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Armin Schwienbacher

University of Amsterdam and Catholic University Louvain

December 2006



RICAFE2 - Regional Comparative Advantage and Knowledge Based Entrepreneurship

A project financed by the European Commission, DG Research
under the 'Citizens and governance in a knowledge-based society' (FP6) programme
Contract No : grant CIT5-CT-2006-028942.

Financial Markets Group, London School of Economics and Political Science, LSE, UK
Dipartimento di Scienze Economiche e Finanziarie Prato, Università di Torino, TORINO, Italy
Centre for Financial Studies, CFS, Germany
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Tilburg University, UTIL.CER, Netherlands
University of Southern Switzerland, USI, Switzerland
The Institute of Physics, IBP, Serbia

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*Contact details: University of Amsterdam; Finance Group; Roetersstraat 11; 1018WB Amsterdam (The Netherlands); Phone: +31-20-5255815; Email: A.Schwiebacher@uva.nl. The author has benefited from numerous discussions with Ulrich Hege and Charles Van Wymeersch. He also thanks Stefan Arping, Christopher Hennessy, Patrick Legros, Enrico Perotti, Isabelle Platten, Loic Sadoulet, Mark Seasholes and Ernst-Ludwig von Thadden for their encouragement and constructive comments on this paper, and participants at the 2000 FMA European doctoral meetings, the CEPR conference on the “Evolution of Market Structure in Network Industries,” the Belgian Financial Research Forum 2001, the 2001 FMA European conference, the 2001 AFFI conference, the CEPR-WZB conference on “Innovation Policy and International Markets,” and seminars in Amsterdam, Berkeley, Groningen, Leuven, Montreal, Namur and Tilburg. The paper was completed while the author was a visiting scholar at the University of California at Berkeley, Haas School of Business. Financial support by the EU Grant Ricaf2 CIT5-CT-2006-028942 and the Intercollegiate Center for Management Sciences (ICM) in Belgium is gratefully acknowledged. The usual disclaimer applies.

INNOVATION AND VENTURE CAPITAL EXITS

Abstract

This paper analyzes how startups financed by venture capital choose their innovation strategy based on the investor's exit preferences, and thereby form different outcomes in the product market. It considers innovation choices and venture capital exits (IPO vs trade sale) in a setting in which entrepreneurs derive private benefits from staying independent, which is better guaranteed under an IPO. Since the venture capitalist typically does not take such benefits into account when choosing the exit route, the entrepreneur has incentives to distort the innovation strategy in order to induce the venture capitalist to bring the company public. This protects the entrepreneur's private benefits but comes at the expense of eroding expected monetary value. Our analysis generates a number of empirical implications for the link between innovation, valuation, venture capital exit routes and market structure.

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

JEL Classification: G24; G32; L10; O31

NON-TECHNICAL SUMMARY

Innovation is considered since long time as a critical driver of economic growth and value creation. An important channel through which innovation is financed in developed economies is venture capital funds. Venture capital funds invest in start-up companies with the clear desire of exiting after 4-7 years. Since most high-tech start-ups initially do not generate profits to pay dividends or buy back shares, the exit route is the primary way the venture capitalist can realize a positive return on the investment. Exit conditions are therefore crucial for financing. The two main exit routes are a trade sale (or “acquisition”) and an initial public offering (IPO). In contrast to a trade sale, an IPO keeps the firm independent, and allows entrepreneurs to remain in control of their company after the venture capitalist’s exit. Many entrepreneurs therefore prefer an IPO over a trade sale, as they tend to enjoy staying at the company in a management role. Venture capitalists therefore require explicit intervention rights on exit issues to force an exit and thus to avoid being locked into shareholding in the event of a disagreement with the entrepreneur.

While the exit route can have substantial effects on the value of the venture and on the incentives of the parties’ contractual relationship, little attention has been paid to how venture capitalists actually decide on the type of exit. Most of the existing studies have considered the IPO the only exit route for successful ventures (mainly because they cannot disentangle different exit routes), although most exits still occur through a trade sale. Many authors indicate that exit through an IPO has been limited to the most innovative and promising ventures.

In reality, the structure of the product market is a crucial variable in determining future profits of these new firms. Moreover, venture capitalists often finance innovative ventures that challenge established firms in their core market. How the entry of a new innovative firm affects the market structure and how established firms react to it are critical factors. Motivated by these empirical observations on exit choices, we aim at investigating the question of why entrepreneurs may shape different firms. To extend this research, we explore to which extent the ultimate organizational form of entrepreneurial firms (i.e., whether a stand-alone or an acquired firm) is related to innovation and how exit choices by the venture capitalist affect the entrepreneur’s incentives to innovate.

In particular, we examine innovation choices and venture capital exits (IPO vs trade sale) in a setting in which entrepreneurs derive private benefits from staying independent. In this paper, the shape of the entrepreneurial firm is determined by the innovation choices of the entrepreneur at the early-stage of the company. We show that the entrepreneur might distort the innovation scope of her project if that makes the company more attractive for an IPO in case the project is successful. In that way, the entrepreneur is more likely to remain in control of her company. This protects the entrepreneur’s private benefits from staying independent but comes at the expense of eroding

expected monetary gains. This may lead to a conflict that has not yet been studied.

We explicitly introduce product market characteristics into the analysis, which is critical to derive profit level under IPO and TS. We consider a market where there is already an incumbent firm but the start-up may differentiate its product from the existing one. When both products are close substitutes and thus the degree of innovation is marginal, there is a high competitive threat from entry, and the established firm will be ready to pay a high premium. In this case, a trade sale is most likely, since the incumbent has an incentive to make an offer that is higher than what the company would get through a public offering. When the product is very innovative and therefore more differentiated, the market is partially segmented. In this case, there is less of a competitive threat from this entry and an IPO is more likely. This motivates control benefits-driven entrepreneurs to differentiate their products from the competition more than would be optimal from a purely profit-maximizing point of view. The considered product market structure is well in line with empirical evidence provided by Bhidé (2000). Among the Inc. 500 company founders he surveyed, only 6% entered entirely new markets. In most cases, entrepreneurs entered markets that had some form of substitute products that may have differed along several dimensions.

In choosing the optimal level of innovation, we consider a finance-related “innovation technology” based on a risk-return trade-off. Greater innovation entails a lower chance of success. Combined with the product market outcomes, this generates a number of key results for the incentives of entrepreneurs to innovate and optimal contracts in terms of cash flow and control rights. We show that entrepreneurs may change innovation strategy in either way. They may take less risk in that they prefer to increase their chance of having a successful product. However, if it does not secure an IPO after successful innovation, entrepreneurs may also distort their strategy by taking excessive risk in order to improve the chances for an IPO. This leads to greater variability in innovation strategies when control plays a key issue in entrepreneurial decision-making. The analysis provides further empirical predictions for the links between innovation, venture capital exits, and market structure.

1 Introduction

Innovation is considered since long time as a critical driver of economic growth and value creation. An important channel through which innovation is financed in developed economies is venture capital funds (see Kortum and Lerner, 2000, for evidence on the contribution of venture capital finance to innovation). These are specialized in financing innovative, high-growth ventures, and contributed to the success of many of the most successful new firms of the last few decades such as Microsoft, Google, Dell, Intel Computer and Apple. Indeed, they have all received venture capital finance in their initial stage of development (see, e.g., Gompers and Lerner, 1999, and Da Rin *et al.*, 2006, for a related discussion on the US and Europe). From the macroeconomic perspective, Wasmer and Weil (2000) find significant positive impact of venture capital activities on short-term and long-term employment (see also Keuschnigg, 2004).

However, venture capital funds invest in start-up companies with the clear desire of exiting after 4-7 years. Since most high-tech start-ups initially do not generate profits to pay dividends or buy back shares, the exit route is the primary way the venture capitalist can realize a positive return on the investment. Exit conditions are therefore crucial for financing. The type of exit is an important issue not only for the venture capitalist, but also for the entrepreneur. The latter must understand that the venture capitalist will eventually want to exit the venture, and that very often this means the venture will be sold to another company. An entrepreneur who wants to retain control of the company afterward will need to find the funds required to buy out the venture capitalist or bring the company public (Black and Gilson, 1998). Otherwise, the venture will be sold after a few years to another firm.

The two main exit routes are a trade sale (or “acquisition”) and an initial public offering (IPO). In contrast to a trade sale, an IPO keeps the firm independent, and allows entrepreneurs to remain in control of their company after the venture capitalist’s exit. Many entrepreneurs therefore prefer an IPO over a trade sale, as they tend to enjoy staying at the company in a management role.¹ This may sometimes lead to a conflict between the venture capitalist and the entrepreneur over the exit decision.

Several other authors document the widespread use of contractual arrangements that guarantee the venture capitalist explicit intervention rights, also on exit issues (Cumming, 2002, Kaplan and Strömberg, 2003, Smith, 2005, and Bienz and Walz, 2006). More generally, these rights allow the venture capitalist to force an exit and thus to avoid being locked into shareholding in the event of a

¹Zingales (1994), Dyck and Zingales (2004), and Frey and Benz (2004) indicate control benefits may be substantial and therefore are likely to affect an entrepreneur’s decisions related to control. Kirilenko (2001) provides a theoretical discussion of venture capital finance and control benefits.

disagreement with the entrepreneur. Various potential sources of conflicts over exit issues discussed by Smith (2005), which clearly indicates the need for investors to retain these rights in order to force entrepreneurs keeping exit options alive.

While the exit route can have substantial effects on the value of the venture and on the incentives of the parties' contractual relationship, little attention has been paid to how venture capitalists actually decide on the type of exit. Most theoretical studies take the exit value either as exogenously given or as a reduced form of effort provided by entrepreneur and venture capitalist. Nor does the empirical literature offer much insight into this issue. Most of the existing papers have considered the IPO the only exit route for successful ventures (mainly because they cannot disentangle different exit routes), although most exits still occur through a trade sale.² In reality, the structure of the product market is a crucial variable in determining future profits of these new firms. Moreover, venture capitalists often finance innovative ventures that challenge established firms in their core market. How the entry of a new innovative firm affects the market structure and how established firms react to it are critical factors.

Motivated by these empirical observations on exit choices, we aim at investigating the question of why entrepreneurs may shape different firms. To extend this research, we explore to which extent the ultimate organizational form of entrepreneurial firms (i.e., whether a stand-alone or an acquired firm) is related to innovation and how exit choices by the venture capitalist affect the entrepreneur's incentives to innovate.

In particular, we examine innovation choices and venture capital exits (IPO vs trade sale) in a setting in which entrepreneurs derive private benefits from staying independent (in the spirit of Aghion and Bolton, 1992, and Berglöf, 1994). In this paper, the shape of the entrepreneurial firm is endogenous. We show that the entrepreneur might distort the innovation scope of her project if that makes the company more attractive for an IPO in case the project is successful. In that way, the entrepreneur is more likely to remain in control of her company (Black and Gilson, 1998). This protects the entrepreneur's private benefits from staying independent but comes at the expense of eroding expected monetary gains (what we call in this paper the *independence bias*). This may lead to an agency conflict that has not yet been studied. Our analysis generates a number of empirical implications for the link between innovation, venture valuation and observed venture capital exit routes.

We explicitly introduce product market characteristics into the analysis, which is critical to derive

²Many authors indicate that exit through an IPO has been limited to the most innovative and promising ventures (Gompers, 1995, Cochrane, 2005, Darby and Zucker, 2002, and Cumming and MacIntosh, 2003). According to Gompers (1995), the annual return of venture capital in the US is 60% when exit occurs through an IPO, and only 15% when venture capitalists sell their stake to another company.

profit level under IPO and TS. Our basic market setting uses a vertical product differentiation framework to model competition in the product market. This allows to model innovation in the form of quality improvements compared to existing products. This study primarily focuses on this kind of innovation. We believe this characterizes well a large number of innovative firms financed with venture capital. Most innovative ventures backed by venture capital provide quality enhanced products to markets, and not so much products that are similar to those that already exist (but potentially at lower production cost). This considered product market structure is well in line with empirical evidence provided by Bhidé (2000). Among the Inc. 500 company founders he surveyed, only 6% entered entirely new markets. In most cases, entrepreneurs entered markets that had some form of substitute products that may have differed along several dimensions.

An example of the type of innovation is the digital camera, assuming that an established company produces a camera with a particular resolution of pictures, and a newcomer can produce a digital camera with higher resolution. Since both products are close substitutes when the degree of innovation is marginal, there is a high competitive threat, and the established firm will be ready to pay a high premium. In this case, a trade sale is most likely, since the incumbent has an incentive to make an offer that is higher than what the company would get through a public offering. When a new camera product is very innovative and therefore more differentiated, the market is partially segmented. Consumers who value little high quality cameras will prefer to buy one from the incumbent at reduced price, while others will be ready to pay more for the better camera. In this case, there is less of a competitive threat from this entry and an IPO is more likely. This motivates control benefits-driven entrepreneurs to differentiate their products from the competition more than would be optimal from a purely profit-maximizing point of view.

This distortion is an important issue any time entrepreneurs seek venture capital finance. Remaining private in order to avoid being acquired by another firm is hardly an option for venture-backed startups (this would require that investors do not sell their shares), since venture capitalists are not long-term investors. This means that their shares will be sold after a few years, either through an IPO or trade sale. The issue analyzed here is therefore particularly important for venture capital as there the exit stage is part of the financing process. If venture capitalists were ready to remain as shareholder in the venture well beyond the commercialization date, the company may operate on a stand-alone basis as a private firm. This would be an additional option next to IPO and trade sale. Since venture capital investors will want to sell their shares in the near future (for various reasons, including the fact that they are managing money from others and fund availability is limited in time), a significant transfer of shares needs to take place. Buying out venture capital

investors is very difficult.³ This usually leaves little room for other alternatives to an IPO or a trade sale.

In an extension, we examine alternative market situations to the vertical differentiation game. In particular, we use a simple entry game, where entering the market is unprofitable for the entrepreneur unless she innovates. We assume that innovation decreases entry costs so that entry becomes profitable. We examine the incentives of the latter to acquire the new venture in order to prevent entry. In principle, the established company may want to acquire the newcomer whenever entry erodes its own profits, but the question again is whether it is ready to pay a premium over what the newcomer is worth as a stand-alone firm. This depends on what is likely to be gained by avoiding the entry of the newcomer. Since the value of the new venture increases with the level of innovation and the incumbent's entry costs are already sunk, more innovative newcomers are more costly to acquire. The premium that an established company is ready to pay for the acquisition is then lower, and thus an IPO more likely.⁴

In choosing the optimal level of innovation, we consider a finance-related "innovation technology" based on a risk-return trade-off. Greater innovation entails a lower chance of success. Combined with the product market outcomes, this generates a number of key results for the incentives of entrepreneurs to innovate and optimal contracts in terms of cash flow and control rights. We show that entrepreneurs may change innovation strategy in either way. They may take less risk in that they prefer to increase their chance of having a successful product. However, if it does not secure an IPO after successful innovation, entrepreneurs may also distort their strategy by taking excessive risk in order to improve the chances for an IPO. This leads to greater variability in innovation strategies when control plays a key issue in entrepreneurial decision-making. The analysis provides further empirical predictions for the links between innovation, venture capital exits, and market structure.

A critical assumption is that the venture capitalist holds rights to decide on the exit route. This is the ultimate source of distortion, since the venture capitalist typically does not take into account the entrepreneur's private benefits (and thus at times opts for a trade sale against the will

³Two possibilities are Management Buyouts (MBOs) and secondary sales. In a MBO, the entrepreneur seeks to buy back the shares of the venture capitalist through alternative sources of capital, mainly debt. In a secondary sale, it is the venture capital investor who directly sells his stake to another large investor, for instance a private equity fund. However, these transactions are only attractive for more mature companies and therefore rare for venture capital investments.

⁴While the entry game and the vertical product differentiation game yield a positive relation between IPO and innovation, in general there is no reason that this holds for all market games. If more innovation sharpens competition, the incumbent may rather acquire the most innovative ventures and let imitators enter the market. In a previous working paper version of this article, we provided more general conditions for a positive link between innovation and IPO and argued that these better apply to the type of industries and investments financed with venture capital.

of the entrepreneur). We believe this is largely backed by empirical evidence (see a later section for references). However, there is no reason to believe that this is optimal, and it may as well be the outcome of optimal contracting. We examine this issue as a relevant extension. It allows the entrepreneur to opt for a public listing at times she does not get compensated by the acquirer for her private benefits. We show that while it partially mitigates the distortion, it does not eliminate it entirely. Indeed, to secure her control benefits, the entrepreneur must also retain control of the venture after the IPO so that the incumbent is not able to acquire control by buying shares on the secondary market. This may happen if the entrepreneur holds less than 50% of the outstanding shares. This additional constraint does not arise when the venture capitalist decides, since the incumbent never has an incentive to acquire control in that way if a trade sale was not optimal in the first place.

The paper is structured as follows. In the next section, we present the related academic literature. The model is then presented in Section 3. The entire model is then solved for the optimal financing strategy in Section 4. Section 5 discusses robustness issues. Empirical implications are presented in Section 6. Section 7 concludes.

2 Related Literature

This research extends three different strands of the literature. The first is the literature on venture capital contracting and control rights allocation, which typically focuses on agency conflicts between entrepreneur and venture capitalist (Hellmann, 1998, Bergemann and Hege, 1998, Repullo and Suarez, 2004, Casamatta, 2003, Inderst and Müller, 2004, Cornelli and Yosha, 2003, and Schmidt, 2003). Among other factors, this research highlights the importance of adequate incentive-based compensation schemes, the importance of efficient venture capital markets, the active role of venture capitalists, and the role of stage financing and convertible securities in mitigating conflicts. Innovation is not explicitly modeled in these papers, and product characteristics are taken as exogenously given.

More closely related research deals with the allocation of control rights, in particular, Aghion and Bolton (1992), Berglöf (1994), and Dewatripont and Tirole (1994). In the spirit of Aghion and Bolton (1992), Berglöf (1994) argues that if the “right to sell control” (representing the right to decide on the exit route) belongs to the investor, the entrepreneur will be vulnerable to expropriation of private benefits in case of a trade sale. Bascha and Walz (2001) extend this analysis to the venture capital context. Dewatripont and Tirole (1994) offer an alternative explanation for a positive link between firm value and the decision to go public (but this abstracts from product market considerations).

They show investors retain important control rights such as the right to sell their shares to outsiders or to another corporation if intermediate prospects of the firm are poor. Retention of these control rights lets investors penalize management for bad intermediate outcomes.

A second strand of the literature addresses venture capital exits. A detailed survey of empirical findings on exit issues is provided by Gompers and Lerner (1999). Most of the work is empirical and focuses on IPOs as the exit route for venture capitalists. Black and Gilson (1998) discuss why there is a strong link between an active venture capital industry and a well-functioning stock market. Cumming, Fleming and Schwienbacher (2006) show the impact of exit market liquidity on venture capital finance. Barry et al. (1990) and Megginson and Weiss (1991) provide evidence that the active role of the venture capitalist seems to be recognized at the IPO through less underpricing. Neus and Walz (2005) offer a theoretical discussion of the reputation-building behavior of venture capitalists. Kanniainen and Keuschnigg (2003) discuss the trade-off venture capitalists face between value-adding and portfolio size. Lerner (1994) shows that venture capitalists successfully time their IPOs when stock market valuation is high. Michelacci and Suarez (2004) provide a further rationale for the importance of IPOs for the venture capital market; they provide a way to recycle invested funds by buying out the venture capitalist who can invest again in new ventures. Darby and Zucker (2002) show that in the biotech industry venture capital fosters innovation and enhances the likelihood companies will be successful. Gompers (1995), Cochrane (2005), Cumming and MacIntosh (2003), and Darby and Zucker (2002) report a positive relationship between firm valuation and the likelihood of going public for venture-backed companies. Hellmann and Puri (2000) show that venture-backed firms move more quickly to commercialize their innovations, evidencing the product market effects in venture capital finance. Kortum and Lerner (2000) examine the relation between innovation and venture capital finance. Other studies examine the effect of the interplay between venture-backed entrepreneurs and established corporations on innovation (e.g., Amador and Landier, 2003, and Ambec and Poitevin, 2001). Finally, using very large databases Das *et al.* (2003) analyze the likelihood of exiting for venture capitalists.

The last strand of the literature studies the inter-connection between financial markets and product markets (see Maksimovic, 1995, and Cestone, 1999, for surveys). Among other things, it points out the disciplining effect of the capital structure on the manager's behavior in the product market. Schmidt (1997) examines the effect of product market competition on managerial incentives. More recently, Cestone and White (2003) shows that strategic decisions of investors may also affect product market outcomes. We add to these insights the effect of venture capital financing and innovation opportunities on both markets.

3 The Model

This section presents the ingredients of our model. In our basic setting, we use a simple model of vertical (i.e., quality) product differentiation to characterize the product market game.⁵ The structure used here is presented in Section 3.1 and is fairly standard. Our primary deviation stems from the introduction of an innovation parameter that we subsequently endogenize. In Section 5, we present a market game based on entry costs.

3.1 Innovation, Product Market and Venture Financing

Assume that initially a monopolist, M (also called incumbent), serves a given market. Consider also 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. All parties involved are assumed to be risk-neutral, and for simplicity, we set their reservation payoffs to zero. The amount of funds needed is denoted by $I > 0$ and is exogenously given. We also assume perfect competition among venture capitalists. This implies that the participation constraint of VC is always binding. 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 $[\underline{\theta}; \bar{\theta}]$, and each consumer's utility is $U(\theta) = \theta s - P$. The variable P denotes the price of the unit purchased and s denotes the quality level of M 's product. 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.

The entrepreneur's innovation offers the opportunity to improve the quality of the incumbent's product. If the innovation is successful, the entrepreneur will be able to produce a related product but at a higher quality level $s(\delta + 1)$, where $\delta \geq 0$ and $\delta \leq \delta_{\max} \equiv 3\underline{\theta}/(\bar{\theta} - 2\underline{\theta})$.⁶ This upper bound implies that when there are two firms in the market, all consumers are served so that the incumbent and the entrepreneur share the full market demand (the so-called *covered market assumption*). Consumer heterogeneity, which is measured by the difference between $\bar{\theta}$ and $\underline{\theta}$, is assumed to be large enough for two firms to coexist; this requires that $\bar{\theta} > 2\underline{\theta} > 0$. For the sake of simplicity, we assume also that the production cost of the good is zero, regardless of the quality level.

We endogenize the level of innovation δ . By choosing its level, we assume that the entrepreneur affects the expected payoffs in two ways: by increasing δ , (1) entry costs will be reduced in the case of successful innovation (which will produce higher profits); and (2) the probability of succeeding

⁵More general product market conditions (including additional product market games) are provided in an earlier working paper version (available upon request).

⁶In fact, the analysis could be extended beyond δ_{\max} by changing the reservation utility of consumers, but bounding keeps the analysis tractable. For the mathematical derivation of δ_{\max} , see Part I in the Appendix.

is lessened. These components have opposite effects on expected profits and stylizes the common notion of a risk-return trade-off. The venture's probability of success is denoted by $p(\delta)$. In what follows, we will restrict ourselves to the functional form $p(\delta) = 1/(\delta + d)^2$ with $d \geq 1$.⁷

In practice, the variable δ may relate to different aspects of the venture's R&D activities, but particularly the scale and scope of the innovation as well as the business strategy. Some of these decisions are clearly endogenous even after the venture capitalist has signed the contract. But the model of vertical product differentiation allows a much broader interpretation of δ than technological innovation; it covers all aspects that allow the entrepreneur to differentiate its product and business strategy from its competitor. Therefore, we do not require completely open-ended research. While δ may apply to more than technology, we relate it primarily to technological issues. We therefore consider products with high δ as being highly innovative and products with low δ as imitators.⁸

3.2 Non-Contractibility and Competence

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. Typically, the entrepreneur manages the venture on a day-to-day basis, which effectively gives her considerable discretionary power on the choice of δ . This contractual incompleteness is assumed throughout, so that E has full discretion over the research path δ .

Similarly, exit issues are here assumed to be at the discretion of the venture capitalist; he is assumed to be the only one able to negotiate efficiently with potential buyers. This is captured by assuming that VC retains the control rights pertaining to exit (meaning throughout the right to decide on the choice of exit). Similar to Dewatripont and Tirole, (1994), the threat of a TS ex ante forces the entrepreneur to cooperate at the exit stage. This should therefore provide a rationale

⁷This modeling approach differs from many other studies of agency problems. An alternative modeling approach is through effort costs in that achieving higher innovation levels δ requires more costly effort from the entrepreneur. However, this approach would not lead to much insights here. If effort only affects probability of success (which is the most widely adopted framework), there is no effect on innovation. In order to incorporate innovation into the analysis, one needs to assume that effort relates (primarily) to innovation and thereby to ex post profits. However, this would have no effect either on the agency problem examined here (the independence bias) if the level of control benefits is unrelated to profit level, as done in the approach used here. Therefore, the alternative modeling approach of modeling entrepreneurial effort does not provide any meaningful insights into the discussion of innovation level, beyond the conventional channel of effort affecting the innovation level in a very direct way. Since the risk-return tradeoff is central to any investment decision, the approach adopted here seems more worthwhile to explore.

⁸Alternatively, the amount of capital required (I) could also affect riskiness if considered endogenous. "Aiming higher" may require more capital in some cases. However, the resulting effects do not add much to the analysis and the results hinge on specific assumptions imposed.

why in practice venture capitalists wish to retain substantial control rights regarding exit and often oppose committing to an IPO. This allows VC to force the entrepreneur to sell her shares and thus to make a trade sale possible.⁹ We exclude for the time being the possibility that control rights are endogenously allocated to either party; we discuss this later.

3.3 Exit Routes

The venture capitalist exits after the R&D stage (in the spirit of Michelacci and Suarez, 2004, we assume it is more profitable for VC to sell the shares and to invest the amount in a new project).

Exit routes include:

- (1) IPO: The company is listed on a perfectly competitive stock market. We assume that the shares are sold to widely dispersed investors, none of them obtaining a controlling stake in the firm. The entrepreneur therefore stays at the company and manages it. E further gets non-transferable private benefits of $b > 0$.
- (2) Trade sale (TS): The venture is sold to the incumbent M that acquires the innovative technology and retains his monopoly position in the product market. In addition to the acquisition cost, M incurs a fixed inefficiency cost of $F > 0$.¹⁰
- (3) Liquidation: With probability $1 - p(\delta)$, E is unsuccessful in developing the new product, and the venture is liquidated. The liquidation value is normalized to zero.

The fact that there is an inefficiency cost under a TS is a critical assumption. Without this inefficiency, an IPO would never be optimal. Note that all we need to assume is the relative inefficiency of a TS compared to an IPO. The simplest interpretation is that technology cannot be transferred entirely to the incumbent under a TS. Another possible source of this cost is the presence of agency problems due to a lack of information available to shareholder under a monopoly situation. As argued by Scharfstein (1988), Hart (1983) and Hermalin (1992), duopoly competition that would result under an IPO may generate better information to value firms in the related product market

⁹Drag-along rights make a trade sale possible by forcing entrepreneurs to also sell their shares to the buyer. Since the venture capitalist typically is a minority shareholder and the buyer buys only if it can acquire a majority in the portfolio company, the venture capitalist will exercise the drag-along right whenever he wishes to consummate a trade sale against the will of the entrepreneur. This increases the venture capitalist's chances of making a deal with a potential buyer; a trade sale might be difficult if he holds only a small equity stake and the entrepreneur does not want to sell hers. See Chemla *et al.* (2002) for a detailed presentation of financial clauses.

¹⁰Alternatively, the inefficiency may involve a cost proportional to the depth of innovation. This can be modeled as M achieving a technological level of only $s(\gamma\delta + 1)$ under a TS, with $0 \leq \gamma \leq 1$. This would mean that only a proportion γ of the innovation is transferred. This yields qualitatively similar results as the fixed costs assumed here.

and detect adverse managerial behavior, as opposed to a monopoly case where the single firm has no meaningful comparable firm. This may lead to higher agency costs under a TS. Empirical evidence is provided by Krishnawami and Subramaniam (1999), Gilson et al. (1998), and Chemmanur and Paeglis (2001), among others.¹¹

3.4 Financial Contracts and Stages of the Game

Let us first describe the content of the financial contracts considered here. Let us denote the venture's value in case of innovation by $\Pi > 0$. Its exact value will be derived in the next section. 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-type claims).¹² More generally, this can be interpreted as a linear contract. For a given contract, the expected profits of VC and E are given by

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

$$\Pi_e = p(\delta) \cdot [\alpha(\Pi(\delta) - D) + B(\delta)] \quad (2)$$

where $B(\delta) = b$ under an IPO and 0 under a TS. The variable $D \geq 0$ represents debt payment from the successful entrepreneur to VC . 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 herself; VC gets the remainder. By definition we require $0 \leq \alpha \leq 1$.

The kind of contracts is consistent with what is used in practice (see, e.g., Cumming, 2002, Kaplan and Strömberg, 2003, Smith, 2005, and Bienz and Walz, 2006). While venture capital finance predominantly uses preferred equity (combined with convertibility and participating features) in the US, Bienz and Walz (2006) provide evidence for the widespread use of debt-equity mixes in Europe.

The game evolves over three stages, as depicted in Figure 1. In stage 1, E offers a take-it-or-leave-it contract to VC . If he accepts the contract, the project is financed, and VC invests the amount

¹¹Alternatively, F can be 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 can be used by the trade sale buyer. In this case, F is close to zero. But if the innovation involves intangible assets, such as the human capital of the entrepreneur or key employees, then not all of the assets can be fully captured by the buyer. Other possible explanations of inefficiency from a trade sale are a lack of clear boundaries of the firm after the acquisition (inducing difficulties in providing optimal incentive contracts to the entrepreneur and key employees), the presence of technological switching costs for the acquiring firm, organizational inefficiencies, and differences in managerial culture (start-ups are often said to have their own particular culture and to be based on new business models). Veld and Veld-Merkoulova (2006) and Allen et al. (1995) provide empirical evidence that point to some of these inefficiencies, which lead to corporate spin-offs.

¹²These can be either standard debt payments or preferred equity issued to VC , in which case D stands for the payment of preferred dividends. Alternatively, any mix of debt-like claims and equity can be achieved by issuing participating preferred equity to the venture capitalist.

I. In stage 2, R&D takes place. E chooses δ , the degree of innovation. In the last stage, the exit decision is made by VC , which may accept or refuse any offer made by M for a TS. The profit is then paid out. If the venture goes public, it enters the product market as a competitor of M . As usual, the game is solved by backward induction.

4 Analysis of the Model

4.1 Exit Decision of the Venture Capitalist

We solve the last stage by first deriving the venture's profit levels. We then determine the optimal exit strategy for the venture capitalist. In the case of a successful R&D stage and if the venture remains independent, the payoff of the entrepreneur's project can be calculated as

$$\Pi(\delta) = \left[\frac{1}{9}(2\bar{\theta} - \underline{\theta})^2 s \right] \cdot \delta \equiv \mu(\bar{\theta}, \underline{\theta}, s) \cdot \delta \quad (3)$$

$\Pi(\delta)$ is therefore the equilibrium ex post profit of the venture as a stand-alone firm. Note that $\Pi(\delta)$ increases with δ . The variable $\mu(\cdot)$ is a function of all the product market parameters and is used to simplify notation. This result, along with the other closed-form profit levels employed later, is derived in Part I of the Appendix.

The following condition must be satisfied for a TS to be profitable:

$$\underbrace{\frac{1}{4}\bar{\theta}^2 s(\delta + 1) - F}_{\text{profit of the } M \text{ in case of acquisition}} - \underbrace{\frac{1}{9}(\bar{\theta} - 2\underline{\theta})^2 s \delta}_{\text{profit of the } M \text{ in case of no acquisition}} > \Pi(\delta) \quad (4)$$

A trade sale occurs if the gain for M from acquiring the entrant (left-hand side) exceeds the cost of the acquisition. In principle, an established company may always want to acquire the newcomer, but the question is whether it is ready to pay a premium; and this depends on the gains from limiting entry, while taking into account costs F . The left-hand side represents the maximum offer M will make. Equation (4) can be interpreted in another way by simply shifting the second term of the left-hand side to the other side of the inequality. Then the condition says that a trade sale is optimal if the monopoly profit exceeds the non-cooperative duopoly outcome (the sum of profits of M and the new entrant).

Solving equation (4) for δ yields

$$\delta < \delta_c \equiv \frac{Y - F}{X - Y} \quad (5)$$

with $X \equiv \left[\frac{1}{9}(\bar{\theta} - 2\underline{\theta})^2 s + \frac{1}{9}(2\bar{\theta} - \underline{\theta})^2 s \right]$ and $Y \equiv \frac{1}{4}\bar{\theta}^2 s$. The denominator is always strictly positive, since the assumption $\bar{\theta} > 2\underline{\theta}$ implies that $X > Y$. For any $\delta < \delta_c$, M will therefore make a higher

offer than the market before any IPO occurs.¹³ It follows that more innovative ventures are more likely to go public. Since competition is greatest when products are close substitutes, the established firm will be ready to pay a premium in this case, and an acquisition is then most likely. But when the new product is differentiated enough, the business-stealing effect is smaller and thus gains from limiting entry are reduced. This is represented in Figure 2 and summarized in Lemma 1:¹⁴

Lemma 1 *Denote $\delta_c = [Y - F] / [X - Y]$. The optimal exit route of a venture capitalist is a trade sale if $\delta < \delta_c$ and an IPO if $\delta \geq \delta_c$.*

This provides results regarding exit choices *conditional* on having innovated. There is a threshold level δ_c for two reasons. The first reason is inefficiency of a trade sale. As F increases, a TS becomes more costly. The second one is the competition effect, which is lessened as the tastes of consumers become more heterogeneous. In other words, δ_c declines as consumer heterogeneity increases, since competition between the incumbent and the entrepreneur is lower.¹⁵ This highlights the idea that an IPO is limited to the most promising ventures, while a trade sale is a more universal exit route. It may take place for very promising ventures (because F is low) as well as for less promising ventures (as a result of a low δ).

4.2 Optimal Degree of Innovation and Financial Contracts

First-Best Degree of Innovation: Having solved stage 3, we now focus on the first two stages. Before solving these stages, we compute the first-best level of innovation (denoted by δ_{fb}), which is when the entrepreneur does not require any outside finance. This is given by the maximization problem:

$$\max_{\delta} \quad p(\delta) \cdot [\Pi(\delta) + b] - I \quad (6)$$

We summarize this outcome in Lemma 2:

¹³If $\bar{\theta} < 2\underline{\theta}$, then IPO occurs at any level of δ , since consumer heterogeneity is too small for two firms to coexist. The incumbent would then be driven out of the market. This would imply a predatory effect. Notice also that any private benefits accruing to M would then matter for the decision to do a TS since the only way to retain them will be to acquire the venture. But when $\bar{\theta} > 2\underline{\theta}$, M 's private benefits do not matter, since he remains in the market independent of VC 's exit choice.

¹⁴For comparison, it is easy to derive the first-best exit decision, when E does not require any external finance. The cost of acquisition then is $\Pi(\delta) + b$ instead of $\Pi(\delta)$. In this case, the left-hand side of equation (4) needs to be modified accordingly.

¹⁵Asymmetric information may affect the value δ_c as investors may no longer be ready to pay the amount $\Pi(\delta)$. The analysis of its ultimate impact largely depends on the source of asymmetric information (e.g., E 's ability to manage the venture or the actual value of δ). For instance, if M is more informed about the true value of δ than investors, M may benefit from a lower acquisition price (we abstract from signaling issues); this in turn would make a TS more likely.

Lemma 2 *The first-best level of innovation is given by $\delta_{fb} = d - 2b/\mu$. The level of innovation that maximizes monetary gains only is equal to d .*

Proof: For the first-best, simply solve the maximization problem in (6) for δ . This yields a unique maximum. In the case of maximizing monetary gains only, solve equation (6) without private benefits. \square

Since the entrepreneur's private benefits are not taken into account by VC at the exit stage, this first-best outcome will not always be chosen by E .

Effect of Contracts on Level of Innovation: We can now solve for the optimal δ in the question at hand. Suppose for a moment that F is very high so that $\delta_c = 0$ (this is just another way to say that we first look at the case where δ_c is not binding so that IPO is always the preferred choice of VC ; cf. Lemma 1). The entrepreneur would then get the control benefits for sure in case of successful innovation. For given values of α and D , the entrepreneur will set δ in stage 2 as follows, denoted by δ^* :

$$\delta^*(\alpha, D) = d - \frac{2b}{\alpha\mu} + \frac{2D}{\mu} \quad (7)$$

Equation (7) is the outcome of E 's first-order condition with respect to δ . Including some debt-like claims increases the optimal choice of δ . This induces E to increase monetary profits because of limited liability. Issuing more equity (i.e., reducing α) has the opposite effect on δ , since it reduces the portion of the monetary gains the entrepreneur will get in case of innovation. She will therefore put more weight on the control benefits. This induces E to choose less innovation in order to increase the probability of success.

Equation (7) also shows the impact of debt-like securities. For pure-equity finance, the entrepreneur would choose a level of innovation that is too low compared to the first-best as she trades off her private benefits with monetary gains. A low level of innovation results in a greater probability of innovating and thus to obtain the private benefits. The first-best level of innovation is never achieved.

Consider now the more general case in which $\delta_c \geq 0$. To simplify the notation, let us denote E 's expected profits as a function of the choice of δ and whether she will get private benefits in the event of successful innovation: $\Pi_e(\delta, B)$. Given a contract signed in stage 1, the entrepreneur's optimal choice of δ then is:

$$\begin{cases} \delta^* & \text{if } \delta_c \leq \delta^* \\ \delta_c & \text{if } \delta_c > \delta^* \text{ and } \Pi_e(\delta_c, b) \geq \Pi_e(d + 2D/\mu, 0) \\ d + \frac{2D}{\mu} & \text{if } \delta_c > \delta^* \text{ and } \Pi_e(\delta_c, b) < \Pi_e(d + 2D/\mu, 0) \end{cases} \quad (8)$$

The if-conditions determine the relevant parameter values of possible financial contracts. The first condition, $\delta_c \leq \delta^*$, ensures that the venture capitalist will prefer an IPO in case of successful innovation. When $\delta_c > \delta^*$, an IPO cannot be achieved by the entrepreneur anymore with δ^* . She needs to choose either δ_c or give up her private benefits (in which case $d + 2D/\mu$ is optimal). The second condition, $\Pi_e(\delta_c, b) \geq \Pi_e(d + 2D/\mu, 0)$, compares expected profits of the entrepreneur under the independence bias with the case where she abandons her control benefits. If the former profit level is higher, she will set the innovation level at δ_c , otherwise at $d + 2D/\mu$. Figure 3 shows the two conditions graphically for $\delta_c > \delta^*$. Above the bold line, E gets sufficient monetary compensation and thus is willing to give up her private benefits. Below the bold line, the opposite occurs; E will take excessive risk by adopting a higher innovation level relative to δ^* .

Contracts: In stage 1, contract design is also influenced by the level of δ_c . Proposition 1 summarizes conditions under which the first-best outcome can be achieved using debt-equity contracts.

Proposition 1 *Whenever $\delta_{fb} \geq \delta_c$, the first-best δ_{fb} is achieved, and there is a unique optimal financial linear contract that combines senior (debt-like) claims (D_{fb}) and equity (α_{fb}):*

$$D_{fb} = \frac{I}{p(\delta_{fb}) \cdot [\Pi(\delta_{fb}) + b] - I} \cdot b \quad \text{and} \quad \alpha_{fb} = 1 - \frac{I}{p(\delta_{fb}) \cdot [\Pi(\delta_{fb}) + b]}$$

Proof: See Part II of the Appendix.

This implies that pure-equity contracts are never optimal whenever $\delta_{fb} \geq \delta_c$, unless the entrepreneur enjoys no private benefits. By introducing debt-like securities for the investor (which is then senior to common equity), the entrepreneur is forced to take more risk in order to obtain some monetary gains from the innovation.

Since Proposition 1 requires $\delta_{fb} \geq \delta_c$, achieving the first-best is more likely when b is sufficiently low, and F , d or consumer heterogeneity sufficiently high. In any other case, the first-best cannot be achieved, and E needs to choose δ_c to get any private benefits. Anticipating this, VC will require equity that satisfies his participation constraint: $p(\delta_c) \cdot (1 - \alpha) \Pi(\delta_c) - I = 0$.¹⁶ The optimal level of innovation when E abandons her private benefits (i.e., the level d – see Lemma 2) is achieved with $D = 0$. In this case, the equilibrium level of α is determined by VC 's participation constraint: $p(d) \cdot (1 - \alpha) \Pi(d) - I = 0$.

¹⁶Here, one type of security is sufficient. In principle, some debt-type claims can be issued, since E will choose δ_c in this configuration. The upper bound for the debt level is given by the condition $\delta_c \geq d + 2D/\mu$. This non-uniqueness stems from the fact that b creates a discontinuity in E 's choice of δ .

To determine the equilibrium outcome, we need to examine the intersection between these last two cases. For pure-equity contracts, it requires:

$$\alpha \cdot [p(d)\Pi(d) - p(\delta_c)\Pi(\delta_c)] \leq p(\delta_c)b \quad (9)$$

The left-hand side of this condition gives the additional monetary gains for the entrepreneur when giving up her private benefits (and thus chooses d); the right-hand side represents the expected value of her private benefits when distorting innovation strategy. If the entrepreneur can retain more than this proportion of the shares, she will set the innovation level to d . The venture capitalist will exit through a TS. Otherwise, if condition (9) is met, the innovation outcome is δ_c and exit occurs through an IPO.

Expected Exit routes: We can now derive predictions from an ex ante perspective. Given optimal contracts, a trade sale occurs only if the losses in expected monetary profits from the distortion are greater than the expected value of E 's private benefits at δ_c . Proposition 2 summarizes the results of this analysis in terms of the exit strategy in optimal contracts:

Proposition 2 Denote $\bar{\delta} \equiv d + \sqrt{\frac{b}{p(d)\Pi(d)-I}}$. From an ex ante perspective, an IPO is expected to occur in equilibrium if $\delta_c \leq \bar{\delta}$; otherwise, the venture capitalist expects to exit through a trade sale.

Proof: We need to solve equation (9) with $\alpha = 1 - I/[p(d)\Pi(d)]$. See Part III of the Appendix.

The term $\sqrt{\frac{b}{p(d)\Pi(d)-I}}$ represents the effect of the independence bias from an ex ante point of view. It is the ratio of private benefits over the venture's net present value at the profit-maximizing innovation level d . The first term d is the threshold value for which the venture capitalist favors an IPO. Figure 4 shows that, in equilibrium, three different cases need to be considered separately. The level δ_c can be situated either to the left of δ_{fb} (Case A), between δ_{fb} and $\bar{\delta}$ (Case B), or to the right of $\bar{\delta}$ (Case C). In Case A, E will receive b with certainty if she is successful. δ_{fb} is therefore optimal. In Case B, it is not worth choosing δ_{fb} , since this would no longer lead to an IPO. Thus, E will set the level of innovation at the corner solution δ_c ; this is the lowest level of δ for which she can still remain independent in case of successful R&D. In Case C, the threshold level δ_c is now too high, so that E will have to take too much risk to remain independent. Here the entrepreneur is ready to give up independence, and chooses instead to maximize monetary gains only. Therefore, a TS occurs only in Case C.

Corollary 1 states the comparative static results from Proposition 2 with respect to product market characteristics:

Corollary 1 *From an ex ante perspective, the likelihood of an IPO increases with the private benefits of the entrepreneur (b), the inefficiency of a TS (F), and the riskiness of the project (d).*

Note that greater consumer heterogeneity (the difference $\bar{\theta} - \underline{\theta}$) has an ambiguous effect. On the one hand, it makes an IPO more likely in that it weakens competition in the product market, and thus reduces δ_c ; on the other hand, it also makes the venture more valuable in the case of innovation, which in turn induces E to put a greater weight on monetary gains. The overall ex ante impact on IPO then depends on which effect predominates.

Equilibrium Level of Innovation: Proposition 3 summarizes findings on the equilibrium depth of innovation as a function of the threshold δ_c :

Proposition 3 *In equilibrium, the entrepreneur will choose levels of innovation that may differ from the first-best value as follows:*

$$\begin{cases} \delta_{fb} & \text{if } \delta_c \leq \delta_{fb} \\ \delta_c & \text{if } \delta_{fb} < \delta_c \leq \bar{\delta} \\ d & \text{if } \delta_c > \bar{\delta} \end{cases} \quad (\text{see Proposition 1})$$

Proof: See Part IV of the Appendix.

The threshold $\bar{\delta}$ was derived in Proposition 2 and defined the level of innovation above which we expect an IPO to occur in case of successful innovation. The exit stage generates uncertainty for the entrepreneur about the future control of the firm. This in turn provides her with incentives to favor business and R&D strategies that induce the venture capitalist to bring the venture public. Proposition 3 shows that the level of innovation exhibits an inverse U-shaped pattern. When the likelihood of a TS is low (low δ_c), the entrepreneur chooses the first-best level of innovation. But as the acquisition threshold becomes larger, the entrepreneur distorts the level of innovation and chooses an excessively high level. As the threat of a TS becomes significant (very high δ_c), E eventually gives up her control benefits and again chooses a lower δ .

An important source of this distortion is the fact that VC retains the exit rights. If exit rights are instead retained by the entrepreneur, the distortion may at times be reduced as long as VC can force E to take a decision (i.e., make an exit possible for VC through either an IPO or a TS). However, the distortion will not entirely disappear since the incumbent firm can acquire the venture once public by buying all shares not held by the entrepreneur. If this is more than 50% of all outstanding shares, the ultimate market structure is the same as under a trade sale. We leave this discussion for Section 5.2 where we consider the optimal allocation of exit rights.

Product Market Structure: The different levels of innovation are all function of the product market parameters introduced earlier on. Therefore, we can generate predictions with respect to these market variables. First, an increase in consumer heterogeneity reduces the degree of competition between participating firms and thus reduces the threshold level δ_c . It also increases δ_{fb} . Thus, achieving the first-best outcome where the entrepreneur can enjoy her private benefits is more likely. Second, higher costs F make the achievement of first-best and an IPO also more likely, again since it leads to higher acquisition costs (thus, a lower threshold level of δ_c). Third, and less surprising, IPOs are more likely when control benefits are important, since the independence bias is more worthwhile for the entrepreneur. Some of these effects are presented in Figure 5.

In terms of valuation, recall that profit maximization occurs at a level of innovation of d . Private benefits reduce expected valuations, since the innovation outcome is more likely to be away from the pure profit maximization outcome. However, this only holds for IPOs, not trade sales. Fund returns are not affected by trade sale candidates. Realized valuation however is different, since any venture with a level of innovation greater than δ_c is more likely to go public and also more profitable. Unsuccessful ventures, on the other hand, are liquidated.

Moreover, an increase in private benefits of control may lead to an increased variation in innovation levels. First, it reduces δ_{fb} , which leads to a reduced level of innovation in the unconstrained situations (as described in Proposition 1). And second, it increases $\bar{\delta}$, the threshold level at which the entrepreneur is ready to give up her private benefits, since greater benefits requires larger compensations. Thus, distortions away from the profit-maximizing level of innovation increases in both directions, leading to increased variability of innovation in a cross-sectional perspective.

5 Extensions and Robustness

In this section, we present some extensions. We also discuss the robustness of some modeling assumptions.

5.1 Market Power of Venture Capitalist

Here, we next investigate to which extent our results rely on the assumptions imposed on bargaining power. In reality, the venture capitalist has important bargaining power vis-à-vis the entrepreneur. Hsu (2004), for example, evidences that reputation provides venture capitalists with substantial power. Herewith, we now assume for sake of argument that VC has all the bargaining power in

stage 1 and examine the effect on the level of innovation and the independence bias.¹⁷

In this case, the minimum that E can achieve is $p(\delta_c)b$ if VC decided to provide no monetary payoff at all (i.e., $\alpha = D = 0$), since in this case E 's best strategy is to choose δ_c . To avoid this outcome, VC has to set the financial contract so that the entrepreneur is at least compensated for this "deviation payoff".

Proposition 4 *Denote by $\tilde{\delta}$ the level of innovation for which VC is indifferent between compensating E and accepting that E distorts. In equilibrium, the entrepreneur will choose the following levels of innovation:*

$$\begin{cases} d & \text{if } \delta_c \leq d \\ \delta_c & \text{if } d < \delta_c \leq \tilde{\delta} \\ d & \text{if } \delta_c > \tilde{\delta} \end{cases}$$

Proof: See Part V of the Appendix.

A few points are worth being noted. First of all, VC now has a control device to affect E 's choice of innovation level. Whenever $d \geq \delta_c$, he is able to induce the pure profit -maximizing innovation level (i.e., d) by using a specific financial structure. This requires to set equation (7) (i.e., $\delta^* = d - 2b/\alpha\mu + 2D/\mu$) to the level d . But whenever $d < \delta_c$, a distortion may again arise in the level of innovation, since VC does not always want to compensate E for her deviation payoff. This occurs when the distortion is not too costly to VC . Second, the first-best value δ_{fb} is then never achieved, since E is given the incentives to choose the level of innovation that maximizes expected payoffs (when δ_c is not binding) and not δ_{fb} . Overall, this implies higher exit valuations. However, the independence bias remains. This means that the entrepreneur will continue to trade-off her private benefits with venture returns when $\delta_c > d$ but not too much.

5.2 Allocation of Exit Rights

So far, we excluded exit rights as contractible variable. They were exogenously allocated to the venture capitalist so that the latter could make the exit decision based on pure profit maximization. In this subsection, we endogenize the allocation of exit rights by including them in the initial contract. To keep the discussion simple, let us suppose that the incumbent can compensate the entrepreneur for her private benefits separately from the cash flow rights. This will avoid dealing with renegotiation ex

¹⁷This scenario is similar to a situation in which the entrepreneur is employed by the incumbent firm (but where choosing the level of innovation remains at the discretion of the entrepreneur) and for which the innovative product is spun-off as a separate unit if highly innovative so as to avoid inefficiency costs F . This would be consistent with findings by Allen et al. (1995) and Veld et Veld-Merkoulova (2006) on corporate spin-offs.

post between VC and E (which would lead to exactly the same outcome as making this simplifying assumption).

By giving away exit rights, the venture capitalist will require more cash flow rights in situations where otherwise the entrepreneur would opt for an IPO while VC would prefer a TS. In any case, VC will retain exit rights when $p(\delta_{fb})\Pi(\delta_{fb}) < I$ but $p(d)\Pi(d) > I$, since then E cannot compensate him enough with additional shares. VC would not provide finance anymore if E were to retain exit rights in these cases.

However, this is not the end of the story, since the incumbent may well take control over the venture under an IPO by buying enough shares on the secondary market after the IPO. By offering the amount $(1 - \alpha)\Pi$, M is able to acquire all shares that are not held by the entrepreneur.¹⁸ This in turn allows the incumbent to take control over the venture if the entrepreneur holds less than 50% of the outstanding shares after the IPO. Since the entrepreneur then loses control, she will lose her control benefits and thus will also be ready to sell her own shares for the amount $\alpha\Pi$. Therefore, it is not enough to leave exit rights to the entrepreneur, the latter must also be able to retain the majority after the IPO. Thus, it is only optimal to allocate exit rights to the entrepreneur as long as $p(\delta_{fb})\Pi(\delta_{fb}) \geq I$ and the entrepreneur holds less than 50% of the outstanding shares after the IPO.¹⁹ Note that this is not needed when VC holds the control rights, since M would not want to acquire the venture on the secondary market under the decision rule derived in Lemma 1, since costs F makes it not worthwhile.

The first-best outcome requires that E either obtains her private benefits through an IPO or is compensated for it under a trade sale by the incumbent. The next proposition summarizes the optimal outcomes when the allocation of exit rights is endogenous.

Proposition 5 *Denote $\delta_c^E = (Y - F - b) / (X - Y)$. Achieving first-best requires an IPO exit for any $\delta \geq \delta_c^E$. This can be achieved if, first, exit rights are given to the entrepreneur, and second, provided she holds the majority of shares after the IPO. Otherwise, the independence bias remains.*

Proposition 5 implies that achieving the first-best outcome is more likely when control rights can

¹⁸Here, α stands for the fraction of shares held by the entrepreneur after the IPO.

¹⁹Typically, shares other than common shares are automatically converted prior to an IPO (Hellmann, 2006), primarily as a way to clean up the balance sheet. This means that the true condition is not whether $\alpha_{fb} > 1/2$ but (as pointed out in the text) that the entrepreneur holds more than 50% of outstanding shares after the IPO. To calculate the fraction of shares retained by the entrepreneur after conversion of D by the venture capitalist, the following condition must hold (i.e., so that VC is fully compensated): $(1 - \alpha_{prior})\Pi + D = (1 - \alpha_{new})\Pi$, where α_{prior} (α_{new}) denotes the fraction of shares held by the entrepreneur just prior (after) to the conversion. This yields: $\alpha_{new} = \alpha_{prior} - D/\Pi$.

be allocated endogenously, since the first-best is achieved more often. As a result, IPO as exit route is also more likely. The critical situations are between δ_c^E and δ_c , since then VC and E disagree on the exit route to adopt. If the entrepreneur holds the control rights and majority in the venture after the public listing, she will prefer an IPO and thus retains her private benefits. Moreover, within this parameter range, the incumbent is not ready to compensate the entrepreneur for b . In any other cases, the allocation of control rights is irrelevant.²⁰ It also means that allocating control rights to the entrepreneur is optimal only if expected returns of the venture are sufficiently high so that she retains substantial fractions of cash flow rights after financing. Otherwise, the entrepreneur is unlikely to retain majority control after the IPO. In this case, she will again trade-off her private benefits with monetary costs from distorting. Therefore, the independence bias does not vanish completely.

Another interesting contracting environment to analyze is when E is compensated for the loss of private benefits under a TS. This makes sense because it drives the independence bias. The problem of such compensation is that joint profits of E and VC are different whether exit occurs through an IPO or a TS. Since joint profits amount to only Π under a TS (while under an IPO they are $\Pi + b$), δ_{fb} is optimal only under an IPO. Furthermore, because VC would have to disburse the amount b under a TS, he would also require more cash flow rights in stage 1 if a TS is anticipated. Thus, such a compensation scheme would not yield the first-best.

5.3 Competition in Contestable Markets

For the market game studied so far, we can also analyze the outcome in terms of exit route (Lemma 1) if M faces competition in the product market from firms other than the entrepreneur. We introduce competition as constraints imposed on M in setting the price of its low-quality product. Following Baumol et al. (1982), we introduce competition using the contestable markets model. A market is contestable if another firm can set the price below the one of a monopolist and earn positive profits in equilibrium. More specifically, assume these other firms may produce the same good with quality

²⁰ Although we do not explicitly model that, this reasoning works only when the venture capitalist does not need the cooperation of the entrepreneur for a successful IPO. Whenever E does not care about exit (for which she typically needs to exert some effort), VC may not be able to exit properly. For instance, assume both parties need to exert some non-verifiable effort in order to make an IPO possible. The entrepreneur typically needs to do the road shows, while the venture capitalist builds the syndicate and prepares the IPO (this requires using VC 's personal contacts to certify the quality of the venture). Then, whenever there is a disagreement on the exit route, one party always has the incentive not to exert the required effort. If the level of innovation is below δ_c , VC has no incentive to exert the needed effort since he prefers a TS; E , however, would prefer an IPO. If the depth of innovation is larger than δ_c , both parties are ready to exert effort since an IPO yields highest valuation and provides E with private benefits. A similar argument applies when ceding control rights to E involves transaction costs.

level s but at marginal cost $c > 0$. Since M 's marginal cost is set to zero, this parameter measures the difference in costs with these competing firms. Thus, M now cannot set the price above c . We originally assumed M 's equilibrium price was unconstrained; additional competition was therefore irrelevant. Now we consider that c is sufficiently small so that M is forced to set the price of the low-quality good at c in order to retain demand. The degree of competition is therefore not directly measured by the number of incumbents but rather by the competitive pressure faced by M .

The following proposition summarizes the results:

Proposition 6 *In more contestable product markets, exit through an IPO is more likely.*

In Part VI of the Appendix, we derive the optimal exit decision and show that the results stated in Lemma 1 still hold. Furthermore, the threshold value of δ for an IPO to occur declines with the degree of competitive pressure. An IPO is therefore more likely in a competitive market. Gains stemmed from avoiding entry vanish as the product market becomes more competitive. Greater competitive pressure makes M less able to benefit from freely setting the price of the high-quality product after a trade sale.

5.4 Entry Game

Here we present a different product market setting. We examine a simple entry game in which entry is unprofitable unless the entrepreneur innovates. Entry costs are denoted by $A > 0$. Innovation gives the entrepreneur access to the market with reduced entry costs by the proportion δ ; i.e., E then has entry costs $A(1 - \delta)$.²¹ The incumbent generates profits $\bar{\pi} > 0$ if it retains its monopoly position. When the entrepreneur enters as a stand-alone firm, profits of both firms are π , where $\bar{\pi} > 2\pi > 0$.²² For a given level of innovation, the payoff of the entrepreneur's project therefore is $\Pi(\delta) = \pi - A(1 - \delta)$. For simplicity, we impose the constraint $A = \pi$ (this only simplifies the analysis, since it avoids carrying through the analysis a threshold level of δ for which entry becomes profitable – under this condition, it is profitable whenever $\delta > 0$).²³ At the same time, this constraint implies that no entry takes place without innovation. Note A is incurred by the entrepreneur at

²¹Here, entry costs are related to costs that either M has already sunk or that involve expenses that any new market participant would have to incur. An example would be the development of a distinctive distribution network to access costumers. Since M is already in the market, these costs are sunk so that they do not need to be incurred another time.

²²The type of competition does not matter here. For instance, these profit levels could be derived from a Cournot equilibrium setting.

²³For sake of simplicity, we do not explicitly show the boundary conditions implied by the fact that δ can only take valued between zero and one. However, this is available upon request.

$t = 3$ in case of entry into the product market. Thus, if δ is high, entry costs are low, implying a high price for acquiring the entrant.

It is straightforward to show that previous results qualitatively hold.

Proposition 7 *Conditional on innovating, an IPO will take place whenever $\delta \geq 1 + [\bar{\pi} - F - 2\pi] / A$.*

This implies that if the entrepreneur innovates, an IPO is more likely if realized innovation is sufficiently high so that a large fraction of entry costs are eliminated. We therefore obtain qualitatively similar results in terms of choice of exit route as for the market structure of quality differentiation examined as benchmark case. There is a threshold level for three reasons. The first reason is inefficiency of a trade sale. As F increases, a TS becomes more costly. The second one is the entry cost, which makes entry less profitable to the entrepreneur. The acquisition price is then lower. Finally, the third one is the “business-stealing” effect in case of entry. The greater the loss for the incumbent, the more likely an acquisition. In other words, an increase in total acquisition gains makes a TS more profitable.

6 Empirical Implications

As pointed out earlier, the independence bias discussed here is particularly important for venture capital as there the exit stage is part of the financing process. This in turn affects the kind of empirical studies that can be used to relate to this work, since the more conventional studies on the decision to go public does not directly apply here. In these studies, remaining private is the primary alternative to an IPO, while for venture capital finance the primary alternative is a trade sale. In fact, remaining private is hardly an option once the venture capitalist aims at exiting.

Moreover, the discussion on different product market outcomes as result of different innovation levels highlights the need for clearly controlling for product market characteristics when examining the potential link between innovation and choice of exit route, especially when considering the full spectrum of exit routes. Most of the existing empirical studies has only considered its impact on the likelihood of going public, and only few controls for product market structure have been considered (one study is the one by Hellmann and Puri, 2000, but it does not focus on exit choice). This paper provides some guidelines for such examinations. One variable is the degree of consumer heterogeneity that affects the degree of competition and thereby ultimately the gains from acquisitions. It requires taking into account variations in consumer characteristics, e.g., the relative importance of different types of consumers (like the ratio of business to leisure costumers). An illustrative example for this approach is by Borenstein and Rose (1994), who examine the airline industry. Our empirical

predictions with respect of market structure would however require a cross-industry analysis, taking into account heterogeneity in consumer characteristics across industries. Our ex post analysis predicts more IPOs in markets with greater consumer heterogeneity.

Two sets of empirical implications arise out of this analysis. The first one stems from the ex post outcome summarized in Lemma 1, the second one arises from the ex ante analysis. This leads to empirical implications for any analysis at the investment stage while the ex post analysis deals with empirical implications for the exit stage. Note that the ex ante result on exit strategy is not about IPO versus TS but about IPO versus everything else, including liquidation.

Ex post (i.e., in case of successful innovation), the depth of innovation of a venture is expected to be positively correlated with its likelihood of going public. As mentioned in the Introduction, this relationship has been evidenced in various empirical papers, and our analysis provides a possible rationale for these findings. Greater innovation implies higher realized profits due to greater product differentiation with the incumbent's product, which in turn makes an IPO more likely. While the trade-off on the choice of innovation depth described in this paper implies a positive link between innovation and profitability ex post in case of success (see Lemma 1), ex ante it is not since there is a trade-off between innovation and probability of success. This leads to an inverse U-shaped relationship between "pursued" innovation strategy and expected profitability.

Admittedly, there is no exact measure for degree of innovation, but several authors have tried to examine this relationship using different original proxies; see, e.g., Hellmann and Puri (2000), Kortum and Lerner (2000) and Darby and Zucker (2002). For venture-backed firms, they evidence a positive relation between innovation and success, arguing that this is a result of the active involvement of venture capitalists in their portfolio companies.

Alternatively, since ex post the value of the venture is also innovation-driven, we expect the return on venture capital investments to be positively correlated with the decision to go public.²⁴ Gompers (1995), Cochrane (2001), Darby and Zucker (2002), and Cumming and MacIntosh (2003) provide empirical evidence for such a relationship. Our analysis provides a possible rationale for these findings. The analysis predicts that IPOs are more likely in markets with greater consumer heterogeneity. To our knowledge, these empirical predictions have not been tested so far and have not been derived either by any other theory. The closed related analyses generating similar predictions is by Dewatripont and Tirole (1994) and Bascha and Walz (2001). However, none of these papers introduce product market variables so that the value of the innovation is largely exogenous. The first

²⁴ A further empirical prediction of the analysis is the following: the likelihood that a venture will go public is expected to be negatively affected by the incumbent's R&D expenditures. The more the incumbent innovates, the higher the required threshold level for the newcomer to achieve an IPO (since what matters is the difference in product qualities, which is expressed by δ).

is based on incomplete contracting and threats to managerial interests (which forces the entrepreneur to work hard), while the second on reputational gains for the venture capitalist that are assumed to increase with the venture's return.

Moreover, we should expect that the likelihood of going public increases with the inefficiency costs of a trade sale. These costs may arise for a number of reasons, as pointed out in Section 3.3. First, it is likely to be positively related to the ratio of intangible assets to total assets in the venture. Asset intangibility may be one essential source of inefficiency as it makes the transfer of technology more difficult and thus costly. This ratio should be greatest for high-tech companies, since they typically have the highest fraction of asset intangibility. This is very much in line with findings by Darby and Zucker (2002), who show that a main driver for going public is the quality of human capital (measured by the quality of the company's star researchers). Furthermore, findings by Allen et al. (1995) lead to the conclusion that inefficiency of a trade sale is further enhanced if the incumbent is highly diversified, since then it becomes more difficult to give the right incentives to the venture's management. An acquirer that is active in many different industries at the same time may have conflicting objectives and may pursue different strategies in each industry. The share price of the diversified acquirer is then not a good performance benchmark. In contrast, a venture that is run as separate entity can provide clear incentives to its management by tying up its managerial compensation to the share price of the venture only.

At the same time, given that the entrepreneur's private benefits lead to less innovation when the threshold for an IPO is low and to more innovation when the threshold is high (due to the independence bias), we should expect higher variance in the level of innovation in countries where private benefits are an important factor for starting a venture. Private benefits have been proxied in a number of studies in various ways; cf. Footnote 1. In particular, Dyck and Zingales (2004) provide cross-country levels of control benefits that could be used for determining countries with high entrepreneurial benefits.

With respect to capital structure, our theoretical analysis conjectures that the use of debt-type claims (such as (convertible) preferred equity) is associated with more IPOs. This is to account for the effect of private benefits on the innovation incentives of the entrepreneur. When she does not expect any private benefit of control (and thus a TS), it is optimal to use equity only in order to avoid any risk-shifting behavior by the entrepreneur.

7 Conclusion

A specificity of venture capital finance is the exit stage of investors once their active involvement is not needed anymore. Venture capitalists typically retain important control rights regarding choice and timing of exit. The aim of this research was to incorporate the level of innovation in the analysis of the exit decision, and take it into account in the financial contracting between the venture capitalist and the entrepreneur. In doing so, the shape of the entrepreneurial firm becomes endogenous, and the paper examines how it is affected by the exit decision of the venture capitalist as well as the level of innovation. It is first shown that more innovative and profitable ventures are more likely to go public than ventures with more imitative or derivative projects. The model presented also provides a possible explanation for why in practice we observe both types of exit route.

The decision concerning the exit route can induce an agency problem when the entrepreneur receives private benefits from remaining independent after the exit of the venture capitalist. This exit stage produces uncertainty for the entrepreneur about the future control of the firm, which in turn provides the entrepreneur incentives to favor business and R&D strategies that make an IPO more likely. This will lead to riskier strategies aiming at excessive innovation.

Finally, this research contributes to the literature that links product and financial markets. It analyzes some particularities of the venture capital market, namely the exit of the venture capitalist and its effect on financing. The fact that venture capitalists want to sell their shares after the R&D stage affects innovation and product market outcomes.

8 Appendix

Part I: Product Market Outcomes in the Vertical Product Differentiation Game

We compute two different outcomes: (1) profit of M in case of a TS; and (2) profits of M and E in case of an IPO. Solving the two last cases allows one to derive the exit condition expressed by equation (4).

(1) In case of a TS, the aggregated profit of the incumbent (to avoid inefficiency, here we do not impose the covered market assumption) is (with denoting Π^a this level of profit for M)

$$\Pi_a = P_2[\bar{\theta} - \tilde{\theta}] + P_1[\tilde{\theta} - \theta_c]$$

with $\tilde{\theta} = (P_2 - P_1) / (s\delta)$ and $\theta_c = P_1/s$. 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. $\tilde{\theta}$ gives the marginal utility of the indifferent consumer (that is, the one that is indifferent between buying from M and the innovative entrant);²⁵ θ_c is derived from the condition $U(\theta_c) \geq 0$ and 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 (i.e., the condition $U(\theta_c) = 0$). All the consumers with higher marginal utility buy for sure, while consumers with $\theta < \theta_c$ do not buy. By construction, we require $\theta_c \geq \underline{\theta}$. Deriving the first-order conditions for both prices yield: $P_1 = P_2 / (\delta + 1)$ and $P_2 = P_1 + \frac{1}{2}\bar{\theta}s\delta$. Thus, the equilibrium prices are $P_1^* = \frac{1}{2}\bar{\theta}s$ and $P_2^* = \frac{1}{2}\bar{\theta}s(\delta + 1)$ with demands $D_1 = 0$ and $D_2 = \frac{1}{2}\bar{\theta}$ respectively. This implies that in equilibrium the incumbent will stop producing its former 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 $\tilde{\theta}$). To compensate, M will have to lower P_2 . At equilibrium: $\Pi^a = \frac{1}{4}\bar{\theta}^2 s(\delta + 1)$.

(2) In case of an IPO, let us denote by index 1 the incumbent and the entrant by index 2. 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 $D_1 = \tilde{\theta} - \underline{\theta}$ and $D_2 = \bar{\theta} - \tilde{\theta}$, respectively. Their maximization problems are the following:

$$\begin{aligned} \max_{P_1} \quad & P_1 \cdot (\tilde{\theta} - \underline{\theta}) && \text{for the } M \\ \max_{P_2} \quad & P_2 \cdot (\bar{\theta} - \tilde{\theta}) && \text{for the entrant.} \end{aligned}$$

with again $\tilde{\theta}(P_1, P_2) = (P_2 - P_1) / (s\delta)$. This yields:

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

²⁵This is derived by solving the following condition: $U(s(\delta + 1), P_2) = U(s, P_1)$.

We now have all the profit levels at equilibrium needed for equation (4). Since the reservation value of consumers was normalized to zero, we limit ourself to δ_{\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 $U(\tilde{\theta}) = \tilde{\theta}s(\delta + 1) - P_2 \geq 0$). This is required from the covered market assumption, and defines $\delta_{\max} \equiv 3\underline{\theta}/[\bar{\theta} - 2\underline{\theta}]$.

Part II: Proof of Proposition 1

In this proposition, we only consider cases in which E is certain to obtain her private benefits. In stage 2, she then chooses the depth of innovation that maximizes Π_e given a financial contract:

$$\delta^* \in \arg \max \left\{ p(\delta) \cdot [\alpha(\Pi(\delta) - D) + b] \right\}$$

subject to $0 \leq D \leq \Pi(\delta)$ and $0 \leq \alpha \leq 1$. This yields: $\delta^* = d - \frac{2b}{\alpha\mu} + \frac{2D}{\mu}$ (equation (7)). In stage 2, the entrepreneur offers to VC a take-it-or-leave-it contract that makes his participation constraint binding:

$$(\alpha_{fb}, D_{fb}) \in \arg \max \left\{ \Pi_e(\delta^*(\alpha, D), \alpha, D) \right\} \quad \text{subject to } \Pi_{vc}(\delta^*(\alpha, D), \alpha, D) \geq 0$$

The Lagrangian function is

$$\mathcal{L}(\alpha, D, \lambda) = p(\delta^*(\alpha, D)) \cdot \left[\alpha(\Pi(\delta^*(\alpha, D)) - D) + b \right] + \lambda \left[\Pi_{vc}(\delta^*(\alpha, D), \alpha, D) \right]$$

with λ as the Lagrangian multiplier. The first two first-order conditions, $\partial \mathcal{L} / \partial \alpha = 0$ and $\partial \mathcal{L} / \partial D = 0$, yield the conditions $D = b(1 - \alpha) / \alpha$, while $\partial \mathcal{L} / \partial \lambda = 0$ gives VC 's binding participation constraint: $p(\delta^*(\alpha, D)) \cdot [(1 - \alpha)(\Pi(\delta^*(\alpha, D)) - D) + D] - I = 0$. Solving for α and D yields α_{fb} and D_{fb} as presented in Proposition 1. Finally, substituting these equilibrium levels of debt-like claims and equity into δ^* leads to δ_{fb} , the first-best depth of innovation. Notice that the feasibility conditions $0 \leq \alpha_{fb} \leq 1$ and $0 \leq D_{fb} \leq \Pi(\delta_{fb})$ are always satisfied if $\delta_{fb} \geq 0$ and the investment is profitable ex ante. \square

Part III: Proof of Proposition 2

Here we solve the more general case in which $\delta_c \geq 0$. In stage 3, VC exits through an IPO if the depth of innovation is greater than δ_c , otherwise through a TS (cf. Lemma 1).

Given a contract signed in stage 1, the entrepreneur's optimal depth of innovation in stage 2 is given by equation (8). There are two free parameters in the condition $\Pi_e(d + 2D/\mu) \geq \Pi_e(\delta_c)$, namely F and b , which ensures that both cases are possible if $\delta^* < \delta_c$.

E will deviate from δ^* if $\delta^* < \delta_c$, since she then receives no private benefits anymore when choosing δ^* . To still obtain them, she needs to set the depth of innovation to δ_c . This is optimal for him as long as the expected value of her private benefits under δ_c compensates her for the distortion in expected monetary gains; for a given contract, this is the case when $\Pi_e(\delta_c) \geq \Pi_e(d + 2D/\mu)$. Otherwise, she gives up her private benefits and chooses a depth of innovation of $d + 2D/\mu$.

In stage 1, we derive the optimal contracts subject to VC 's binding participation constraint. Let us consider two cases first: one in which E gets b for sure and one in which she gets no private benefits for sure. The first case yields the outcome studied in Proposition 1, with $\delta^* = \delta_{fb}$ and the capital structure stated in the same Proposition. In the latter case, the optimal choice of innovation depth is $d + 2D/\mu$ and the Lagrangian function to maximize is the following:

$$\mathcal{L}(\alpha, D, \lambda) = p(d + 2D/\mu) \cdot \left[\alpha (\Pi(d + 2D/\mu) - D) \right] + \lambda \left[\Pi_{vc}((d + 2D/\mu), \alpha, D) \right]$$

with λ as the Lagrangian multiplier. The first two first-order conditions, $\partial \mathcal{L} / \partial \alpha = 0$ and $\partial \mathcal{L} / \partial D = 0$, yield the conditions $D = 0$, while $\partial \mathcal{L} / \partial \lambda = 0$ gives VC 's binding participation constraint. Under the constraint $D = 0$, the optimal level of innovation is d and the optimal level of α simply is the solution to $p(d) \cdot [(1 - \alpha)\Pi(d)] = I$.

An additional case remains, namely E may have the incentive to deviate from d and choose to δ_c . This may happen if $\delta_{fb} < \delta_c$ and for the given financial contract, $\Pi_e(d + 2D/\mu) < \Pi_e(\delta_c)$. Anticipating E 's decision, VC will then require equity that satisfies his new participation constraint: $p(\delta_c) \cdot (1 - \alpha) \Pi(\delta_c) - I = 0$; one type of securities is again sufficient. It is straightforward to check that given these contracts, the entrepreneur has no incentive to deviate. Also, if $\delta_c < d + 2D/\mu$, then $\Pi_e(\delta_c) > \Pi_e(d + 2D/\mu)$ for a given contract.

To determine the equilibrium outcome for δ , we need to examine the intersection between these last two cases. Here, we only need to focus on pure-equity contracts. This requires the following condition to be met:

$$\alpha \cdot [p(d)\Pi(d) - p(\delta_c)\Pi(\delta_c)] \leq p(\delta_c)b \quad (10)$$

If the entrepreneur can retain at least this proportion of shares, she will go for d . In contrast, the venture capitalist will expect a proportion of shares equal to $\frac{I}{p(d)\Pi(d)}$ and exit occurs through a TS. Otherwise, the outcome is δ_c and VC will want $\frac{I}{p(\delta_c)\Pi(\delta_c)}$ of the shares.

In equilibrium, a trade sale only occurs if losses in expected monetary profits from distorting are greater than the expected value of her private benefits at δ_c ; i.e.,

$$\left[1 - \frac{I}{p(d)\Pi(d)} \right] \cdot [p(d)\Pi(d) - p(\delta_c)\Pi(\delta_c)] \leq p(\delta_c)b$$

When solving for δ_c , we obtain that an IPO occurs whenever $\delta_c \leq d + \sqrt{\frac{b}{p(d)\Pi(d)-I}}$. \square

Part IV: Proof of Proposition 3

In Proposition 2, we directly derived the equilibrium depth of innovation for all three relevant cases. We also derived $\bar{\delta}$ as the limit condition between Cases B and C. We obtain δ_{fb} in Case A (if $\delta_c \leq \delta_{fb}$); δ_c in Case B (if $\delta_{fb} < \delta_c \leq \bar{\delta}$); and d in Case C (if $\bar{\delta} < \delta_c$). \square

Part V: Proof of Proposition 4

In stage 3, VC 's exit strategy is outlined in Lemma 1. In stage 2, E 's optimal choice of δ is as in Section 4.2. What changes is the financial contract in stage 1, which now puts E on her reservation value. We proceed as in Proposition 2 and distinguish between 3 separate cases: (A) $\delta_c \leq d$, (B) $d < \delta_c \leq \bar{\delta}$, and (C) $\bar{\delta} < \delta_c$, where $\bar{\delta}$ still needs to be derived. Since VC does not gain from E 's private control benefits, he will try to induce the maximization of the venture's expected monetary profits. Thus, in Case A, he will enforce $\delta^* = d$, which requires $D = b/\alpha$. Combined with E 's "deviation payoff" $p(\delta_c)b$, this yields the follow financial structure: $D = p(d) \cdot \Pi(d)/p(\delta_c)$ and $\alpha = \frac{p(\delta_c)b}{p(d) \cdot \Pi(d)}$.

If $d < \delta_c$, this cannot be achieved anymore. E will either choose δ_c if she is not sufficiently compensated, otherwise $d + 2D/\mu$. Thus, VC offers either $D = \alpha = 0$ (in which case E chooses δ_c) or $D_o = 0$ and $\alpha_o = \frac{p(\delta_c)b}{p(d)\Pi(d)-p(\delta_c)\Pi(\delta_c)}$ to achieve d (again, only one type of securities is sufficient). In the latter case (which is Case C), E is exactly compensated for her "deviation payoff" so that she chooses d to maximize the expected value of her shares.

Again, in stage 1 we need to examine the limit between Cases B and C. This is when VC is indifferent between compensating E and providing incentives to E to choose d . This is the case iff $p(\bar{\delta})\Pi(\bar{\delta}) - I = p(d)[(1 - \alpha_o)\Pi(d)] - I$. Solving this condition yields $\bar{\delta}$.

Thus, the "independence bias" does not vanish, since VC does not always find it profitable to compensate E . Thus, the latter will sometimes distort the depth of innovation towards δ_c .

Notice also that whenever $d \geq \delta_c$, the limited liability condition for E is never violated, since $\Pi(d) - D_{vc} = \Pi(d)(1 - p(d)/p(\delta_c)) \geq 0$ and $p(d) \leq p(\delta_c)$. \square

Part VI: Competition with Contestable Markets (Proposition 6)

Assume that a large number of other firms (i.e., at least two) may produce the same good with quality level s but at marginal cost $c > 0$. We consider cases where the following constraint holds $c < P_1^*$; otherwise, the previous analysis holds.

In case of an IPO, in equilibrium $P_1^* = c$ and $P_2^* = \frac{1}{2}[c + \bar{\theta}s\delta]$. Furthermore, $\bar{\theta} = \frac{1}{2}[\bar{\theta} - c/s\delta]$. This yields $\Pi_1 = c[\frac{1}{2}(\bar{\theta} - c/s\delta) - \theta]$ and $\Pi = \frac{1}{4}[c + \bar{\theta}s\delta][\bar{\theta} + c/s\delta]$. Since $P_1^* = \frac{1}{3}(\bar{\theta} - 2\theta)s\delta$,

notice that $c < P_1^*$ requires the following condition to hold: $c < \frac{1}{3} (\bar{\theta} - 2\underline{\theta}) s\delta$; this gives a maximum threshold for c to make the competitive pressure effective.

In case of a trade sale, M maximizes $\Pi^a = P_2[\bar{\theta} - \tilde{\theta}] + P_1[\tilde{\theta} - \theta_c]$, with $\tilde{\theta} = \frac{P_2 - P_1}{s\delta}$ and $\theta_c = P_1/s$. Deriving the first-order conditions for both prices yield $P_1^* = c$ and $P_2^* = c + \frac{1}{2}\bar{\theta}s\delta$ for prices as well as $\tilde{\theta} = \frac{1}{2}\bar{\theta}$ and $\theta_c = \underline{\theta}$ for demand levels. Thus, in equilibrium: $\Pi^a = \frac{1}{2}\bar{\theta} [c + \frac{1}{2}\bar{\theta}s\delta] + c [\frac{1}{2}\bar{\theta} - \underline{\theta}]$.

We can now re-write equation (4) as

$$\underbrace{\frac{1}{2}\bar{\theta} \left[c + \frac{1}{2}\bar{\theta}s\delta \right] + c \left[\frac{1}{2}\bar{\theta} - \underline{\theta} \right] - F}_{\text{profit of the } M \text{ in case of acquisition}} - \underbrace{c \left[\frac{1}{2} (\bar{\theta} - c/s\delta) - \underline{\theta} \right]}_{\text{profit of the } M \text{ in case of no acquisition}} > \frac{1}{4} [c + \bar{\theta}s\delta] [\bar{\theta} + c/s\delta]$$

The condition for a TS is now satisfied for any δ such that $\delta < \delta_c'' \equiv \frac{c^2}{4Fs}$. Notice that $d\delta_c''/dc > 0$. The results stated in Lemma 1 therefore qualitatively still holds and the critical value of δ that makes an IPO more likely is decreasing with the degree of competition.

It remains to be shown that the firms generating the competitive pressure never have an incentive to bid more than M for the entering venture. Their condition for making a bid is:

$$\underbrace{\frac{1}{4} [c + \bar{\theta}s\delta] [\bar{\theta} + c/s\delta] - F}_{\text{in case of acquisition}} - \underbrace{0}_{\text{in case of no acquisition}} > \frac{1}{4} [c + \bar{\theta}s\delta] [\bar{\theta} + c/s\delta]$$

which requires $F < 0$. Thus, they will never bid for the newcomer. \square

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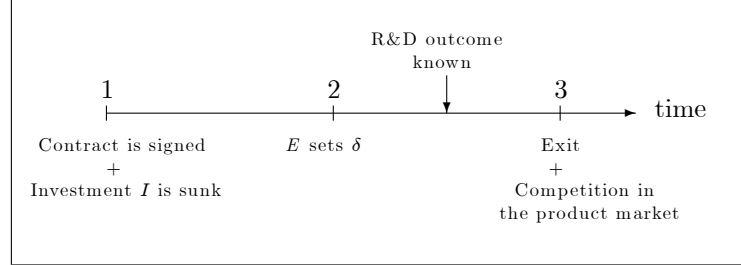


Figure 1: Time line of the game

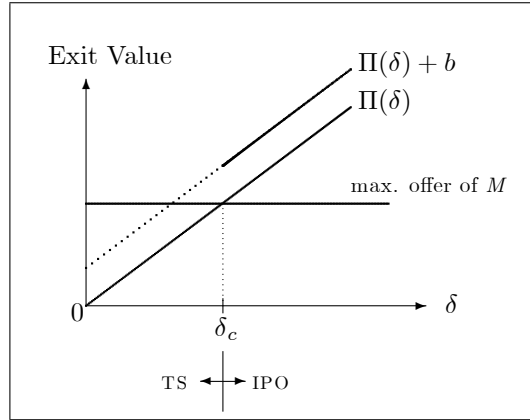


Figure 2: Exit decision of the venture capitalist

Note: Π represents the monetary value of the venture as a stand-alone firm and also the minimum offer that M has to make in a TS. The maximum offer to M is given by the left-hand side of equation (4). To the left of δ_c , M is ready to pay a premium for the acquisition of the venture.

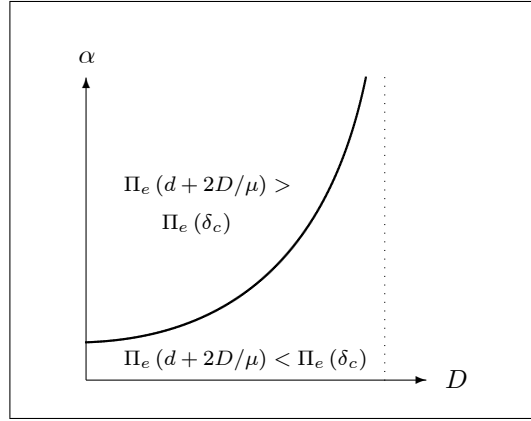


Figure 3: "Independence bias" for a given financial contract when $\delta_c > \delta^*$ (Cases B vs. C)

Note: The bold line shows all pairs (D, α) for which $\Pi_e(\delta_c) = \Pi_e(d + D/\mu)$. Above this convex curve, E sets the depth of innovation to $d + D/\mu$ and VC exits through a TS in case of successful innovation. Below this curve, E chooses δ_c and the venture goes public if it innovates. The dashed line represents the condition $\delta_c = d + D/\mu$; to the right of this vertical line, $\delta_c < d + 2D/\mu$ and thus $\Pi_e(\delta_c) > \Pi_e(d + D/\mu)$ for any given contract (this is shown in Part II of the Appendix). Above the bold line, E sets the depth of innovation to $d + 2D/\mu$; below this line, he chooses δ_c .

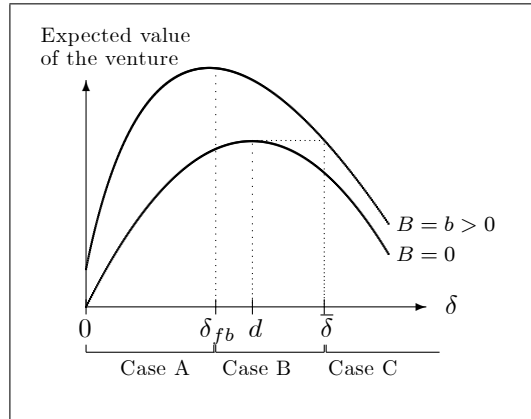


Figure 4: Expected total value of the venture and optimal choice of δ

Note: The upper curve gives the expected value of the venture in equilibrium when taking into account the private benefits of the entrepreneur; its global maximum is denoted δ_{fb} . The lower line is without private benefits.

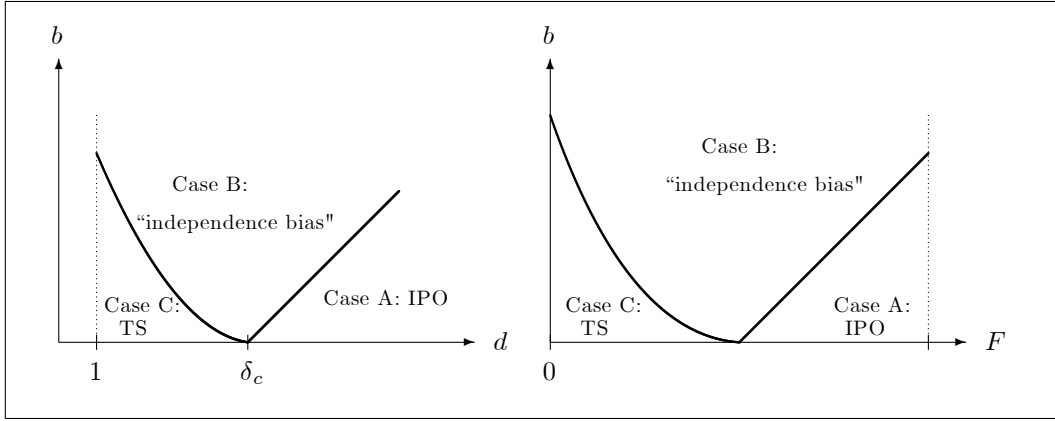


Figure 5: Comparative static analysis

Note: The first panel shows the different combinations of (d, b) leading to the Cases A, B and C. The lines show the intersections between the three cases: the condition $\delta_c = d + 2\sqrt{\frac{b}{p(d)\Pi(d)-I}}$ for Cases B versus C, and $\delta_{fb} = \delta_c$ for Cases A versus B. The second panel presents the different Cases for any combination of (F, b) .