightforward to see that the parameter δ cancels out so that δ_c^2 is either 0 or 1. Solving the above equation yields the following condition to get $\delta_c^2 = 0$:

$$(\overline{\theta}/\underline{\theta}) < \frac{1}{(16\gamma - 13)}\left[6\sqrt{5\gamma - 4} - 8\,(1 - \gamma)\right].$$

An IPO occurs whenever this condition is satisfied,[28] and the relationship between n and likelihood to go public is strictly positive. Otherwise, it may happen that $\delta_c^2 < \delta_c^1$ for some parameter values of γ. This condition sets an upper bound to the consumer heterogeneity in this market (i.e., the ratio $(\overline{\theta}/\underline{\theta})$ is bounded above). Similarly, it also implies an upper limit to the value of γ.

For sake of completeness we still need to show that this is also true when taking into account the potential excessive distortion arising from the entrepreneur's private benefits. When computing the solutions for all $n \geq 1$, we get similar conditions as in the benchmark model for the likelihood to go public:

$$\delta_c^1 \quad \leq \quad d + 2\sqrt{db/\mu} \qquad \text{with } \mu \text{ as in equation (2)}$$

[28] For $\gamma \geq \frac{4}{5}$ (otherwise the term under the square root would be negative), the condition is a strictly convex and decreasing function of γ and converging to 2 as γ approaches unity. The other root of the solution is $(\overline{\theta}/\underline{\theta}) > \frac{1}{(16\gamma-13)}\left[-6\sqrt{5\gamma - 4} - 8\,(1 - \gamma)\right]$ and is always negative.

$$\delta_c^2 \leq d + 2\sqrt{db/\eta} \qquad \text{with } \eta = \frac{1}{4}\overline{\theta}^2 s$$

$$\delta_c^3 \leq d + 2\sqrt{db/\sigma} \qquad \text{with } \sigma = \frac{1}{4}\overline{\theta}^2 s$$

Thus, since $\delta_c^1 > \delta_c^2 > \delta_c^3$ and $\mu > \eta = \sigma$ (see the above table for $n = \{1, 2, 3\}$), we have a positive relationship between the number of incumbents and the likelihood to go public for innovative ventures.

It is certainly worth computing the equilibrium solution for Cournot competition also. Then, the shift to perfect competition is somewhat smoother. When doing this, we can establish qualitatively similar results regarding the relationship between ex ante market concentration and IPO activities.

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