The Organization of the Innovation Industry: Entrepreneurs, Venture Capitalists, and Oligopolists*

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Abstract

The starting point of this paper is that the exit of venture-backed firms often takes place through sales to large incumbent firms. We show that in such an environment, venture-backed firms have a stronger incentive to develop basic innovations into commercialized innovations than incumbent firms, due to strategic product market effects. In turn, this will increase the price for basic innovations, thereby triggering more basic innovations by entrepreneurs. Consequently, the presence of a venture capital market implies that more basic innovations are created and that these become better developed.

Keywords: Acquistions, Entrepreneurship, Innovation, Venture Capital

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1. Introduction

There is a growing awareness of the role played by venture capitalists in the innovation process.[1] They have come to specialize in financing early-stage investment for entrepreneurs and providing business experience.[2] In a study on venture capital and innovation, Kortum and Lerner (2000) find venture-backed firms to be the source of up to 10% of all US industrial innovation, while they only account for 3% of total R&D outlays. Moreover, Hellmann and Puri (2000) find venture capital to be associated with a significant reduction in the time required for bringing a product to the market. This poses the question of why venture-backed firms are more successful than incumbent firms in bringing commercialized innovations to the market.

In the literature, informational advantages, abilities, better monitoring and control have been suggested to explain why venture capitalists are more successful in creating commercialized innovations. In this paper, we add an additional aspect in that the exit of the venture-backed firm often takes place through a sale to a large incumbent firm.[3] [4] We show that in such an environment, venture-backed firms have a stronger incentive

[1] See, for instance, Gompers and Lerner (2001).

[2] Hellmann and Puri (2002) find evidence of US venture capital being related to a variety of professionalization measures, such as human resource policies, the adoption of stock options plans, and the hiring of a marketing VP. Bottazzi, Da Rin and Hellmann (2004) find similar evidence for European venture capital.

[3] For instance, Cochrane (2003) uses data over the period 1987 to June 2000 from the VentureOne database, and shows that 20 % of the ventures were acquired, 21 % were IPOs, 9% went out of business while 49% remained private. This dataset consists of 16,613 financing rounds, with 7765 companies, and a total of $112,613 million raised. In a sample of 248 VC exits, Cumming and MacIntosh (2003) found similar figures.

According to the National Venture Capital Association, there were more exits by acquisition than exits by IPO in six out of the last eight years. One spectacular acquisition was a little know company called Cerent, which was acquired by Cisco for $6.9 billion. See Hellmann (2004).

[4] Granstrand and Sjölander (1990) present evidence from Sweden, and Hall (1990) evidence from the US that firms acquire innovative targets to gain access to their technologies. More recently, Bloningen and

to develop basic innovations into commercialized innovations than incumbent firms, due to strategic product market effects on the acquisition price. In turn, this will increase the price for basic innovations, thereby triggering more such innovations by entrepreneurs. Consequently, the presence of a venture capital market implies that more basic innovations are created and better developed.

We consider a market served by several incumbent firms competing in oligopoly fashion. In the initial stage of the interaction, there is an entrepreneur investing in an innovative activity that might lead to the creation of a *basic innovation*, which may be a prototype, a product or a production process, which is novel but requires additional development for commercial use. In the second stage, the entrepreneur may sell the basic innovation to one of the incumbent firms. Alternatively, the entrepreneur can seek support from one among several venture capitalists competing to provide expertise and financial support to develop the basic innovation. To focus on product market effects as a determinant of the ownership of the basic innovation, we model the sale of the basic innovation as a first-price perfect information auction, where incumbent firms and venture capitalists bid for the basic innovation.

If the entrepreneur "sells" the basic innovation to a venture capitalist, the venture-backed firm invests in the development of the basic innovation, where further development will increase the possessor's profit, but decrease the profits of the rival incumbent firms in the product market. The venture-backed firm will then exit by selling the *developed* innovation at a first-price perfect information auction, where the incumbent firms are the potential buyers.[5] If, on the other hand, an incumbent firm obtains the innovation

Taylor (2000) find evidence from US high-tech industries of firms making a strategic choice between the acquisition of outside innovators and in-house R&D. In the biotech industry, Lerner and Merges (1998) note that cooperation between start-up innovators and established firms is the norm, not the least through acquisitions.

OECD (2000, 2002) argues that established firms increasingly rely on knowledge networks, and that knowledge and new technologies are often acquired by buying other firms or merging with them.

[5]Note that we abstract from the principal-agent conflict between buyers and sellers. Kaplan and Ström-

directly in stage 1, the acquiring firm invests in development. In the final stage, given the innovation and development pattern, the incumbent firms compete in oligopoly fashion in the product market.

We first show that a venture-backed firm has an incentive to develop the basic innovation further than an incumbent firm, due to strategic product market effects.[6] The reason is that an incumbent firm only takes into account how its *own profit* increases when investing in development. The venture-backed firm, in contrast, takes into account how the *acquisition price* of the developed innovation is affected. In equilibrium, the acquisition price is shown to equal an incumbent firm's valuation of obtaining the developed innovation which, in turn, consists of the profit for this firm of obtaining the developed innovation net of its profit, if a rival firm obtains it. The venture capitalist thus internalizes that investments in the development of the basic innovation increase in the acquisition price, not only from generating an increase in the acquirer's profit, but also through the negative impact on the non-acquirer's profit (caused by the development of more competitive assets).

We then to turn to the question of how the presence of a venture capital market affects entrepreneurs' incentives to innovate. In the policy debate, it has been argued that a well-functioning venture capital market will increase the innovative activity in the industry, thereby contributing to the economic growth of a country.[7] In line with this view, we show that the entrepreneurial effort to innovate is higher when venture capitalists support entrepreneurs to develop their basic innovations into developed innovations, as compared to a case where the incumbent directly acquires basic innovations. The reason is that a venture-backed firm maximizes the net acquisition price when determining the develop-

berg (2001) show that venture capitalists attempt to mitigate the principal-agent conflicts in three ways suggested by theory – through sophisticated contracting, pre-investment screening, and post-investment monitoring and advising.

[6] Hellmann and Puri (2000) provide empirical evidence of venture capital financing being related to product market strategies and outcomes of start-ups.

[7] See, for instance, OECD (1999) and European Commission (1995, 1999).

ment level. This implies that the venture-backed firm obtains a net acquisition price equal to an incumbent firm's maximum valuation of a developed innovation. Bidding competition among venture capitalists for such an opportunity then bestows the entrepreneur with a higher reward for successful innovation which, in turn, induces a higher entrepreneurial effort to innovate.

A further result derived is that when venture capitalists and incumbent firms are equally efficient in developing basic innovations and compete to gain control over these, preemptive acquisitions by incumbents occur. The reason is that incumbent firms take into account that venture-backed firms will invest more aggressively in development, as explained above. Preemptive acquisitions by incumbent firms thus preempt such, for them, excessive investments in development. However, it is also shown that the presence of venture capitalists as potential financiers of entrepreneurial firms increases the acquisition price and hence, the entrepreneurial efforts to innovate. This follows from the fact that venture-backed firms would invest more aggressively in development to resell developed inventions to incumbent firms. As a consequence, to obtain the entrepreneur's innovation, the acquiring incumbent firm must at least pay the entrepreneur a price for the innovation matching the venture-backed firms' valuations, which exceeds the prevailing price if only incumbents were to bid.

To our knowledge, no paper in the literature on venture capital deals with the venture capitalists' role in the organization of the innovation industry, where the exit of the venture-backed firm takes place by the acquisition of an oligopolist.[8] More in general, this paper might be seen as a contribution to the literature on industrial structure and innova-

[8] See Hellmann (2002) for one of the few studies where venture capitalists compete with established firms financing entrepreneurs. The author shows that if the innovation is a complement to the established firm's business, the established firm will finance the project. Otherwise, the venture capitalist is the leading financier. However, oligopolistic effects are abstracted away, which is the focus of our paper.

tion.[9] [10] We extend this literature by allowing for the interaction between entrepreneurs, venture capitalists and oligopolists, an interaction which in the policy debate has been argued to be of great importance for the functioning of the innovation industry.

The model is spelled out in Section 2. In Section 3, we explore how the incentives to develop basic innovation differ between venture-backed firms and incumbent firms. In Section 4, we study how the pattern of basic innovations and their development depend on the role played by venture capitalists in the innovation industry. In Section 5, we study how the importance of the venture capital market for the innovation and development pattern depends on the return to investment in a particular industry. To this end, a Linear-Quadratic Investment Cournot Model is applied. Section 6 concludes.

2. The Model

The model is illustrated in Figure 2.1. We consider an oligopoly industry served by a set $i \in \mathcal{I}$ of symmetric incumbent firms, where $\mathcal{I} = \{1, 2, .., i, ..., N_I\}$. There is also an entrepreneur, denoted E, which in stage zero invests in a research effort e that could lead to the creation of a unique productive asset, referred to as the *basic innovation*. If successful, this entrepreneur can sell the basic innovation to one of the incumbent firms in stage 1. Alternatively, the entrepreneur can seek support from a venture capitalist providing expertise and financial support to develop the basic innovation. The entrepreneur may then choose from a set $j \in \mathcal{J}$ of symmetric venture capitalists, where $\mathcal{J} = \{1, 2, .., j, .., N_J\}$. The venture capitalists compete to lend the entrepreneur financing in return for equity holdings in the firm. To focus on product market effects as a determinant of the ownership of the basic innovation, we model the sale of the basic innovation as a first-price perfect

[9] See pages 630-643 in Scherer and Ross (1990) for an overview. See Kranton and Minehart (2000) and Inderst and Wey (2003) for some recent contributions studying the interdependency between vertical structure and incentive to invest.

[10] See Baumol (2002) for an extensive description of the innovation industry.

information auction where incumbent firms and venture capitalists bid for it.

If the entrepreneur obtains financing and support from a venture capitalist j in stage 1, the venture-backed firm can, in stage 2, invest k_{V_j} in the development of the basic innovation thereby creating a *developed* innovation, where further development will increase the possessor's profit, but decrease the profits of the rival incumbent firms in the ensuing product market. In stage 3, the venture-backed firm j exits by selling the developed innovation at a first-price perfect information auction, where the N_I incumbent firms are the potential buyers of the *developed* innovation.[11] An acquiring incumbent firm i may then make an additional investment in stage 4 to further develop the innovation. This investment is denoted by $k_{A_i}(k_{V_j})$. Note that since both incumbent firms and venture capitalists are ex-ante symmetric, we can drop the indexing and simply write $k_A(k_V) = k_{A_i}(k_{V_j})$.

If, on the other hand, an incumbent firm i obtains the innovation directly in stage 1, the game moves directly to stage 4, and the acquiring firm invests k_{A_i} in development where, once more, ex-ante symmetry implies $k_A = k_{A_i}$.[12] Finally, in stage 5, the incumbent firms compete in oligopoly interaction, setting an action x_i.

3. Venture capitalists and the incentives to develop innovations

Let us first examine how the incentives of venture-backed firms and incumbent firms to develop innovations differ, taking as given that the entrepreneur has succeeded with an innovation in stage 0. It is then instructive to assume that one of the venture capitalists has gained control over the basic innovation in stage 1. Hence, we proceed along the right-hand branch of the game tree in Figure 2.1.

[11] Note that we assume that the seller could only sell the innovation exclusively to one buyer. In some situations, several buyers might purchase a licence to use the innovations. A more detailed study of this issue is left to future research.

[12] We assume that only the acquiring venture capitalist or the acquiring incumbent firm spends resources on development. It can be shown that our main results would also hold when investments by non-acquiring incumbent firms are included in the analysis.

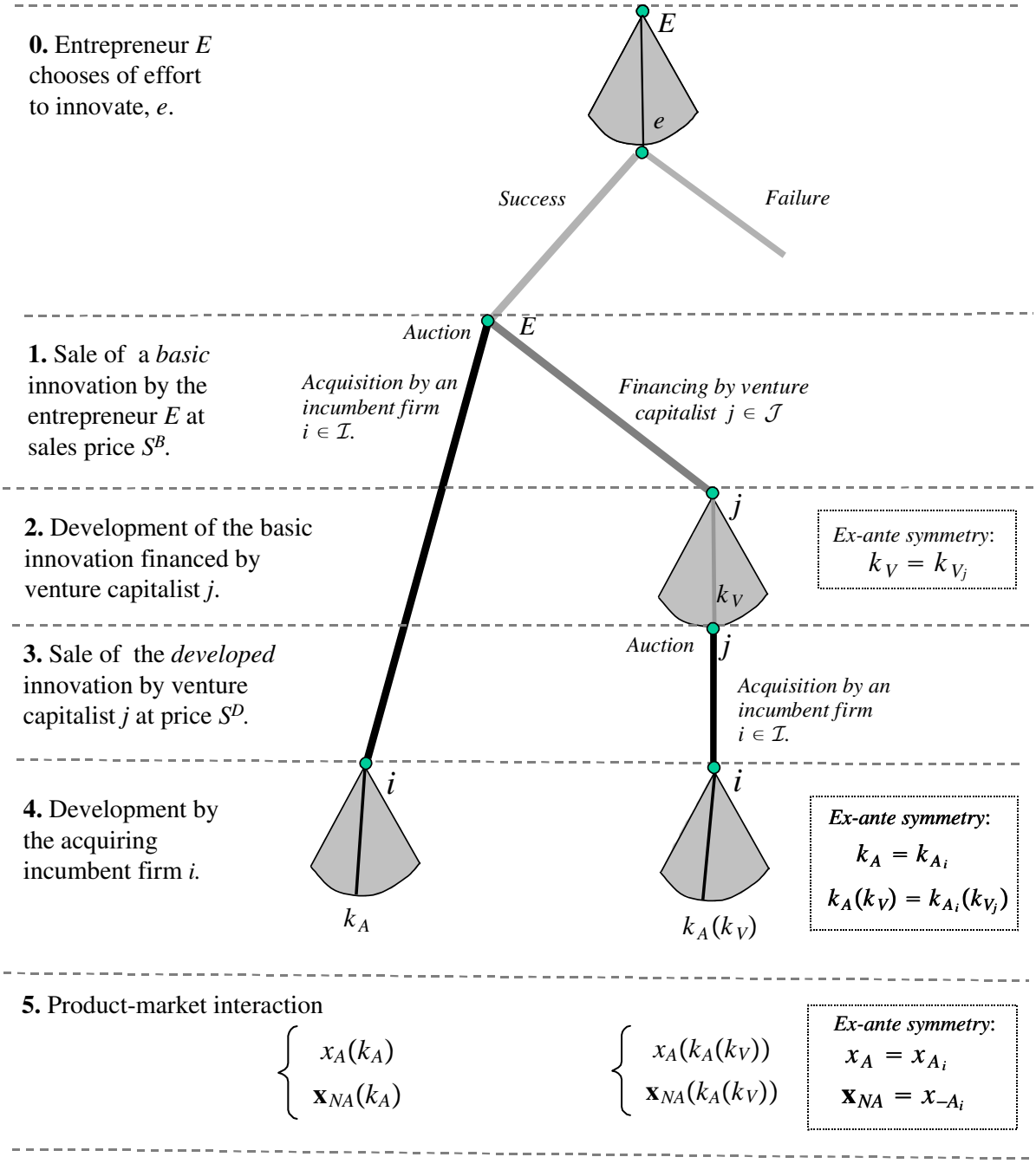

Figure 2.1: The structure of the game.

3.1. Stage 5: Product-market equilibrium

Using backward induction, we start with the product market interaction in stage 5, where firm i chooses an action $x_i \in R^+$ to maximize its *direct* product market profit, $\Pi_i(x_i, \mathbf{x}_{-i}, k_A)$, which depends on its own and its rivals' market actions, x_i and $\mathbf{x}_{-i}$ (which is the $(N_I - 1) \times 1$ vector of actions taken by rival incumbent firms), as well as the total amount of development undertaken (by the acquiring incumbent and/or by the venture-backed firm) on k_A. We may consider the action x_i as setting a quantity or a price, as will be shown in later sections. Thus, we assume that there exists a unique Nash-Equilibrium in actions, $\mathbf{x}^*(k_A)$, defined from the first-order condition (3.1):

$$\frac{\partial \Pi_i}{\partial x_i}(x_i^*, \mathbf{x}_{-i}^*; k_A) = 0, \tag{3.1}$$

where $\mathbf{x}_{-i}^*$ is the actions by firm i:s rivals.

Using the ex-ante symmetry among incumbent firms, we only need to distinguish between two firm types, i.e. the acquiring firm (denoted A) and the non-acquiring firms (denoted *NA).* The actions are then simply $x_A = x_{A_i}$ and $x_{NA} = x_{-NA_i}$, where x_{NA} is one of the $(N_I - 1) \times 1$ arguments in the vector $\mathbf{x}_{NA}$ of symmetric actions taken by non-acquiring incumbent firms Since the optimal actions for the acquirer (x_A^*) and the optimal actions for the non-acquirers $(\mathbf{x}_{NA}^*)$ only depend on k_A, we can define the *reduced-form* product market profits of the acquirer and a non-acquirer as direct functions of k_A:[13]

$$R_A(k_A) \equiv \Pi_A(x_A^*(k_A), \mathbf{x}_{NA}^*(k_A), k_A), \quad R_{NA}(k_A) \equiv \Pi_{NA}(\mathbf{x}_{NA}^*(k_A), x_A^*(k_A)). \tag{3.2}$$

We shall assume the reduced-form product market profit for a firm of type $h = \{A, NA\}$, $R_h(k_A)$, to have the following characteristics:

Assumption 1: $\dfrac{dR_A}{dk_A} > 0$ and $\dfrac{dR_{NA}}{dk_A} < 0$.

[13] To save space, the arguments in $R_{NA}(k_A) \equiv \Pi_{NA}(\mathbf{x}_{NA}^*(k_A), x_A^*(k_A))$ are written with a slight abuse of notation. Note that $R_{NA}(k_A) = \Pi_{NA}(x_{NA}^*(k_A), \underbrace{x_{NA}^*(k_A), ..., x_{NA}^*(k_A)}_{N-2}, x_A^*(k_A))$.

Assumption 1 states that the reduced-form product market profit for the acquirer is strictly increasing in investments of development in the innovation, whereas such investments strictly decrease the rivals' profits. To keep the exposition simple, we use the derivatives of reduced-form product market profits in Assumption 1, $\frac{\partial R_A}{\partial k_A}$ and $\frac{\partial R_{NA}}{\partial k_A}$, keeping in mind that these summarize the total effects on the product-market profits.[14]

3.2. Stage 4: Optimal development by the acquiring incumbent

The acquiring incumbent firm's optimal choice of investment depends on the level of investment made by the venture-backed firm in stage 2. Assume that the acquirer faces a strictly convex investment function, $C(k)$, such that $C'(k) > 0$ and $C''(k) > 0$. We can then write the maximization problem facing the acquiring incumbent firm in stage 4, as follows:

$$\underset{\{k_A\}}{Max} : R_A(k_A) - C(k_A \mid k_V). \tag{3.3}$$

In (3.3), $C(k_A \mid k_V)$ denotes the total cost of investing k_A in development, given the choice of the venture capitalist, k_V:

$$C(k_A \mid k_V) = \int_{k_V}^{k_A} C'(k)dk. \tag{3.4}$$

The associated marginal cost of investing in development k_A is:

$$C'(k_A \mid k_V) = \begin{cases} 0 : k_A \leq k_V \\ C'(k_A) : k_A > k_V \end{cases}, \tag{3.5}$$

[14] As also shown in Section 5, Assumption 1 holds in the Linear-Quadratic Cournot model, but it is also compatible with other oligopoly models. For example, Farrell and Shapiro (1996) show that under Cournot competition and general assumptions on demand and costs, an increase in capital for a firm (i) increases this firm's profit, while (ii) decreasing the profits of its competitors. Moreover, using a quantity-setting conjectural variation oligopoly model under a set of stability criteria, Dixit (1986) shows that a change, which is prima facie favorable for a firm, as is an increase in effective capital, reduces the profits of all other firms. Finally, it can be shown that Assumption 1 extends to a linear Bertrand model with differentiated goods.

that is, investments in development acquired from the venture capitalist, k_V, can be used without any costs, whereas any additional investments in development are subject to the marginal cost, $C'(k_A)$, which is illustrated in Figure 3.1.

We assume that $R_A(k_A) - C(k_A \mid k_V)$ is strictly concave in k_A. The optimal choice by the acquiring firm if the venture capitalist were not to invest at all (i.e. $k_V = 0$), k_A^*, is then defined from the unconstrained optimum condition (3.6):

$$\frac{dR_A}{dk_A} = C'(k_A^*), \tag{3.6}$$

where k_A^* is illustrated in point $\mathcal{A}$ in the upper diagram in Figure 3.1.

For a given investment choice by the venture capitalist, k_V, the optimum investment level of development for the acquiring incumbent firm, k_A^{opt}, becomes:

$$k_A^{opt} = \begin{cases} k_V : k_A^* \leq k_V \\ k_A^* : k_A^* > k_V \end{cases} . \tag{3.7}$$

This optimal choice is illustrated in Figure 3.1. When $k_A^* \leq k_V$, the acquiring firm refrains from investing in development and just uses the (cost-less) investment from the venture capitalist, $k_A^{opt} = k_V$. Given that $k_A^* > k_V$, the optimal investment $k_A^{opt} = k_A^*$ is given from (3.6).

3.3. Stage 3: Sale of the developed innovation by the venture-backed firm

To focus on the product-market forces as the determinants of the equilibrium market structure, we model the acquisition process in stage 3 as a perfect information auction where the N_I incumbent firms simultaneously post bids which are then accepted or rejected by the venture capitalist.[15] Each incumbent firm announces a bid, b_i, for the developed

[15] We assume that the venture capitalist and the established firm cannot write a contract. As argued in the introduction, we observe that in practice, acquisitions are frequently used to gain access to innovations and patents. This could be explained by its being difficult to write a contract prior to the innovation being in place in this environment, due to problems of incomplete and asymmetric information.

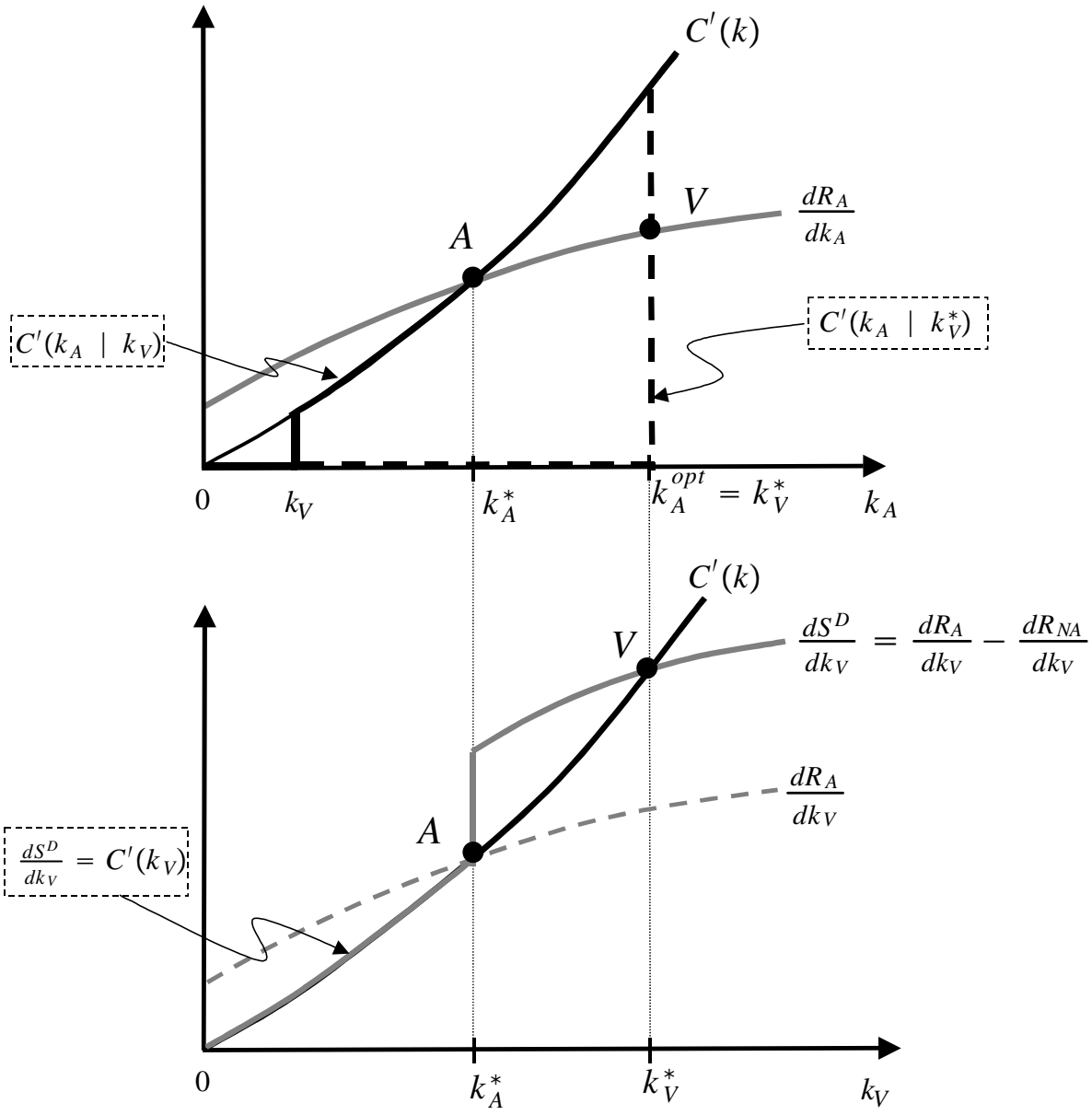

Figure 3.1: Illustrating optimal development by an acquiring incumbent firm and a venture capitalist.

innovation, where $\mathbf{b} = (b_1, ..., b_i, ...b_{N_I}) \in R^{N_I}$ is the vector of these bids. Following the announcement of $\mathbf{b}$, the developed innovation may be sold to one of the incumbents at the bid price, or remain in the ownership of the venture-backed firm.[16] The equilibrium acquisition price is denoted by S^D.

We now turn to incumbent firms' valuations of obtaining the developed innovation w_{II}, defined in (3.8). The first term shows the profit for an incumbent firm when possessing the innovation. The second term shows the profit if it is obtained by a rival incumbent firm:

$$w_{II} = \begin{cases} R_A(k_V) - R_{NA}(k_V) : & k_A^* \leq k_V \\ R_A(k_A^*) - C(k_A^* \mid k_V) - R_{NA}(k_A^*) : & k_A^* > k_V \end{cases}, \tag{3.8}$$

where $C(k_A^* \mid k_V) = \int_{k_V}^{k_A^*} C'(k)dk$. Note that since incumbent firms are symmetric ex-ante, their valuations are symmetric. It is then straightforward to derive the following lemma[17]:

Lemma 1. *In stage 3, the developed innovation is acquired by an incumbent firm, at a price, S^D, equal to a rival incumbent firm's valuation of the developed innovation, i.e. $S^D = w_{II}$.*

Proof. See Appendix A.1.

3.4. Stage 2: Optimal development by the venture-backed firm

The venture-backed firm invests in development of the basic innovation, maximizing the net sales price of a developed innovation, i.e., $S^D(k_V) - C(k_V)$. To focus on the product market effects, we assume the venture-backed firm and the incumbent firms to face the same variable cost function when investing in development. Using Lemma 1 and (3.8),

[16] If more than one of the incumbent firms make such a bid, each such firm obtains the assets with equal probability. The acquisition is solved for Nash equilibria in undominated pure strategies. There is a smallest amount, ε, chosen such that all inequalities are preserved if ε is added or subtracted.

[17] The correct acquisition price is $w_{II} - \varepsilon$, but to simplify the presentation, we use w_{II}.

this problem is then defined as:

$$\underset{\{k_V\}}{Max}: \; S^D(k_V) - C(k_V) \tag{3.9}$$

$$s.t \;\; : \;\; S^D(k_V) = \begin{cases} R_A(k_V) - R_{NA}(k_V) : & k_A^* \leq k_V \\ R_A(k_A^*) - C(k_A^* \mid k_V) - R_{NA}(k_A^*) : & k_A^* > k_V \end{cases} \tag{3.10}$$

$$s.t \;\; : \;\; C(k_A^* \mid k_V) = \int_{k_V}^{k_A^*} C'(k) dk.$$

The first line in (3.10) indicates the sales price for a developed innovation when the acquirer only uses the venture capitalist's investment in development without sequential investment, $k_A^{opt} = k_V$, whereas the second-line in (3.10) shows the sales price when the acquirer invests $k_A^{opt} - k_V = k_A^* - k_V > 0$ sequentially.

The venture capitalist's maximization problem (3.9) is illustrated in the lower diagram in Figure 3.1. The first-order condition, given that $k_V < k_A^*$, is

$$\frac{dS^D}{dk_V} = C'(k_V) : \qquad k_V < k_A^*. \tag{3.11}$$

However, using that $S^D(k_V) = R_A(k_A^*) - C(k_A^* \mid k_V) - R_{NA}(k_A^*)$ for $k_V < k_A^*$ implies that $\frac{dS^D}{dk_V} = \frac{d}{dk_V} \int_{k_V}^{k_A^*} C'(k) dk = C'(k_V)$; consequently, the acquisition price increases with the same amount as the cost of development. Hence, any k_V in this interval will be optimal.

In contrast, if the venture capitalist reflects on a development choice $k_V > k_A^*$, it maximizes $R_A(k_V) - R_{NA}(k_V) - C(k_V)$ and hence, the first-order condition now becomes:

$$\frac{dS^D}{dk_V} = \frac{dR_A}{dk_V} - \frac{dR_{NA}}{dk_V} = C'(k_V^*) : \qquad k_V > k_A^*, \tag{3.12}$$

where, once more, we assume $C(k)$ to be sufficiently convex so that $R_A(k_V) - R_{NA}(k_V) - C(k_V)$ is strictly concave in k_V. The optimal k_V is indicated as k_V^* in the lower diagram in Figure 3.1. Comparing expressions (3.6) and (3.12), we see that the venture capitalist has stronger incentives to invest in development than the acquiring firm, since the venture capitalist achieves a higher acquisition price by not only taking into account the increase

in profits for the acquirer $\frac{dR_A}{dk_V}$, but also by exploiting the negative externalities on the non-acquirer, captured by the last term $\frac{dR_{NA}}{dk_G}$, which is negative from Assumption 1. This is also illustrated in Figure 3.1. From the lower graph, we may note that k_V^* is indeed the global optimum since increasing k_V slightly above k_A^* must increase the net sales price. Turning to the upper graph in Figure 3.1, we may note that it is indeed also optimal for the acquiring firm to fully use the venture capitalist investment, i.e. $k_A^{opt} = k_V^*$.

We have the following result:

Proposition 1. *(i) The optimal level of development by a venture-backed firm which resells the developed innovation to an incumbent firm exceeds the optimal level of development by the acquiring incumbent firm, i.e.* $k_V^* > k_A^*$. *(ii) When acquiring a developed innovation through a re-sale from a venture-backed firm, the acquiring incumbent firm performs no further development,* $k_A^{opt} = k_V^*$.

Thus, proposition 1 shows that a venture capitalist has a stronger incentive to develop an innovation than an incumbent firm, since it internalizes the negative effect of development on the non-acquiring firm's profit through the higher acquisition price.

4. Venture capitalists' and entrepreneurs' incentives to innovate

We here turn to the question of how the presence of venture capitalists affects the entrepreneur's efforts to produce innovations in stage 0. Once more, we focus on product-market forces as the determinants of the equilibrium innovation pattern by assuming that the entrepreneur sells the basic innovation to the highest bidder at an auction in stage 1. We apply the same acquisition process as in section 3.3 and refer to the description of the game provided in that section. In the auction, incumbent firms' bids are interpreted as direct payments for a full acquisition, while venture capitalists' bids are interpreted as offers of finance and support in return for a stake of the proceeds of the sale of the developed innovation in stage 3. To simplify, we assume that the venture capitalist obtains the total proceeds of the sale of the venture-backed firm in stage 3.

More specifically, we examine how the entrepreneur's effort to innovate depends on which agents participate in the acquisition game in stage one. To this end, we will compare three different cases:

Case 1: Only incumbents bid for the entrepreneur's basic innovation in stage 1.

Case 2: Only venture capitalists bid for the entrepreneur's basic innovation in stage 1.

Case 3: Both venture capitalists and incumbent firms bid for the entrepreneur's basic innovation in stage 1.

Case 1 would correspond to an industrial organization where there is no well-functioning venture capitalist market and thus, entrepreneurs rely on selling innovations directly to incumbent firms. To this end, we assume that there is not only a variable cost for developing basic innovations but also a fixed cost F. In this case, we assume the fixed cost for the venture-backed firm to be sufficiently large**,** so that venture capitalists do not bid for the innovation, i.e. $F_V = \infty$, while we assume the fixed cost for incumbent firms to be zero, i.e. $F_I = 0$.

Case 2 would capture an industrial organization, where venture capitalists are specialized in developing investments, thereby facing a lower cost of developing basic innovations. To this end, we assume the fixed costs for incumbents to be sufficiently large to have incumbent firms not bidding for the basic innovation, i.e. $F_I = \infty$, while we assume the fixed cost for venture capitalists to be zero, i.e. $F_V = 0$.

Case 3 assumes the fixed costs to be $F_I = F_V = 0$, ensuring that both types of agents bid for the basic innovation.

4.1. Stage 0: Innovation by the entrepreneur

In stage 0, the entrepreneur E undertakes an effort, e, to discover an innovation. Let innovation costs $y(e)$ be an increasing convex function in effort, i.e. $y'(z) > 0$, and $y''(z) > 0$. Let the probability of making an innovation be z and the probability of a failure

$1-z$, where $z \in [0,1]$ and the probability z is an increasing concave function of effort, i.e. $z'(e) > 0$ and $z''(e) < 0$. $\pi_E = z(e)S^B - y(e)$ is then the expected net profit of undertaking effort for the entrepreneur, where S^B is the acquisition price obtained in the auction for the basic innovation in stage 1. The entrepreneur then maximizes π_E, optimally choosing effort e. The optimal effort e^* is given from:

$$\frac{d\pi_E}{de} = z'(e)S^B - y'(e) = 0, \tag{4.1}$$

with the associated second-order condition, $\frac{d^2\pi_E}{de^2} = z''(e) - y''(e) < 0$.

Applying the implicit function theorem in (4.1), we can state the following Lemma:

Lemma 2. *The innovative effort by the entrepreneur in stage 0, e and hence, the probability of a successful innovation z, increase in the acquisition price obtained in stage 1, S^B, i.e. $e'(S^B) > 0$.*

Having established that entrepreneurial effort in stage 0 is an increasing function of the acquisition price obtained in stage 1, we can now proceed to examine the link between the presence of a venture capitalist market and innovations by entrepreneurs.

4.2. Equilibrium innovation and development when only incumbent firms can acquire basic innovations (Case 1)

We here determine the equilibrium pattern of innovation and development in the case where only incumbent firms bid for the innovation. The game is solved backwards. Note from Figure 2.1 that in this case, we proceed directly from stage 1 to stage 4. In stage 4, the acquiring incumbent firm faces an unconstrained optimization choice of how much to invest in development. The optimal choice k_A^* is then given from equation (3.6).

Let us now turn to stage 1. To distinguish incumbent firms' valuations of obtaining the entrepreneur's basic innovation in stage 1 from the corresponding valuation of acquiring a developed innovation from a venture-backed firm in stage 3, w_{II}, we write the stage 1 valuation as v_{II}:

$$v_{II} = R_A(k_A^*) - C(k_A^*) - R_{NA}(k_A^*). \tag{4.2}$$

Using symmetry and the reasoning in the proof of Lemma 1, it is then straightforward to derive the following lemma, where we define S_I^B as the equilibrium sales price when only incumbents $i \in \mathcal{I}$ bid for the basic innovation:

Lemma 3. *If only incumbent firms bid for the basic innovation in stage 1, this is acquired by an incumbent firm at a price* $S_{\mathcal{I}}^B = v_{II}$.

Lemma 2, Lemma 3 and equation (3.6) imply that when only incumbent firms bid for the innovation, the acquiring firm invests k_A^* in development, inducing an acquisition price $S_I^B = v_{II}$, thereby leading to an entrepreneurial effort of $e(v_{II})$. This is summarized in column two of table 4.1 below.

Table 4.1: Equilbrium market structure under different industrial organizations.

	Case 1:	Case 2:	Case 3:
Active bidders in stage 1:	Incumbent firms	Venture capitalist	Both venture capitalists and incumbent firms,
Assumptions:	$F_I = 0$ $F_V = \infty$	$F_V = 0$ $F_I = \infty$	$F_I = F_V = 0$
Equilibrium buyer :	Incumbent	Venture Capitalist	Incumbent
k_A^{opt} :	k_A^*	k_V^*	k_A^*
S^B :	v_{II}	v_V	v_V
e :	$e(v_{II})$	$e(v_V)$	$e(v_V)$

4.3. Equilibrium innovation and development when only venture capitalists can acquire basic innovations (Case 2)

Let us now examine the case where only venture capitalists bid for the innovation in stage 1. Having solved for stages 2 to 5 in section 3, we turn to the auction in stage 1. A

venture capitalist's valuation of the entrepreneur's basic innovation, denoted v_V, is the sales price of the developed innovation gain in stage 3, net the investment costs. Noting from Proposition 1 that (i) k_V^* is the equilibrium investment level of the venture-backed firm in stage 2, and that (ii) the optimal behavior in stage 4 upon an acquisition by an incumbent firm is to simply use the venture capitalist's optimal investment without further development, $k_A^{opt} = k_V^*$, we can write the venture capitalist's valuation of the entrepreneur's basic innovation as:

$$\begin{aligned} v_V &= S^D(k_V^*) - C(k_V^*) \\ &= R_A(k_V^*) - R_{NA}(k_V^*) - C(k_V^*). \end{aligned} \tag{4.3}$$

Using the symmetry among venture capitalists and the reasoning in the proof of Lemma 1, it is straightforward to derive the following lemma, where we define $S_{\mathcal{J}}^B$ as the equilibrium sales price when only venture capitalists $j \in \mathcal{J}$ bid for the basic innovation:

Lemma 4. *If only venture capitalists bid for the basic innovation in stage 1, it is acquired by a venture capitalist at a price* $S_{\mathcal{J}}^B = v_V$.

Lemma 2, Lemma 4 and Proposition 1 imply that when only venture capitalists bid for the basic innovation, the venture-backed firm invests k_V^* in development**,** inducing an acquisition price $S_{\mathcal{J}}^B = v_V$, thereby leading to an entrepreneurial effort of $e(v_V)$. This is summarized in column three of table 4.1.[18]

[18] We assume that the seller of the innovation cannot use a sophisticated selling mechanism**,** but must use a simple first-price sealed bid auction. This implies that some possibilities for creating rents are neglected. In this case, it might be argued that venture-backed firms should be able to extract more rents by selling the basic innovation**,** threatening to aggressively develop the innovation if it does not receive a maximum willingness to pay from one of the incumbent firms. That is, an incumbent firm would be willing to pay $v_{IV} = R_A(k_A^*) - C(k_A^*) - R_{NA}(k_V^*)$, which would give the venture-backed firm larger proceeds as compared to the case when it develops the innovation and then sells it, since it would then get $w_{II} - C(k_V^*) = R_A(k_V^*) - C(k_V^*) - R_{NA}(k_V^*)$, where $w_{II} - C(k_V^*) < v_{IV}$. If this were possible, the implication of the existence of a venture capital market would be that it triggers even more basic innovations, but that these are not developed to the same extent.

4.4. Equilibrium innovation and development when both incumbent firms and venture capitalists can acquire basic innovations (Case 3)

Let us now turn to the determination of the equilibrium pattern of innovation and development, when both types of agents bid for the entrepreneur's innovation. The game is solved backward and from the above discussion, we know that if an incumbent acquires the basic innovation, it will be developed to k_A^*, whereas if obtained by a venture capitalist, it will be developed to k_V^*.

With this knowledge, we can turn to stage 1 and solve the acquisition game. We have defined $v_V = R_A(k_V^*) - R_{NA}(k_V^*) - C(k_V^*)$ as the value for a venture capitalist of obtaining the innovation, and $v_{II} = R_A(k_A^*) - C(k_A^*) - R_{NA}(k_A^*)$ as the value for an incumbent firm of obtaining the innovation when a rival incumbent firm would otherwise obtain it. There is a third valuation to consider in this case, which is the value for an incumbent firm of obtaining the innovation when it would otherwise be obtained by a venture capitalist. This valuation is defined:

$$v_{IV} = R_A(k_A^*) - C(k_A^*) - R_{NA}(k_V^*). \tag{4.4}$$

Note that the profit for an incumbent firm of not obtaining the innovation differs from the corresponding one in v_{II}, since here, a more developed innovation is obtained by a rival incumbent firm.

We can then state the following Lemma, where we define $S^B_{\mathcal{I}x\mathcal{J}}$ as the equilibrium sales price when both venture capitalists $j \in \mathcal{J}$ and incumbent firms $i \in \mathcal{I}$ bid for the basic innovation:

Lemma 5. *If both incumbent firms and venture capitalists bid for basic innovations in stage 1, (i) the valuations of the entrepreneur's basic innovation can be ranked* $v_{IV} > v_V > v_{II}$*,which implies that (ii) the basic innovation is acquired by an incumbent firm at a price equal to a venture capitalist's valuation,* $S^B_{\mathcal{I}x\mathcal{J}} = v_V$.

Proof. (i) 1. $v_{IV} = R_A(k_A^*) - C(k_A^*) - R_{NA}(k_V^*) > R_A(k_V^*) - R_{NA}(k_V^*) - C(k_V^*) = v_V$ since from (3.6), we know that k_A^* maximizes $R_A(k) - C(k)$. 2. $v_V = R_A(k_V^*) - R_{NA}(k_V^*) -$

$C(k_V^*) > R_A(k_A^*) - C(k_A^*) - R_{NA}(k_A^*) = v_{II}$, from (3.12), we know that k_V^* maximizes $R_A(k) - R_{NA}(k) - C(k)$. (ii): See Appendix A.2. ■

Consequently, from Lemma 2, Lemma 5 and (3.7), it follows that when both incumbent firms and venture capitalists bid for the innovation, it is acquired by an incumbent firm investing k_A^* in development, thereby inducing an acquisition price $S_{IV}^B = v_V$ and leading to an entrepreneurial effort $e(v_V)$. This is summarized in column four of table 4.1.

Lemma 5 points at several noteworthy implications. First, an incumbent firm taking the development behavior of a venture-backed firm into account is willing to pay more than a venture capitalist to obtain the innovation, i.e. $v_{IV} > v_V$**,** since the venture-backed firm would develop the innovation more aggressively in stage 2. A direct acquisition by an incumbent firm avoids such over-investment in development, and therefore an incumbent firm values the basic innovation more highly than does a venture capitalist.

Second, the valuation of a venture capitalist exceeds that of an incumbent firm when it considers that a failure to acquire the innovation would imply a direct acquisition by a rival incumbent, i.e. $v_V > v_{II}$. This follows directly from the fact that a venture capitalist maximizes incumbent firms' valuations of the innovation $R_A(k) - R_{NA}(k) - C(k)$ by choosing k_V^* in stage 2 (to resell a developed innovation in stage 3). In contrast, an incumbent maximizes its product market profit $R_A(k) - C(k)$ by choosing k_A^* in stage 4 (upon a direct acquisition in stage 1).

Note also that an incumbent firm is willing to pay more to prevent a venture capitalist than a rival incumbent firm from acquiring the basic innovation in stage 1, i.e. $v_{IV} > v_{II}$**,** since a venture-backed firm would develop the innovation more aggressively than a rival incumbent firm. This would lead to an even lower profit for an incumbent as a non-acquirer in the product market competition ensuing in stage 5. Consequently, acquisitions by incumbent firms thus preempt such, for them, excessive investments in development. Accordingly, we can state the following corollary:

Corollary 1. *When venture capitalists and incumbent firms are equally efficient in devel-*

oping basic innovations and compete to gain control over these, we have that incumbents acquire basic innovations to preempt, for them, excessive investments in development that would be undertaken by venture-backed firms.

4.5. Comparing different organizations of the innovation industry

We are now set to compare the different industrial organizations of the innovation industry. From table 4.1, we can then state the following proposition.

Proposition 2. *Comparing the three different industrial organizations in table 4.1, we have (i) that the industrial organization without venture capitalists leads to the lowest level of innovations and development, and (ii) that the industrial organization where only venture capitalists can bid for the entrepreneur's innovation leads to the highest level of innovations and development.*

Proof. From table 4.1, we have that $S_{\mathcal{I}}^{B} = v_{II}$ and the corresponding development level is k_A^*, $S_{\mathcal{J}}^{B} = v_V$ and the corresponding development level $k_V = k_V^*$ and $S_{\mathcal{I}x\mathcal{J}}^{B} = v_V$ and the corresponding development level k_A^*. Then, by Lemma 5, we have that $v_V > v_{II}$ and consequently, $S_{\mathcal{I}}^{B} < S_{\mathcal{J}}^{B} = S_{\mathcal{I}x\mathcal{J}}^{B}$. Finally, from by Proposition 1, we have that $k_V^* > k_A^*$. ■

The proposition supports the often held view that a well-functioning venture capitalist market will increase both innovation and development. Proposition 1 showed that investments for development when a venture capitalist sells a developed innovation exceeded the corresponding investment implied by a direct sale of the innovation to an incumbent firm in stage 1, i.e. $k_V^* > k_A^*$. The reason is that a venture capitalist internalizes the market rivalry among incumbent firms when investing in development, since such investments were guided by maximization of the net acquisition price in the auction of the developed innovation in stage 3. It then follows that the auction in stage 1 must produce a higher acquisition price, as well as induce a higher entrepreneurial effort to innovate, when only venture capitalists bid in stage 1.

As shown in Lemma 5, preemptive acquisitions by incumbents occur when venture capitalists and incumbent firms are equally efficient in developing basic innovations. However, the presence of venture capitalists as potential supporters of venture-backed firms increases the acquisition price and hence, the entrepreneurial efforts to innovate. This follows from the fact that venture-backed firms would invest more aggressively in development in order to resell developed inventions to incumbent firms. As a consequence, to obtain the entrepreneur's innovation, the acquiring incumbent firm must at least pay the entrepreneur a price of the innovation matching the venture-backed firm's valuation, which exceeds the prevailing price if only incumbents were to bid. Thus, we have the following corollary:

Corollary 2. *The presence of venture capitalists increases the acquisition price for basic innovations also in situations where they do not acquire basic innovations.*

Proof. (i) Follows directly from Lemma 5. (ii) By Lemma 5, we have that $v_V > v_{II}$ and therefore, $S^B(v_V) > S^B(v_{II})$. ■

These results present a possible explanation of why venture-backed firms are observed to be so much more successful than incumbent firms in bringing commercialized innovations to the market. The most straightforward explanation to this observation is that venture-backed firms are simply much more efficient than incumbent firms due to, for instance, informational advantages, abilities, better monitoring and control. However, it might then be believed that "less" skilled venture capitalist would enter the market and reduce this difference in efficiency. Thus, some restrictions on the entry of less skilled venture capitalist seem necessary for this argument. Our argument does not need such an entry restriction, however, since we show that in an oligopoly venture, capitalists will produce more development than incumbents in equilibrium. Moreover, we show that they must be substantially more efficient to exist in equilibrium, otherwise incumbents will preemt venture capitalists entering the market by acquiring basic innovations.

5. Innovation and development pattern: return to investment and cost of development

In this section, we will study how the importance of the venture capital market for the innovation and development pattern depends on the return to investment and the cost for development for incumbent firms and venture-backed firms, respectively. To this end, we apply a Linear-Quadratic Cournot model (LQC), allowing us to derive explicit solutions for the optimal behavior by agents in all stages of the game.[19]

In the LQC model, it is assumed that the product market competition is Cournot-duopoly in homogeneous goods and that firms face a linear demand, $P = a - \frac{Q}{s}$, where a indicates consumer willingness to pay and s denotes market size. We distinguish between two types of incumbent firms: the acquirer of the innovation is denoted by A, whereas the non-acquirer is denoted by NA. The direct product market profit is $\Pi_h = (P - c_h)x_h$, where x_h is the output for a firm of type $h = \{A, NA\}$. Investments in development k are assumed to reduce the acquirer's marginal production cost, i.e. $c_A = c - k_A$. The non-acquirer is assumed to have the marginal cost $c_{NA} = c$. We let $C(k_h) = \frac{\mu k_h^2}{2} + F_h$ be the total investment cost for development faced by the venture capitalists (i.e. $h = V$) and an incumbent firm (i.e. $h = A$), respectively.

The model is solved backwards. It is straightforward to derive that the optimal Cournot quantities, in stage 5, from (3.1), become $x_A^*(k_h) = s\frac{\Lambda+2k_h}{3}$ and $x_{NA}^*(k_l) = s\frac{\Lambda-k_h}{3}$, where $\Lambda = a - c > 0$ is assumed. Using linear demand, reduced profits are given by $R_A(k_h) = s\left(\frac{\Lambda+2k_h}{3}\right)^2$ and $R_{NA}(k_h) = s\left(\frac{\Lambda-k_h}{3}\right)^2$.

In stage 4, we can note that the first-order condition for the acquirer in (3.6) can be

[19] This type of framework, typically modelling an investment game followed by a stage with oligopoly interaction, has been applied in, for example, d'Aspremont and Jacquemin (1988), Leahy and Neary (1997) and Neary (2002). A central difference between the latter papers and our study, is that our application examines the effects of adding an acquisition game.

written:

$$\frac{dR_A}{dk_A} = \underbrace{\frac{\partial \Pi_A}{\partial x_{NA}} \frac{dx^*_{NA}}{dk_A}}_{\substack{Strategic\ effect \\ (+)}} + \underbrace{\frac{\partial \Pi_A}{\partial k_A}}_{\substack{Direct\ effect \\ (+)}} = C'(k_A), \tag{5.1}$$

where the benefit of investing consists of a *strategic effect* (where an increase in k_A affects the non-acquiring incumbent's optimal product-market action, $\frac{dx^*_{NA}}{dk_A} = -\frac{s}{3} < 0$, and the profits through $\frac{\partial \Pi_A}{\partial x_{NA}} = -\frac{x^*_A}{s} < 0$) and a *direct cost-saving effect* (where $\frac{\partial \Pi_A}{\partial k_A} = x^*_A > 0$), which are balanced against the marginal cost of investing (where $C'(k_A) = \mu k_A > 0$).

In stage 3, given that a venture-backed firm has developed the basic innovation, Lemma 1 applies and the developed innovation is sold at the price $S^D = w_{II} = R_A(k_v) - R_{NA}(k_v)$.

In stage 2, the first-order condition for the venture-backed firm in (3.12), becomes

$$\frac{dS^D}{dk_V} = \underbrace{\frac{\partial \Pi_A}{\partial x_{NA}} \frac{dx^*_{NA}}{dk_V}}_{\substack{Strategic\ effect \\ (+)}} + \underbrace{\frac{\partial \Pi_A}{\partial k_V}}_{\substack{Direct\ effect \\ (+)}} - \underbrace{\frac{\partial \Pi_{NA}}{\partial x_A} \frac{dx^*_A}{dk_V}}_{\substack{Strategic\ effect \\ (-)}} = C'(k_V). \tag{5.2}$$

where**,** for expositional reasons**, we** use the derivates in terms of the direct profit function. From (5.1), it can be noted that an acquiring incumbent firm internalizes that investing in development changes the optimal product-market action taken by rivals ($\frac{dx^*_{NA}}{dk_A}$), but only considers how this affects its *own* profit through the strategic effect ($\frac{\partial \Pi_A}{\partial x_{NA}} \frac{dx^*_{NA}}{dk_A}$). In contrast, from (5.2)**,** we can note that *in addition*, the venture capitalist takes into account the strategic effect on the non-acquirer (i.e. the term $\frac{dR_{NA}}{dk_V} = \frac{\partial \Pi_{NA}}{\partial x_A} \frac{dx^*_A}{dk_V}$), that is, it takes into account how investments into development by the acquirer make this firm more aggressive on the product market (where $\frac{dx^*_A}{dk_A} = \frac{2s}{3} > 0$) and how this affects the non-acquirer's profit ($\frac{\partial \Pi_{NA}}{\partial x_A} = -\frac{x^*_{NA}}{s} < 0$).

Indeed, solving the optimal investment for an acquiring incumbent firm k^*_A in (5.1) and the optimal investment for the venture capitalist in (5.2), we can verify Proposition 1:

$$k^*_V = \frac{2\eta}{3 - 2\eta}\Lambda, \quad k^*_A = \frac{4\eta}{9 - 8\eta}\Lambda, \quad k^*_V - k^*_A = 2\eta \frac{(3 - 4\eta)}{(3 - 2\eta)(9 - 8\eta)}\Lambda > 0, \tag{5.3}$$

where $\eta = \frac{s}{\mu}$ can be interpreted as the relative return to development (increasing in market size s and decreasing in development costs μ).[20]

[20] Calculations show that $9 - 8\eta > 0$ holds from the second-order condition associated with (5.1),

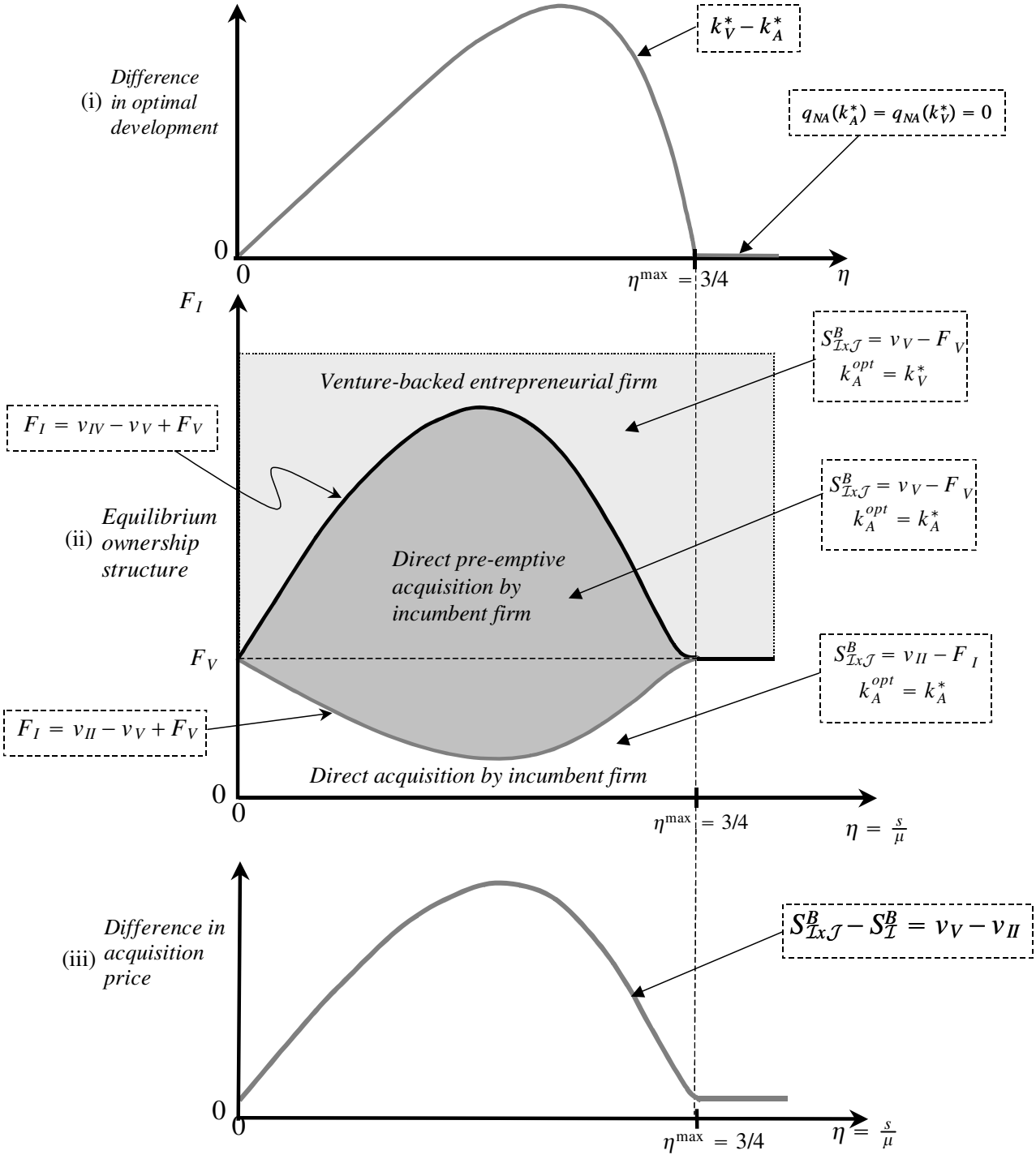

Figure 5.1: The Linear-Quadratic Model.

We now turn to solving the optimal behavior in the acquisition auction games in stage 1. In tables B.1 and B.2 in the Appendix, we derive the valuations v_{IV}, v_{II} and v_V required to solve the auction. Note that in contrast to section 4, we make no specific assumptions on the fixed costs of development, F_h, which implies that Lemma 5 does not apply. However, note that $v_{IV} > v_{II}$ holds, as this inequality is not affected by fixed costs.

The ranking of the pair of valuations v_{IV} and v_V, v_{II} and v_V will depend on the fixed cost of development for incumbents and venture-backed firms, respectively, and the return to investment. This is illustrated in Figure 5.1(ii), where we depict two curves. The first curve, $F_I = v_{IV} - v_V + F_V$, shows combinations of fixed-costs and the relative return to development η at which the motive for incumbents to preempt venture capitalists from obtaining the basic innovations is balanced by a fixed-cost advantage for venture capitalists. The second curve, $F_I = v_{II} - v_V + F_V$, shows combinations of fixed-costs and return to development η at which a venture capitalist's incentive to aggressively invest in development (to maximize incumbents' willingness to pay in stage 3) is balanced by a fixed-cost disadvantage.

It can be shown that venture-backed firms emerge in equilibrium if and only if $v_{IV} < v_V$. Figure 5.1(ii) then illustrates that (a) venture-backed firms emerge in equilibrium when their cost advantages are sufficiently large, and (b) venture-backed firms emerge in equilibrium when the returns to development η are either low or high. In contrast, incumbent acquisitions occur when the return to development is of medium size.

The pattern in Figure 5.1(ii) can be explained from Figure 5.1(i), where we examine how the difference $k_V^* - k_A^*$ behaves when varying the return to development η. Note that investments in development by a venture capitalist k_V^* always exceed investments by an incumbent firm k_A^*, but that this difference is inversely U-shaped.[21] When η is close to

$3 - 2\eta > 0$ holds from the second-order condition associated with (5.2) and $3 - 4\eta > 0$ must be fulfilled to have $x_{NA}^*(k_h^*) > 0$. Additional information is given in table B.1.

[21] To see why, first note that when the return to development is $\eta = 0$ (due to a small market or costly development), this implies that $k_V^* = k_A^* = 0$.

Then, note that the right-hand sides of (5.1) and (5.2)) yield: $\frac{dS^D}{dk_V} - \frac{dR_A}{dk_A} = \frac{4s}{3}[x_A^*(k_V^*) - x_A^*(k_A^*)] + \frac{2}{3}x_{NA}^*$

zero, very little development takes place in either case, which implies that there is less over-investment by venture capitalists and hence, the preemptive motive for incumbents to outbid venture capitalists is weak. This is also the case at a sufficiently large return to development (i.e. close to $\eta^{\max} = 3/4$), since the non-acquiring firm then has a small market share, thereby weakening the strategic motive for over-investment by venture capitalists.[22] Hence, as shown in Figure 5.1(ii), in these regions, small cost advantages for venture capitalists induce venture-backed firms. However, at medium returns to development, market competition is stronger, as is the strategic over-investment from venture capitalists. The preemptive motive for an incumbent firm to obtain the basic innovation is therefore strong and direct acquisitions by incumbent firms emerge even for large (but not too large) cost advantages for venture capitalists.

Summing up, we thus have the following result on the equilibrium industrial organization of the innovation industry in the LQM model

Proposition 3. *In the Linear-Quadratic Model, venture-backed firms emerge in equilibrium when their cost advantages are sufficiently large and when the returns to development are either sufficiently low or sufficiently high.*

Finally, let us turn to stage 0 where, from Lemma 2, we know that innovation effort

$= \frac{4s}{3}\left[s\frac{\eta(3-4\eta)}{(9-8\eta)(3-2\eta)}\right]\Lambda + \frac{2}{3}\frac{s}{3}\left(\frac{3-4\eta}{3-2\eta}\right)\Lambda$, where the first term represents the difference in the sum of strategic- and cost-saving effects on the acquirer and the second term is the crucial term, i.e. the strategic effect on the non-acquirer only internalized by the venture capitalist. Inserting the optimal quantities given from table B.1 in the Appendix, we observe that $\frac{dS^D}{dk_V} - \frac{dR_A}{dk_A} > 0$ when $\eta = 0$.

Finally, note that $k_V^* - k_A^* = 2\eta\frac{(3-4\eta)}{(3-2\eta)(9-8\eta)}\Lambda = 0$ at $\eta^{\max} = 3/4$). The acquirer becomes a monopolist and the investment behavior of venture-backed firms and the incumbent firms are then symmetric.

[22] This follows directly from (5.1) and (5.2), since comparing the marginal benefit of investing into development for a venture capitalist and an incumbent firm, we have

$$\frac{dS^D}{dk_V} - \frac{dR_A}{dk_A} = -\frac{\partial \Pi_{NA}}{\partial x_A}\frac{dx_A^*}{dk_V} = \frac{2}{3}x_{NA}^*.$$

That is, the strategic effect on the non-acquirer will be decreasing in this firm's market size. Moreover, in table B.1 in the Appendix, we show that $x_{NA}^* = \frac{s}{3}\left(\frac{3-4\eta}{3-2\eta}\right)\Lambda$.

increases in the sales price in the auction in stage 1, S^B. In Figure 5.1(iii), we depict how the difference in sales price between the industrial organization where venture capitalists are present and the one where they are not, $S^B_{\mathcal{I}x\mathcal{J}} - S^B_{\mathcal{I}}$, depends on the return to investments in the industry, η. Figure 5.1(iii) then illustrates that the sales price difference (and thereby the highest difference in innovation) will be for relatively high levels of returns to investment, but not too high so that one firm becomes too dominant in the market.

6. Conclusions

This paper takes as its starting point that the exit of venture-backed firms often takes place through a sale to a large incumbent firm. We show that in such an environment, venture-backed firms have a stronger incentive to develop basic innovations into commercialized innovations than incumbent firms, due to strategic product market effects. In turn, this will increase the price for basic innovations, thereby triggering more basic innovations by entrepreneurs. Consequently, the presence of a venture capital market implies that more basic innovations are created and that these become better developed.

Moreover, we provide a possible explanation why venture-backed firms are observed to be so much more successful than incumbent firms in bringing commercialized innovations to the market. The most straightforward explanation to this observation is that venture-backed firms are simply much more efficient than incumbent firms due to, for instance, informational advantages, abilities, better monitoring and control. However, it might then be believed that "less" skilled venture capitalists would enter the market and reduce this difference in efficiency. Thus, some restrictions on the entry of less skilled venture capitalists seem necessary for this argument. Our argument does not need such an entry restriction, since we show that in an oligopoly, venture capitalists will produce more development than incumbents in equilibrium. Moreover, we show that to exist in equilibrium, they must be substantially more efficient, otherwise incumbents will preemt venture capitalists entering the market by acquiring basic innovations.

A commonly cited problem for the European economies is the lack of a thriving entrepreneurial sector, not the least as compared to the Anglo-Saxon economies, and that the lack of a well-functioning venture capital market might be one of the important explanations for this. The results in this paper suggest that the lack of a well-functioning venture capital market would be most detrimental to the speed of innovation in industries with a high return to investment, since the strategic product market effects would be particularly strong in these types of markets. Consequently, our model predicts that the entrepreneurial sector in Europe should be relatively less successful in serving industries such as the high tech industries, where R&D spending is high, and relatively more successful in industries such as textile and restaurants, with low levels of R&D.

Moreover, our model predicts that the less efficient venture capital market in Europe would lead to more preemptive acquisitions by large incumbent firms, leading to lower levels of development of basic innovations in Europe, and thereby a lower return to R&D measured in output.

Our results indicate that consumers are likely to benefit from a well-functioning venture capital market, since total output is likely to increase. Moreover, total surplus is also likely to be higher when the relative cost of innovations is sufficiently low. However, established firms would be likely to lose from the presence of a venture capital market, since the venture-backed firm captures more of the industry surplus than what its innovation creates. Indeed, if the relative cost of innovation is sufficiently high, the negative effects on established firms' profits could dominate the positive gain for consumers from the increase in innovations, thereby leading to the total surplus being reduced when a venture capital market is introduced.

Naturally, the model used is restrictive in several dimensions. First, we have assumed that the incumbent firm keeps the innovation when acquiring it. It might be the case that after development, it might benefit from reselling it to one of its rivals. However, in the Appendix, we show that in this symmetric set-up, the incumbent firm will be indifferent between selling and keeping the developed innovation. But, in a setting with asymmetric

firms, an incumbent firm would not be indifferent between selling and not selling. If there is a sufficiently more efficient owner in the market, a sale is likely to take place. However, it is also likely that it is costly to sell an innovation to a rival firm, due to different types of transaction costs. For instance, it likely that the value for the buyer would decrease since it is difficult for the seller to commit not to use its knowledge about the innovation to develop a similar product in the future. In this paper, we therefore assume that the incumbent firm keeps the innovation if acquiring it. Yet, it is interesting to better understand when incumbent firms would keep new innovations and when they would sell them to rival firms. This is an issue left to future research.

Second, it might be questionable whether the venture-backed firm has the ability to develop as efficiently as the acquiring incumbent firm, or in line with its specific needs. The above finding might explain why a venture-backed firm does develop basic innovations, even though being inferior when it comes to development.

Third, the incumbent firms' valuations of the innovation might differ substantially. For example, the acquiring incumbent might have firm-specific assets particularly well matching the innovation for sale. The acquiring incumbent might then have a stronger incentive to develop the basic innovation than the venture-backed firm. To see this, note that the acquisition price equals the valuation of the innovation for the incumbent firm with the second highest valuation. This incumbent firm's valuation might then not be so sensitive to development, while the acquiring incumbent's profit is. However, also note that the opposite might be true. It then follows that the venture-backed firm's incentive to invest relative to that of the acquirer increases even further.

Conducting a welfare evaluation of the existence of a venture capital market is outside the scope of this paper. However, let us discuss some welfare implications that might indicate some areas of interesting future research. Let us start with consumer surplus effects. It follows directly that the consumer surplus will be at least as high under the industrial organization with venture capitalists as in that without venture capitalists. This follows directly from Proposition 2, where it was shown that the investment levels will be

highest in the industrial organization with venture capitalists. Moreover, it follows from Lemma 2 that the effort level will be higher and thus, the probability of an innovation will increase. Accordingly, the expected consumer surplus will be at least as high in the industrial organization with as in the one without venture capitalists.

Let us now turn to total surplus effects. Here, the analysis becomes more involved since the producer surplus might be reduced when a venture capital market is introduced. To see this, consider the situation where we assume the total cost of the innovation to be equal to the expected gain. This implies that no expected surplus is captured by the entrepreneur. It then follows that the introduction of a venture capital market will decrease the expected total producer surplus in the industry, which follows from the fact that non-acquiring firms' profits decrease in the development level of the innovation and that in equilibrium, the acquirer's net profit cannot exceed the profit of a non-acquiring firm. Consequently, the expected aggregate producer surplus decreases in this special case. It is left to future research to evaluate these welfare effects in detail.

A. Appendix:

A.1. Proof of Lemma 1

First, consider the equilibrium candidate where incumbent i_w acquires the innovation, denoted $\mathbf{b}^*$. Note that $b^*_{i_w} > v_i - \varepsilon$ is a weakly dominated strategy, since no owner will post a bid over its maximum valuation of obtaining the innovation. If $b^*_{i_w} < v_i - \varepsilon$, firm i_s benefits from deviating to $b^{**}_{i_s} = b^*_{i_w} + \varepsilon$, since it then obtains the innovation and pays a price lower than its valuation of obtaining it. Last, consider candidate $b^*_{i_w} = v_i - \varepsilon$, $b^*_{i_s} = v_j - 2\varepsilon$. Then, no owner has an incentive to deviate. Thus, this is a Nash equilibrium and the only NE where firm i_w obtains the assets.

Second, note that the situation where no incumbent obtains the innovation cannot occur if there is no reservation price at the auction. ■

A.2. Proof of Lemma 5(ii)

Consider the equilibrium candidate where incumbent firm i_w obtains the innovation and where venture capitalist j_s has the second highest bid, denoted b^*. Then, $b^*_{i_w} > v_V$ is not an equilibrium since firm i_w would then benefit from deviating to $b_{i_w} = v_V$ since $b^*_{j_s} < v_V$, otherwise venture capitalist j_s uses a dominated strategy. $b^*_{iw} < v_V - \varepsilon$ is not an equilibrium, since venture capitalist j_w would then benefit from deviating to $b_{j_w} = v_V - \varepsilon$. If $b^*_{i_w} = v_V$ and $b^*_{j_s} = v_V - \varepsilon$, then firm i_w has no incentive to deviate. By deviating to $b'_{i_s} \leq b^*_{i_w}$, firm i_s's, $i_s \neq i_w, i_s$'s payoff does not change. By deviating to $b'_{i_s} > b^*_{i_w}$, firm i_s's payoff decreases, since it must pay a price above its willingness to pay, v_{ii}. Accordingly, firm i_s has no incentive to deviate. Venture capitalist j has no incentive to deviate since $b'_j \geqslant b^*_{i_w}$ is a dominating strategy and the payoff does not change by deviating to $b'_j < b^*_{i_w}$.Thus, b^* is a Nash equilibrium. There is also a similar equilibrium where $b^{**}_{i_w} = v_V - \varepsilon$ and $b^*_{j_s} = v_V - 2\varepsilon$. However, since ε is very small, we treat them as the same equilibrium in the main analysis.

Consider the equilibrium candidate where venture capitalist j_w obtains the innovation,

denoted b^*. First, note that $b^*_{j_w} > v_V - \varepsilon$ is a dominating strategy. Then, note that if $b^*_{j_w} \leq v_V - \varepsilon$, incumbent i_w has an incentive to deviate to $b'_{i_w} = b^*_{j_w} + \varepsilon$ since $v_{IV} > v_V$. This contradicts the assumption that b^* is a Nash Equilibrium. ■

B. The Linear Quadratic Cournot Model

Tables B.1 and B.2 are used to derive Figure 5.1. Table B.1 provides information on investment levels, output and net profits in the linear quadratic Cournot model. Table B.2 shows the expressions for stage 1 valuations.

Table B.1: The Linear Quadratic Cournot model.

	Development by:	
	Incumbent firm (A):	Venture Capitalist (V)
k_h^* :	$\frac{4\eta}{9-8\eta}\Lambda$,	$\frac{2\eta}{3-2\eta}\Lambda$,
x_A^* :	$s\frac{3}{9-8\eta}\Lambda$	$\frac{s}{3}\left(\frac{3+2\eta}{3-2\eta}\right)\Lambda$
x_{NA}^* :	$s\frac{3-4\eta}{9-8\eta}\Lambda$	$\frac{s}{3}\left(\frac{3-4\eta}{3-2\eta}\right)\Lambda$
$R_A(k_h^*) - C(k_h^*)$:	$s\frac{1}{9-8\eta}\Lambda^2$	$s\left(\frac{9-6\eta+4\eta^2}{3-2\eta}\right)^2\Lambda^2$
$R_{NA}(k_h^*)$:	$s\left(\frac{3-4\eta}{9-8\eta}\right)^2\Lambda^2$	$\frac{s}{9}\left(\frac{3-4\eta}{3-2\eta}\right)^2\Lambda^2$

C. Proof that the incumbent firm is indifferent between selling the innovation and keeping it.

We first derive the optimal restructuring level for an incumbent firm that is about to sell the innovation to one of its rivals. A innovation selling established firm invests in development of the basic innovation, maximizing the net sales price of a developed innovation net the

Table B.2: Valuations in the Linear Quadratic Cournot model.

Stage 1- valuations
$v_{II} = R_A(k_A^*) - C(k_A^*) - R_{NA}(k_A^*) = 16s\eta\frac{(1-\eta)}{(9-8\eta)^2}\Lambda^2$
$v_{IV} = R_A(k_A^*) - C(k_A^*) - R_{NA}(k_V^*) = \frac{4s}{9}\eta\frac{\left(32\eta^2-75\eta+45\right)}{(3-2\eta)^2(9-8\eta)}\Lambda^2$
$v_V = R_A(k_V^*) - R_{NA}(k_V^*) - C(k_V^*) = \frac{2s}{3}\eta\frac{1}{(3-2\eta)}\Lambda^2$
Differences in stage 1-valuations:
$v_{IV} - v_V = \frac{2s}{9}\eta\frac{(3-4\eta)^2}{(9-8\eta)(3-2\eta)^2}\Lambda^2$
$v_{II} - v_V = -\frac{2s}{3}\eta\frac{(3-4\eta)^2}{(9-8\eta)^2(3-2\eta)}\Lambda^2$

reduction in its own product market profit, i.e., $S^D(k_I)-C(k_I)+R_{NA}(k_I)$. Recall that it is assumed that the venture-backed firm and the incumbent firms face the same variable cost function when investing in development. Using Lemma 1 and (3.8), this problem is then defined as:

$$\underset{\{k_I\}}{Max}: \; S^D(k_I)-C(k_I)+R_{NA}(k_I) \tag{C.1}$$

$$s.t \;\; : \;\; S^D(k_V) = \begin{cases} R_A(k_I) - R_{NA}(k_I): & k_A^* \leq k_I \\ R_A(k_A^*) - C(k_A^* \mid k_I) - R_{NA}(k_A^*): & k_A^* > k_I \end{cases} \tag{C.2}$$

$$s.t \;\; : \;\; C(k_A^* \mid k_I) = \int_{k_I}^{k_A^*} C'(k)dk.$$

The first-order condition, given that $k_I < k_A^*$, is

$$\frac{dS^D}{dk_I} = C'(k_I): \qquad k_I < k_A^*. \tag{C.3}$$

However, using that $S^D(k_I) = R_A(k_A^*) - C(k_A^* \mid k_I) - R_{NA}(k_A^*)$ for $k_I < k_A^*$ implies that $\frac{dS^D}{dk_I} = \frac{d}{dk_I}\int_{k_I}^{k_A^*} C'(k)dk = C'(k_I)$; consequently, the acquisition price increases with the same amount as the cost of development. Hence, any k_I in this interval will be optimal.

In contrast, if the innovation selling incumbent reflects on a development choice $k_I >$

k_A^*, it maximizes $R_A(k_I) - R_{NA}(k_I) - C(k_I) + R_{NA}(k_I)$ and hence, the first-order condition now becomes:

$$\frac{dS^D}{dk_I} = \frac{dR_A}{dk_I} = C'(k_I^*) : \qquad k_I > k_A^*, \tag{C.4}$$

where, once more, we assume $C(k)$ to be sufficiently convex so that $R_A(k_I) - C(k_V)$ is strictly concave in k_I. Comparing expressions (C.4) and (3.6), we see that the selling incumbent firm has the same incentive to invest in development as the the acquiring firm which keeps the innovation. The reason is that the increases in the acquisition price stemming from the negative externalities on the non-acquirer is eliminated by the negative effect on the own product market profit from remaining in the market. Moreover, it is indeed also optimal for the acquiring firm to fully use the venture capitalist investment, i.e. $k_A^{opt} = k_I^*$, since more capital is assumed to increase product market profits.

We have the following result:

Lemma 6. *The optimal level of development by a incumbent firm which resells the developed innovation to an incumbent firm is equal to the optimal level of development by the acquiring incumbent firm, i.e.* $k_I^* = k_A^*$.

Thus, Lemma 6 shows that a incumbent firm which resells the developed innovation to an incumbent firm has an equally strong incentive to develop an innovation as an incumbent firm keeping the innovation.

Let us now turn to the issue of whether the incumbent will sell the innovation to one of its rivals or keep it. When keeping the assets**,** the profit is $R_A(k_A)$ and when selling the assets**,** the profit is $R_A(k_A) - R_{NA}(k_A) + R_{NA}(k_A)$. Consequently, it follows that an incumbent firm is indifferent between selling and keeping the assets. Thus**,** we have the following result:

Lemma 7. *An incumbent firm is indifferent between selling the innovation to a rival and keeping it.*

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