Corporate Venture Capital and the Nature of Innovation

Hannes Maxin[a]

[a]Department of Economics, University of Hannover, Königsworther Platz 1,
30167 Hannover, Germany, E-mail: maxin@mik.uni-hannover.de.

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ABSTRACT
This paper investigates a model where two corporate venture capital firms (CVCs) decide whether to finance a new venture stand-alone or together, called syndication. The CVCs obtain a cash flow if the venture succeeds. In addition, the venture has a positive or negative effect on an asset (e.g. a product or a process) of the CVCs parental companies. This effect may differ among the parental companies. I show that the CVC faced with the weaker positive effect becomes the stand-alone investor only if the cash flow is low. Otherwise, in equilibrium, there are only syndicates or stand-alone investments of the CVC with the stronger positive effect. However, if one CVC faces a positive effect on its parental company's asset whereby the opponent faces a negative effect, then a syndicate is still possible. The model generates empirical predictions for syndicates consisting of several CVCs.

KEYWORDS
Corporate Venture Capital; Syndication; Venture Capital; Nonmonetary Support; Nature of Innovation

1. Introduction

Corporate venture capital plays an important role in financing young firms with uncertain but high growth expectations. I define *corporate venture capital* as minority equity investments by an incumbent company in entrepreneurial firms, similar to Dushnitsky (2012). After passing cyclical investment waves in the last decades, National Venture Capital Association (2018) states that nearly 16% of all venture capital deals are realized with the help of incumbent companies nowadays.[1]

The incumbents frequently use specialized subsidiaries that allocate their corporate venture capital towards young firms. A typical feature of these corporate venture capital firms (CVCs) is that they pursue two different goals: beside high financial returns (e.g. initial public offering or the sale of ownership stakes), there are often more diverse and complex innovation objectives (e.g. an access to new products, a window on new technologies or generating demand).[2] Hence, corporate venture capital can be seen as an access to otherwise untapped innovations that are critical to the incumbents success and longevity.

[1]For a detailed description of the historical background see, for instance, Dushnitsky (2008) and Dushnitsky (2012).

[2]See, for instance Winters and Murfin (1988), McNally (1997), Riyanto and Schwienbacher (2006), Benson and Ziedonis (2009).

By contrast, independent venture capital firms (IVCs) are only driven by financial returns due to the absence of a parental company. As it is well known, both investor types often share the financing cost and the nonmonetary support with other investors. This so-called syndication means in a restrictive sense that a cooperation of two or more investors takes place in a particular financing round. If the term is used more broadly, it also describes situations where investors enter different financing rounds. The former definition can be seen as basis for this paper.

Empirical observations suggest a lack of research about the determinants of syndicates consisting of several CVCs. Park and Steensma (2012) and Souitaris and Zerbinati (2014) state that syndicates between several CVCs are difficult to form. The subsidiaries seek to create an innovation advantage for their parental companies. However, a syndicate with a competitor's investor can prevent this advantage because the other incumbent obtains, for instance, a window on new technologies, too. Beside this, the funds of a CVC syndicate can also contribute to the success of a venture that provides a stronger innovation advantage for the parental company's competitor (spillover risks). Therefore, CVCs prefer to finance ventures with the help of other investors, which are not related to an incumbent (e.g. IVCs). In line with the above literature, Ivanov and Xie (2010) remark that 'CVCs may prevent their portfolio companies from forming alliances with their parent corporations' competitors even though such alliances can bring significant [..] benefits to the start-ups'(p. 133).

Innovative ventures should not only be seen as a positive occurrence for incumbents, in the sense of a complementary effect for their products and technologies. In fact, their innovations can also be characterized as substitutes for some incumbents' assets (Masulis and Nahata 2009). Therefore, the venture's nature of innovation (i.e. complement vs. substitute for the CVCs' parental companies) can lead to conflicts between corporate investors that engage in a syndicate due to their different willingness to provide nonmonetary support (so-called principal-principal conflicts). In this case, syndication between CVCs can have a negative side for the investors, which may also explain why CVCs prefer to cooperate with other investors types (Colombo, Croce, and Murtinu 2014).

Figure 1 plots the number of ventures financed by a stand-alone CVC and by a syndicate consisting of more than one CVC in the USA during the period 1997-2017. In contrast to the above studies, Figure 1 shows that a high number of CVCs cooperate with other CVCs to finance their ventures. Interestingly, it also shows that there is a difference between stand-alone investments and syndicates concerning the venture's nature of innovation (i.e. complement or substitute for the CVC's parental company).

"Insert Figure 1 Here"

In line with this evidence, Sharifzadeh and Walz (2012) and Dimitrova (2015) show that syndicates between several CVCs are not unusual. Moreover, MacMillan et al. (2012) remark that 30% of their investigated CVCs classify other CVCs as important syndication partners. There are also examples where a CVC (e.g. AMD Ventures) initially finances a venture (e.g. InContext Solutions) without any other corporate investor. However, at a later point of time, other CVCs (e.g. Intel Capital) are allowed to participate in the investment, such that a syndicate occurs.[3]

Obviously, the research literature is inconclusive in terms of CVC syndicates. Motivated by these preliminary considerations, I formulate the following research question:

[3]Nevertheless, we focus in this paper only on syndicates where a cooperation of two investors takes place in the same financing round.

what impact does the venture's nature of innovation has on a CVC's syndication decision?

By studying this issue, I state under which conditions a syndicate between several CVCs can occur and emphasize the benefits of this specific cooperation type. In detail, I consider a model where two CVCs have to decide whether to finance a venture as a stand-alone investor or to syndicate with each other to share the investment costs. The critical points are the innovation objectives of the corporate investors. I assume that the success of the venture affects the values of some assets (e.g. products or processes) owned by the parental companies. This change in the assets' values may be positive or negative. Hence, the model has the following two polar cases for the *nature of innovation*: the venture can be a complement (*positive nature*) or a substitute (*negative nature*) for the parental company.[4]

In the model, the change in the assets' values may vary among the incumbents. Thus, the venture can be a weak complement for a parental company, while it is also a strong complement for the other. In reality such a situation may exist if, for example, a CVC has a focus on the IT sector, whereas another CVC is an investor with banking background. Then, a young fintech firm's product can be seen as a complement for both parental companies. However, it may provide a stronger innovation advantage for the latter's parental company in comparison with the former's parental company.

For the model, it is important to point out that the change in the asset's value may be viewed as a positive externality. To understand this, notice that it is sufficient that a stand-alone investor finances the venture. However, the venture's success affects the assets of both parental companies. Thus, a parental company can obtain an innovation advantage without incurring any investment costs.

In this paper, I focus on the CVCs' perspective in terms of their innovation objectives as well as on the investment decision.[5] The main results are the following: first, if the venture is a complement for both CVCs, then the CVC with the weaker complement may become the stand-alone investor only if the venture leads to a low cash flow. The intuition of this result is the following: the venture's success can be considered as a costless impact on some of the incumbent's assets if the other CVC bears the investment costs. Thus, if the cash flow is low and the innovation advantage is sufficiently strong, then a CVC can be better-off to abandon an investment and the monetary returns, respectively.

Second, for a higher cash flow, there are solely syndicates between both investors and stand-alone investments of the CVC with the stronger complement. To understand this point, notice that a syndicate provides a higher support level than a stand-alone investor due to the combined nonmonetary support of two CVCs. I call this the *corporate venture capital value-added hypothesis*. However, the investors have to share the monetary returns of their investment. Syndication can be beneficial for a CVC except if the other CVC obtains a weak innovation advantage. Due to this lower innovation advantage, the potential syndication partner provides a lower support level. Consequently, a stand-alone investment occurs, which also provides a higher cash flow participation for the investor in comparison to a syndicate

I also provide interesting results in terms of ventures whose success has a negative effect of some of the parental companies' assets. In detail, if an investor is confronted

[4]Gompers and Lerner (2000), Park and Steensma (2012) and Dushnitsky (2012) state that corporate venture capital is used to finance complementary ventures. However, Masulis and Nahata (2009) show with their sample, that substitutes are corporate-backed as well.

[5]For simplification, I write that the CVCs obtain the utility of an investment and not the particular parental company.

with a substitute and the other investor faces a complement, then the former investor has an incentive to undermine the venture and to protect its parental company. Consequently, a potential syndicate provides a lower combined support level in comparison to a stand-alone investment of the complementary CVC. However, I show that syndicates between both investors are still possible because they can share the investment costs. These cost reduction compensate the lower value-added, so that a syndicate can also be established by CVCs with countervailing incentives (complement vs. substitute).

An investment situation involving only CVCs may occur because, in contrast to other investor types like independent venture capital firms (IVCs), corporate investors have the ability to support the young firms better by using certain resources.[6] Park and Steensma (2012), for instance, stress that the mobile broadband service provider Airvana succeeds because of its CVC's cost-intensive testing infrastructure owned by the parental company. Emphasizing the importance of the support, Chemmanur and Loutskina (2008) also remark that CVCs provide specialized industry expertise to enable a successful development of their ventures.

This paper is closely related to Hellmann (2002). An important difference is that I focus on the investment decision of two CVCs, whereas Hellmann (2002) investigates the choice of the venture between an IVC and a CVC. Hence, I consider the change in the asset's value for each corporate investor. Moreover, I state that the *value-added* of a syndicate is an important factor. Consequently, I allow all syndication partners to provide nonmonetary support to the venture, in contrast to Hellmann (2002). To my knowledge, no other theoretical paper considers a financing situation with two CVCs.

Syndicates consisting solely of IVCs are widely observed: Brander, Amit, and Antweiler (2002) analyze different theoretical hypotheses that offer rational for syndicates of this investor type. Their empirical study favoring the *value-added hypotheses*, which suggests that syndicates lead to higher cash flows than stand-alone investments due to the different nonmonetary support of several financiers.[7] Tian (2011) examines venture capital syndicates from the point of view of the ventures. Compared to stand-alone investments, he shows that syndicates create a product market value and a financial market value for the ventures. Moreover, Casamatta and Haritchabalet (2007) and Cestone, Lerner, and White (2006) formally show that an additionally screening advise on a potential venture is the reason for a syndicate. In this way, they follow the *selection hypothesis* of Lerner (1994).

The syndication decision of IVCs that are confronted with a CVC as syndication partner is only partially analyzed. Hill et al. (2009) state that syndicates between corporate investors and IVCs lead to a higher investment output per year and a lower closure rate among ventures. In contrast, Colombo and Murtinu (2017) expose the impact exerted on venture's overall economic performance by IVC, CVC and mixed IVC-CVC syndicated investments. The authors show that on average IVC-CVC syndicates do not lead to any improvement in terms of the economic performance. A possible reason can be the presence of principal-principal agency costs generated by conflicting objectives of different investor types. Hellmann (2002) provides the first explicit model and examines the entrepreneur's choice between a CVC and an IVCs. Hellmann (2002) supposes competition for both the valuation and the nonmonetary support. Similar to the present model, Hellmann (2002) stresses that corporate venture

[6] See, for instance Block and MacMillan (1993), Maula (2001), Dushnitsky (2008) and Ivanov and Xie (2010).

[7] Sharifzadeh and Walz (2012) remark six reasons for syndication: risk-sharing (Brander, Amit, and Antweiler 2002), selection (Sah and Stiglitz 1986; Lerner 1994), value-added (Brander, Amit, and Antweiler 2002), steady deal flow (Hochberg, Ljungqvist, and Lu 2007), window dressing (Lerner 1994) and staged financing problems (Fluck, Garrison, and Myers 2005).

capital investments depend strongly on the nature of innovation of the entrepreneur's product. As a result, the analysis shows that if the young firm is a complement to the large company, the CVC is chosen by the entrepreneur. On the other hand, the IVC is the optimal choice if the young firm is a weak substitute. Syndication is optimal, such that the CVC cooperates with the IVC, only if the young firm is a strong substitute.

Another strand of literature considers conflicts between different types of IVCs in syndicates. Cumming, Grilli, and Murtinu (2017) show that the higher the institutional heterogeneity in IVC syndicates, the more likely a venture is liquidated due to conflicting objectives of the investors. The authors also note that if the nonmonetary support of one IVC is substitutable with that of another IVC, then the overall value-added can be reduced because the IVCs are in conflict with one another in terms of who is responsible for supporting the venture. Moreover, the intrinsic differences between heterogeneous IVCs can exacerbate agency and transaction costs for the syndicate members due to the sharing of formal decision making powers among the investors (Grilli and Murtinu 2014). Wright and Lockett (2003) highlight that decisions of a syndicate are typically reached following discussion and consensus. However, in case of conflicts, they also show the importance of the lead investor, in the sense of ensuring timely decisions. This outstanding role of the lead IVC based on the fact that the lead investor holds a larger equity stake than the non-lead members of the syndicate and thus, the lead IVC has a greater decision power.[8]

More generally, these conflicts between syndication partners can be described as principal-principal conflict with horizontal agency costs.[9] Clearly, conflicts between syndication partners can also arise in the case of CVC syndicates due to their innovation objectives, which lead to different interests and preferences and the time-consuming nature of coordination between them (Colombo, Croce, and Murtinu 2014). However, I formally show that syndicates between CVCs with countervailing incentives (complement vs. substitute) are still possible because of the possibility to share the investment cost. This result occurs only for lower substitutes; otherwise syndicates cannot occur.

The remainder of the paper is organized as follows: in the next section I introduce the theoretical model. Section 3 presents the analysis of the investment decision of both CVCs. Section 4 covers some interesting extensions. In Section 5, I derive empirical predictions from the theoretical results and review existing empirical evidence. The last section concludes. All proofs are included in the appendix.

2. The Model

I consider two risk-neutral CVCs, CVC_i with $i \in \{1, 2\}$, and a wealthless venture which needs a capitalization normalized to 1. There are two possible future states of nature that I call success and failure. If CVC_i decides to finance the new venture and it succeeds, then CVC_i obtains the cash flow $R > 1$. If the venture fails, there are no cash flows. Success occurs with probability $q \in (0, 1)$. If CVC_i does not finance the venture, then it obtains a risk-free cash flow, normalized to 1.

[8]See, for more details on conflicts in syndicates Gompers and Lerner (2004), Cumming, Siegel, and Wright (2007), Cumming and Dai (2011), Chahine et al. (2012), Grilli and Murtinu (2014) and Grilli and Murtinu (2015).

[9]For a more detailed description of principal-principal conflicts see, for instance, Filatotchev, Wright, and Arberk (2006) and Young et al. (2008). For principal-agent problems in the field of venture capital see, for example, Kaplan and Strömberg (2001).

In order to highlight the innovation objectives of CVCs, I suppose that a particular asset of the parental company is affected by the success of the venture, following Hellmann (2002). The asset can be thought of as a particular product or process. Specifically, the exogenous variable θ_i represents the change in the asset's value that is caused by the venture's success. The variable θ_i is well-known to all players and does not include any monetary cash flow. If $\theta_i \geq 0$, then the venture is a complement for the parental company's. If $\theta_i < 0$, then the venture substitutes the parental company's asset. Note that θ_i may differ among the parental companies. Therefore, a particular venture can be a complement for a parental company, while it is also a substitute for the other.[10] The venture Chronocam, for instance, that is financed by Intel's and Bosch's CVCs can be seen as a complement for the first and as a substitute for the latter parental company.

CVC_i decides on the nonmonetary support $s_i \in [-1, \infty)$ at the private cost $c(s_i) = \frac{1}{2} \cdot (s_i)^2$. Hence, the CVCs have the possibility to *nurture* (i.e. $s_i \geq 0$) or *undermine* (i.e. $s_i < 0$) the venture, in contrast to Hellmann (2002) and Riyanto and Schwienbacher (2006).[11] Masulis and Nahata (2009) and Ivanov and Xie (2010) have shown that one reason for undermining is the obstruction of the survival of a venture that may turn out to be a possible competitor to the parental company. In this model, the nonmonetary support does not have an impact on the success probability q. It can be seen as a *value-added* or an increase of the value of the venture, namely $(1 + s_i) \cdot (R + \theta_i)$.[12] An investor determines simultaneously with its investment decision the particular support value. The support activities are by and large complex (e.g. mentoring, endorsement to clients) so that they cannot be stated in a contract upon, in contrast to Riyanto and Schwienbacher (2006) and Casamatta and Haritchabalet (2007).

If a contract is offered, then the venture contracts with at least one of the CVCs, which is a simplifying assumption. However, this assumption is not critical since I consider a setting, where the venture needs a specialist investor to have success.[13] For instance, young fintech firms are confronted with comprehensive regulatory conditions (e.g. bank licenses or deposit guarantee), so that an adequate support (i.e. infrastructure) by an incumbent company or its CVC is mandatory for their business. In line with this, several empirical studies found evidence that entrepreneurial firms have a high incentive to obtain external funds and nonmonetary support by a CVC.[14]

All parties have symmetric information. I characterize subgame-perfect equilibria as the solution concept for the following two investment settings.

2.1. Stand-Alone Case

The stand-alone setting is represented by a sequential game with two stages. CVC_1 decides first between investment and no investment. If CVC_1 chooses the latter, then

[10] Chesbrough and Tucci (2002) show that CVC investments may be a complement or a substitute for the internal R&D activities of the parental company. Thus, θ_i can be also interpreted as the impact on the internal R&D activities of the parental company.

[11] For simplification, I write that the variable s_i represents a nonmonetary support although it could be negative.

[12] Note, if $s_i = -1$, then the venture is liquidated by its investor.

[13] I suppose that the CVCs have all the bargaining power or in other words, the venture obtains zero profit, following Riyanto and Schwienbacher (2006). Moreover, the venture has no outside option in the sense of an IVC due to my focus on CVCs. However, the model can easily adapted to such a case. I will discuss this later in the paper.

[14] See for example Gompers and Lerner (2000), Maula (2001), Hochberg, Ljungqvist, and Lu (2007) and Ivanov and Xie (2010).

CVC_2 has the opportunity to offer a contract at the next stage.[15] A stand-alone investment may emerge in markets in which each CVC wants to prevent influence of other corporate investors on the venture. Suppose CVC_i finances the venture. The expected utility is then given by

$$U_i^j = q \cdot (R + \theta_i) \cdot (1 + s_i) - \frac{1}{2} \cdot (s_i)^2 - 1, \text{ if i = j.} \tag{1}$$

The superscript $j = 1, 2$ refer to the particular investor and the subscript $i = 1, 2$ refers to the utility of the considered CVC. If CVC_j finances the venture, then CVC_i obtains the externality θ_i, without incurring any costs. CVC_i invests the funds in the risk-free alternative and obtains zero profit. CVC_i's expected utility is then given by

$$U_i^j = q \cdot \theta_i \cdot (1 + s_j), \text{ if i} \neq \text{j.}$$

Note that the change in the asset's value is reinforced by the nonmonetary support of the opponent. For this investment pattern, the innovation component may be described as a positive externality for complements and as a negative externality for substitutes. If both CVCs reject the venture, then each CVC only obtains $U_i^{no} = 0$ because the risk-free alternative and the investment amount are normalized to 1.

2.2. Syndication Case

In the syndication case, I consider a syndicate, in which both CVCs invest jointly. The CVCs decide simultaneously on the support level s_i, with $i \in \{1, 2\}$. Given this, I show that there is a unique equilibrium in the support levels.

In a second step, I check if this syndicate satisfies the criterion of *stability*. The syndicate is *stable* if and only if it represents a Pareto improvement compared to the equilibrium of the stand-alone setting. Hence, the syndicate is *acceptable* for CVC_i if the utility from syndicate is equal or higher than in the stand-alone case. Otherwise, CVC_i *blocks* the syndicate and the stand-alone setting occurs. The expected utility of syndicate member CVC_i is given by

$$U_i^{syn} = q \cdot \left(\frac{1}{2} \cdot R + \theta_i\right) \cdot (1 + s_i + s_j) - \frac{1}{2} \cdot (s_i)^2 - \frac{1}{2}.$$

In a syndicate, CVC_i obtains half of the cash flow and finances half of the initial outlay.[16] The rest of the potential funds are invested in the alternative and will yield zero return. Thus, the primary cost of a syndicate is that both CVCs have to share the generated cash flow of their investment.[17] The change in the asset value θ_i is a private value for CVC_i and cannot be split. Furthermore, if a syndicate finances the venture, it obtains the support s_i of CVC_i and additional the support s_j of CVC_j.

[15] The results of the model also hold for a situation in which both investors decide simultaneously on an investment. The only difference is that multiple equilibria occur, which does not enrich the main insights of the model.

[16] The results are qualitatively unchanged if one CVC has larger shares or in other words if one CVC is the lead investor.

[17] Yung (2012) remarks that the cost of syndication do not only contain the shareholding. Moreover, to put another IVC on inquiry to a investment object may arise a potential competitor. See, for instance Casamatta and Haritchabalet (2007) and Cestone, Lerner, and White (2006).

This assumption is consistent with the *value-added hypothesis* suggested by Brander, Amit, and Antweiler (2002).[18]

3. Equilibrium Analysis

Without loss of generality, let $\theta_1 \geq \theta_2$. Additionally, I suppose that the venture is a complement for both CVCs ($\theta_i \in \mathbb{R}_+$). I will relax this assumption later and suppose that the venture is a complement for CVC_1 ($\theta_1 \geq 0$) but a substitute for CVC_2 ($\theta_2 < 0$). In the analysis, I will focus on the innovation advantage denoted by θ_i, because this variable can be seen as the CVCs' main characteristic.

3.1. Stand-Alone Case

In the stand-alone case, CVC_1 decides first whether to invest or not. If CVC_1 decides on an investment, then the venture obtains funds from this investor and the game ends. On the other hand, if CVC_1 has not invested, then CVC_2 can decide on an investment.

Consider first the latter case. If CVC_2 decides to finance the venture, then it provides nonmonetary support in order to increase the value of the venture. I derive the optimal support value $\widehat{s}_2$ by solving the respective maximization problem of equation (1):

$$\widehat{s}_2 = \underset{s_2 \in \mathbb{R}}{\operatorname{argmax}} \left\{ q \cdot (R + \theta_2) \cdot (1 + s_2) - \frac{1}{2} \cdot (s_2)^2 - 1 \right\}.$$

The solution to this problem is given by:

$$\widehat{s}_2 = q \cdot (R + \theta_2).$$

Note that the weaker (stronger) the complement the lower (higher) is the nonmonetary support of CVC_2. Likewise, the lower (higher) the cash flow the lower (higher) is the nonmonetary support of CVC_2.

Given that CVC_1 has not invested, CVC_2 thus obtains $U_2^2(\widehat{s}_2)$ if it finances the venture and U_2^{no} otherwise. Comparing these utility levels, the following condition has to be fulfilled for an investment:

$$q \cdot (R + \theta_2) \cdot (1 + \widehat{s}_2) - \frac{1}{2} \cdot (\widehat{s}_2)^2 - 1 \geq 0. \tag{2}$$

Substituting the optimal support $\widehat{s}_2$ into expression (2), yields

$$q \cdot (R + \theta_2) \cdot [1 + q \cdot (R + \theta_2)] - \frac{1}{2} \cdot [q \cdot (R + \theta_2)]^2 - 1 \geq 0 \Leftrightarrow$$

$$\theta_2 \geq \frac{\sqrt{3} - 1}{q} - R \equiv \overline{\theta}_2. \tag{3}$$

[18] By contrast, Hellmann (2002) and Casamatta and Haritchabalet (2007) suppose that only the lead investor of a syndicate provides nonmonetary support.

It is easy to show that $\partial\overline{\theta}_2/\partial q < 0$ and $\partial\overline{\theta}_2/\partial R < 0$. Hence, if the success probability or the cash flow increases, then weaker complements can be financed by CVC_2. To understand this point, consider, for instance, an increase in the cash flow. Then, CVC_2 obtains a higher monetary return and thus, it can accept a lower innovation advantage for a valuable investment. In other words, the higher the cash flow, the less is the investment decision driven by the innovation component.

Intuitively, there exists a threshold, for which CVC_2 decides to finance all ventures, whenever the cash flow is above this threshold:

$$\overline{\theta}_2 < 0 \Leftrightarrow R > \frac{\sqrt{3}-1}{q} \tag{4}$$

Due to this high cash flow level, CVC_2 will always allocate funds towards the venture. Or in other words, the investment decision is only driven by the financial component.

Working backwards, I investigate the optimal action of CVC_1. Suppose first it decides to invest because the venture provides a high expected utility for the investor. Similar to its opponent, CVC_1 provides nonmonetary support in order to increase the value of the venture. The optimal support is analogously given by $\widehat{s}_1 = q \cdot (R + \theta_1)$.

Suppose now condition (3) is not fulfilled, in the sense that CVC_2's innovation advantage is too low for a valuable investment. Then, CVC_2 chooses not to finance the venture and invests the funds in the risk-free alternative with zero profits.

Nevertheless, the venture can be a valuable investment for CVC_1. The intuition is the following: the innovation component θ_i is a private benefit and thus, the investment decision can differ among both CVCs. In reality such a situation may exist if, for example, CVC_2 has a focus on the IT sector, whereas CVC_1 is an investor with banking background. Then, a young fintech firm's product can be seen as a complement for both parental companies. However, it may provide a stronger innovation advantage for CVC_1's parental company in comparison with CVC_2 and thus, the fintech firm is a valuable investment for CVC_1 rather than CVC_2.

Given these preliminary considerations, I check CVC_1's investment decision, in the sense of a comparison of the utility levels $U_1^1(\widehat{s}_1)$ and U_1^{no}. The resulting threshold is analogous to condition (3):

$$\theta_1 \geq \frac{\sqrt{3}-1}{q} - R \equiv \overline{\theta}_1. \tag{5}$$

If the success probability or the cash flow increases, then weaker complements can be financed by CVC_1. Analogously to condition (4), CVC_1 can finance all ventures, if the cash flow is very high, i.e. $R > \sqrt{3}-1/q$.

Last, I assume that condition (3) is fulfilled. Then, CVC_2 can finance the venture if CVC_1 abandons an investment. However, in this case, CVC_1 obtains the innovation advantage θ_1 without incurring any costs (positive externality), i.e. the utility level $U_1^2(\widehat{s}_2)$. Moreover, this utility level is reinforced by the nonmonetary support of CVC_2. On the other hand, if CVC_1 chooses to invest, then it obtains the innovation advantage θ_1 plus the cash flow R in return for the capitalization, i.e. the utility level $U_1^1(\widehat{s}_1)$. CVC_1 provides its own nonmonetary support. Therefore, I have the following condition:

$$U_1^1(\widehat{s}_1) \geq U_1^2(\widehat{s}_2) \Leftrightarrow q \cdot (R + \theta_1) \cdot (1 + \widehat{s}_1) - \frac{1}{2} \cdot (\widehat{s}_1)^2 - 1 \geq q \cdot \theta_1 \cdot (1 + \widehat{s}_2). \tag{6}$$

Substituting the optimal supports $\widehat{s}_1$ and $\widehat{s}_2$ into expression (6), yields

$$q \cdot (R+\theta_2) \cdot [1+q(R+\theta_1)] - \frac{1}{2} \cdot [q \cdot (R+\theta_1)]^2 - 1 \geq q \cdot \theta_1 \cdot [1+q \cdot (R+\theta_2)]$$

$$\theta_2 \leq \frac{R \cdot (2+qR)}{2q\theta_1} + \frac{\theta_1}{2} - \frac{1}{q^2\theta_1} \equiv \varphi(\theta_1). \tag{7}$$

Condition (7) states that CVC_1 will only finance the venture if and only if the innovation advantage of the opponent is sufficiently low. To understand this point, notice that $U_1^2(\widehat{s}_2)$ depends on the nonmonetary support of CVC_2. This support decreases if CVC_2's innovation advantage decreases and thus, CVC_1's utility level becomes also lower. Consequently, a stand-alone investment by CVC_1 is more likely to occur. In line with this, I have $\partial\varphi(\theta_1)/\partial R > 0$. This means that the benchmark $\varphi(\theta_1)$ becomes higher if the cash flow increases. In other words, it is more likely that CVC_1 will finance the venture due to the high monetary returns. Nevertheless, if the opponent's innovation advantage is sufficiently high, then CVC_1 can be better-off to obtain only its own innovation advantage without incurring any costs and a premium in the sense of CVC_2's high nonmonetary support.[19]

I summarize the above analysis in the following proposition, that states the equilibrium behavior of both CVCs in the stand-alone setting:

Proposition 3.1. (Stand-alone investment). *The stand-alone case has a unique equilibrium, that can be characterized as follows.*

(i) Suppose condition (4) *does not hold, in the sense of a lower cash flow. Then,*
  - *no investment occurs if and only if condition* (3) *and* (5) *do not hold.*
  - *CVC_2 becomes the investor if and only if condition* (3) *and* (5) *hold and condition* (7) *does not hold.*

(ii) Suppose condition (4) *holds, in the sense of a higher cash flow. Then, CVC_2 becomes the investor if and only if condition* (7) *does not hold.*

Otherwise, CVC_1 is the investor.

The equilibrium classes of the stand-alone setting are illustrated in Figure 2: each pair (θ_1, θ_2) is assigned to the respective investment pattern: stand-alone investment of CVC_1 and CVC_2 [Denoted by I], respectively, or no investment [Denoted by $\not{I}$]. Recall that the venture is a complement for both CVCs and $\theta_1 \geq \theta_2$.

"Insert Figure 2 Here"

Consider Figure 2. If the cash flow is higher, i.e. Proposition 3.1 part (ii), CVC_1 is better-off investing alone for more couples of $\{\theta_1; \theta_2\}$ in comparison to a lower cash flow level, i.e. part (i). The reasoning underlying this result is straightforward: the surplus of an investment is the combination of the cash flow and the change in the asset's value, that obtains a premium (value-added) through the cost-intensive support of the investor, less the capitalization. If the cash flow increases, then the value-added increases stronger than the costs of the optimal support. As a consequence, the venture becomes valuable for CVC_1 for a wider range of the couple $\{\theta_1; \theta_2\}$.

[19] I can also state that $\partial\varphi(\theta_1)/\partial q < 0$ if $q > 2/R$ and $\partial\varphi(\theta_1)/\partial q > 0$ if $q < 2/R$. Thus, the success probability has a varied impact on $\varphi(\theta_1)$. The intuition is the following: if $q > 2/R$ applies, then $\partial U_1^2(\widehat{s}_2)/\partial q > \partial U_1^1(\widehat{s}_2)/\partial q$. Therefore, CVC_1 prefers not to invest for more complements.

However, Figure 2 illustrates that CVC_1 does not invest if the venture is a stronger complement for both investors, even for a higher cash flow. The intuition of this result is the following: the innovation advantage θ_1 can be viewed as a positive external effect for CVC_1 because it occurs without costs once CVC_2 takes the investment. In addition, CVC_2 provides the costly support and thus, it increases the value of θ_1. This nonmonetary support increases when the own innovation advantage increases. Therefore, CVC_1 is better-off to abandon an invest and to choose the risk-free alternative if the venture is a stronger complement for both investors.

It seems worth noting that if CVC_2 invests, then it always provides the same or a lower nonmonetary support than CVC_1. To see this point, recall that I suppose that the latter investor obtains a higher innovation advantage in comparison to the former, i.e. $\theta_1 \geq \theta_2$ holds for the entire model. Given this, I have

$$\widehat{s}_1 \geq \widehat{s}_2 \Leftrightarrow q \cdot (R + \theta_1) \geq q \cdot (R + \theta_2) \Leftrightarrow \theta_1 \geq \theta_2.$$

Hence, CVC_1 will not provide a lower support level in comparison to CVC_2. Nevertheless, CVC_1 abandons in certain cases to finance the venture, such that the opponent takes the investment. This result occurs due to the innovation advantage, which can be viewed as a positive external effect for CVC_1. The positive externality can prohibit funding of the investor enabling higher nonmonetary support for the venture. In other words, the venture will be worse-off (in case that $\theta_1 > \theta_2$ holds) if CVC_2 is the investor. The following corollary of Proposition 3.1 emphasizes this point.

Corollary 3.2. *If CVC_2 is the stand-alone investor, then the nonmonetary support cannot be higher compared to the support of a stand-alone investor CVC_1.*

3.2. Syndication Case

In this section, I consider a syndicate in which each CVC_i obtains U_i^{syn}. According to the idea of the *value-added hypothesis*, both CVCs provide nonmonetary support for the venture. The CVCs decide simultaneously on the nonmonetary support level s_i, with $i \in \{1, 2\}$. The following proposition shows that there exists a unique equilibrium in support levels in dominant strategies:

Proposition 3.3. (Syndicate Support). *There exists a unique equilibrium in nonmonetary support levels. The equilibrium is given by*

$$s_i^{syn} = q \cdot (\frac{1}{2} \cdot R + \theta_i).$$

The support s_i^{syn} only depends on the change in the asset's value of CVC_i. The change in the asset's value of CVC_j is not relevant because it is a private value. The weaker (stronger) the own complement the lower (higher) is s_i^{syn}. Likewise, the lower (higher) the cash flow the lower (higher) is the nonmonetary support of each investor.[20]

I follow Sørensen (2007) by using a *stability* criterion for the syndicate case. The syndicate is called *stable* if and only if it represents a Pareto improvement compared to the equilibrium utility of the stand-alone setting. First, suppose the equilibrium of the stand-alone setting is characterized by no investment. Hence, CVC_i obtains the

[20]In contrast to Hellmann (2002), the venture has to accept the privately optimal support of the investors, even though it is inefficient and not the first-best solution.

stand-alone utility U_i^{no}. Then CVC_1 accepts a syndicate if the following condition is fulfilled:

$$q \cdot \left(\frac{1}{2} \cdot R + \theta_1 \right) \cdot (1 + s_1^{syn} + s_2^{syn}) - \frac{1}{2} \cdot (s_1^{syn})^2 - \frac{1}{2} \geq 0$$

$$\theta_2 \geq \frac{(3R + 2\theta_1)}{4(R + 2\theta_1)} \equiv \upsilon_1^*(\theta_1).$$

The same approach applies for CVC_2. This investor accepts a syndicate if the following condition is fulfilled:

$$\theta_2 \geq \frac{1}{2q} \cdot \sqrt{4 + [2 + q \cdot (R + 2\theta_1)]^2} - \frac{1}{q} - R - \theta_1 \equiv \upsilon_2^*(\theta_1). \tag{8}$$

Second, I turn to the case when CVC_1 is the stand-alone investor. Hence, CVC_1 obtains $U_1^1(\widehat{s}_1)$, whereas CVC_2 obtains $U_2^1(\widehat{s}_1)$. There exists no strictly profitable deviation from syndication if the following conditions are fulfilled:

$$\theta_2 \geq \frac{1}{4q \cdot (R + 2\theta_1)} \cdot \left(R \cdot (4 + qR) - \frac{1}{4q} \right) \equiv \upsilon_1^{***}(\theta_1) \tag{9}$$

$$\theta_2 \geq \frac{1}{2q} \cdot \sqrt{4 - R \cdot [4q + q^2 \cdot (3R + 4\theta_1)]} \equiv \upsilon_2^{**}(\theta_1) \tag{10}$$

for CVC_1 and CVC_2, respectively.

Last, suppose the equilibrium of the stand-alone setting is characterized by a stand-alone investment of CVC_2. Thus, CVC_1 obtains $U_1^2(\widehat{s}_2)$, whereas CVC_2 obtains $U_2^2(\widehat{s}_2)$. There exist no strictly profitable deviation from syndication if the following conditions are fulfilled:

$$\theta_2 \geq \frac{1}{q^2 R} - \frac{1}{q} - \frac{3R}{4} - \frac{\theta_1^2}{R} \equiv \upsilon_1^{**}(\theta_1) \tag{11}$$

$$\theta_2 \geq \frac{1}{8q\theta_1} \cdot \left(R \cdot [4 + q \cdot (R - 4\theta_1)] - \frac{4}{q} \right) \equiv \upsilon_2^{***}(\theta_1)$$

for CVC_1 and CVC_2, respectively.

Given the above results, the following lemma establishes useful values of the cash flow:

Lemma 3.4. *There exist unique values $\underline{R}, \widetilde{R}, \overline{R} \in \mathbb{R}_+$ with $\underline{R} < \widetilde{R} < \overline{R}$ such that*

- $\upsilon_2^*(0) \leq 0$ *if and only if* $R \geq \widetilde{R}$,
- $\upsilon_1^{**}(0) \leq \overline{\theta}_2$, $\upsilon_2^{**}(0) \leq \overline{\theta}_1$ *and* $\upsilon_2^*(\overline{\theta_1}) \leq 0$ *if and only if* $R \geq \underline{R}$,
- $\upsilon_1^{***}(\theta_1) \leq 0$ *if and only if* $R \geq \overline{R}$.

Lemma 3.4 has an immediate consequence for the next result, which shows that the stability of the syndicate depends on the particular cash flow level:

Proposition 3.5. (Syndication for complements).

(i) Suppose the equilibrium of the stand-alone setting is characterized by no investment. Then a syndicate is stable if $R < \widetilde{R}$ and condition (8) *holds or if $R \geq \widetilde{R}$.*

(ii) Suppose the equilibrium of the stand-alone setting is characterized by an investment of CVC_1. Then a syndicate is stable if $R < \underline{R}$ and condition (10) *holds, if $\underline{R} \leq R \leq \overline{R}$ or if $R > \overline{R}$ and condition* (9) *holds.*

(iii) Suppose the equilibrium of the stand-alone setting is characterized by an investment of CVC_2. Then a syndicate is stable if $R < \underline{R}$ and condition (11) *holds or if $R \geq \underline{R}$.*

Otherwise the syndicate is not stable.

To understand this result, suppose that the equilibrium of the stand-alone setting is characterized by a stand-alone investment of CVC_2 and the venture leads to a low cash flow (i.e. $R < \underline{R}$). Hence, I consider the upper right region of Figure 2 [See, the field with the notation ($\not\mathrm{I}$, I)]. Condition (11) is the only relevant threshold for the comparison of the syndicate utility with the stand-alone utility. That is, CVC_2 always accept a syndicate, whereas CVC_1 considers the threshold $\upsilon_1^{**}(\theta_1)$ (i.e. condition (11)). Given this, the latter investor blocks a syndicate for medium complements, i.e. $\theta_2 \in [\overline{\theta}_2, \upsilon_1^{**})$. This result can be explained as follows: CVC_1 obtains a value-added through the syndicate support, determined by the strength of CVC_2's complement, i.e. a medium value-added. On the other hand, CVC_1 has to bear its share of the investment cost. Intuitively, if the costless impact on the asset exceeds the surplus of a syndicate, then CVC_1 blocks the syndicate. Figure 3 illustrates this deviation from syndication.[21]

"Insert Figure 3 Here"

In anticipation of the later analysis of higher cash flows, I remark that CVC_2 can only be the stand-alone investor if the cash flow is low (i.e. $R < \underline{R}$). If the cash flow increases to medium level (i.e. $\widetilde{R} \leq R < \overline{R}$), then a syndicate is stable for all complements. The surplus of a syndicate is high enough and exceeds the utility from the stand-alone case.

Suppose now that the venture enables a high cash flow (i.e. $R \geq \overline{R}$). CVC_1 blocks a syndicate, if CVC_2 obtains a weak complement, i.e. $\theta_2 \in [0, \upsilon_1^{***})$ due to condition (9). The possible nonmonetary support of CVC_2 is too low to exceed the cost of a syndicate (sharing of the cash flow) so that CVC_1 passes the value-added of the opponent. However, for θ_2 high enough, i.e. $\theta_2 > \upsilon_1^{***}(\theta_1)$, a syndicate is stable.

3.3. Impact of a Substitute

In the current section I relax the assumption that the venture is a complement for both investors and suppose that CVC_2 is confronted with a substitute ($\theta_2 < 0$). Furthermore, the venture is a complement for CVC_1. As a preliminary step, I check this modification for the stand-alone case.

[21]See, the proof of Proposition 3.5 for a detailed illustration.

3.3.1. Stand-Alone Case

CVC_2 chooses to invest in the continuation game if and only if condition (3) is fulfilled. However, the venture is now a substitute. Hence, the cash flow has to be high enough to countervail the negative impact of the substitute on CVC_2's utility. The related cash flow benchmark is given by condition (4), i.e. $R > \sqrt{3}{-1}/_q$. Otherwise, the investor cannot allocate funds to any venture. Notice, I have already shown that CVC_1 can finance all complementary ventures if $R > \sqrt{3}{-1}/_q$.

Recall now that CVC_1 chooses first. It still has the possibility to leave the investment decision to CVC_2. Given this, CVC_1 compares the utility levels $U_1^1(\widehat{s}_1)$ and $U_1^2(\widehat{s}_2)$. Clearly, the nonmonetary support level $\widehat{s}_2$ of the opponent is now lower due to the existence of a substitute ($\theta_2 < 0$). This in turn influences the utility level $U_1^2(\widehat{s}_2)$. I check condition (7) because this benchmark states the innovation advantage level, such that CVC_1 is better-off to leave the investment to CVC_2:

$$\varphi(\theta_1) \geq 0 \Leftrightarrow R \geq \frac{\sqrt{3}-1}{q}.$$

Obviously, this benchmark is equal to condition (4). In other words, whenever the cash flow is high enough for CVC_2 to realize a valuable investment, it is more profitable for CVC_1 to carry out the investment by itself. More precisely, CVC_1 will always finance the venture due to CVC_2's low support level. The existence of a substitute prevent an investment by CVC_2.

Last, I suppose that condition (3) is not fulfilled, in the sense that the venture is not valuable for CVC_2. Then, analogous to Section 2.1, CVC_1 chooses to invest if condition (5) is fulfilled. Otherwise no investment occurs.

I summarize the above analysis in the following proposition, that states the equilibrium behavior of both CVCs in the stand-alone setting if CVC_2 is confronted with a substitute:

Proposition 3.6. (Stand-alone investment for a substitute). *No investment occurs if condition* (5) *does not hold. Otherwise, CVC_1 is the investor.*

3.3.2. Syndication Case

I proceed with the syndication case. The unique equilibrium in support levels is given by $s_i^{syn} = q \cdot \left(\frac{1}{2}R + \theta_i\right)$. Given these support levels there exist a undermining threshold for CVC_2 due to the negative impact of the substitute. This threshold is given by

$$|-\theta_2| > \frac{1}{2} \cdot R. \tag{12}$$

Hence, CVC_2 has now an incentive to hinder the development of the venture if condition (12) is fulfilled. The stronger (weaker) the substitute the stronger (weaker) is the undermining by CVC_2.

Previous research on the negative impact of CVCs on their ventures (Masulis and Nahata 2009; Ivanov and Xie 2010) provided evidence that CVCs face incentives to obstruct the survival of ventures, that may turn out to be possible competitors. For instance, a parental company uses its CVC to obtain information about the product or services of a venture to develop a competitive asset of its own at the venture's expense. Moreover, Dushnitsky and Shaver (2009) state that corporate investors may oust intellectual property in some cases, originally created by the ventures.

The following proposition entails conditions under which the syndicate setting is stable if $\theta_1 \geq 0$ and $\theta_2 < 0$:[22]

Proposition 3.7. (Syndication for a substitute).

(i) Suppose the equilibrium of the stand-alone setting is characterized by no investment. Then a syndicate is stable if $R \geq \underline{R}$ and condition (8) *holds.*

(ii) Suppose the equilibrium of the stand-alone setting is characterized by a stand-alone investment of CVC_1. Then a syndicate is stable if $R < \underline{R}$ and conditions (9) *and* (10) *hold or if $\underline{R} \leq R < \overline{R}$ and condition* (9) *holds.*

Otherwise the syndicate is not stable.

I now compare the situation where the venture is a complement for both investors with a situation where the venture is complement for CVC_1 and a substitute for CVC_2. Intuitively, a syndicate is less often stable if the possible syndication partner of CVC_1 is confronted with a substitute due to a lower nonmonetary support. The next proposition emphasizes this point:[23]

Proposition 3.8. (Corporate venture capital value-added hypothesis). *If the venture is a complement for both CVCs, then a syndicate leads to a higher value-added than a stand-alone investment. Otherwise a stand-alone investor enables a higher value-added.*

Brander, Amit, and Antweiler (2002) formulate their *value-added hypothesis* in the context of syndicates only consisting of IVCs. I expand their idea to CVC syndicates and take into account the feature of an innovation objective. According to the terminology of Brander, Amit, and Antweiler (2002), I call this extension the *corporate venture capital value-added hypothesis*.

For a low up to a medium cash flow (i.e. $R < \overline{R}$), I find that a syndicate can be stable if $\theta_1 \geq 0$ and $\theta_2 < 0$. Indeed, if the cash flow is high (i.e. $R \geq \overline{R}$), then CVC_1 does not accept a syndicate. The venture is too attractive in terms of the cash flow, such that CVC_1 blocks a syndicate and finances the venture as a stand-alone investor.

Suppose now that a medium cash flow occurs (i.e. $\widetilde{R} \leq R < \overline{R}$), a syndicate is stable if the venture is a complement for both investors. The nonmonetary support of two CVCs increase the value of the investment, such that both investors accept a syndicate. However, if the venture is a substitute for CVC_2, the results are less clear. A syndicate is stable for weak substitutes, i.e. $\theta_2 < max[\upsilon_2^*, \upsilon_1^{***}]$, whereby CVC_1 blocks a syndicate for medium and strong substitutes.

It is important to point out that a syndicate can also be stable if CVC_1 provides nonmonetary support ($s_1^{syn} > 0$), whereas CVC_2 undermines the development of the venture ($s_2^{syn} < 0$). This result is stated in the following Proposition.

Proposition 3.9. (Undermining by a CVC). *Suppose conditions* (9)*,* (10) *and* (12) *hold. Then a syndicate is stable if $R < {}^1/_{q\sqrt{3}}$, such that CVC_1 provides nonmonetary support, whereas CVC_2 undermines the development of the venture.*

To understand this point, recall that the syndication partner bears a share of the

[22]See, the proof of Proposition 3.9 for a detailed illustration.

[23]Intuitively, if $\theta_i = 0$, then the present model is modified to an IVC model. Given this, CVC syndicates lead to a higher value-added than IVC syndicates if $\theta_i > 0$ and $\theta_j \geq 0$ or $\theta_i > |-\theta_j|$. Otherwise IVC syndicates lead to a higher value-added.

capitalization. This cost saving exceeds the value-added of a higher nonmonetary support due to a possible stand-alone investment. As a consequence, CVC_1 accepts a syndicate and allows CVC_2 to reduce the negative effect of the venture for itself. The same effect explains why a syndicate is stable for stronger substitutes, if the cash flow decreases down to a lower level.

3.4. Shareholding Decision

Consider a modification of the basic model in which the syndicate shares may differ between the CVCs. The shareholding is denoted by α for CVC_1 and $(1-\alpha)$ for CVC_2, respectively. I suppose again that the venture is a complement for both CVCs (i.e. $\theta_i \in \mathbb{R}_+$). Henceforth, the expected utility of a syndicate is written:

$$\widetilde{U}_1^{syn} = q \cdot (\alpha \cdot R + \theta_1) \cdot (1 + s_1 + s_2) - \frac{1}{2} \cdot (s_1)^2 - \alpha,$$
$$\widetilde{U}_2^{syn} = q \cdot [(1-\alpha) \cdot R + \theta_2] \cdot (1 + s_1 + s_2) - \frac{1}{2} \cdot (s_2)^2 - (1-\alpha).$$

for CVC_1 and CVC_2, respectively. Intuitively, the privately optimal support of CVC_1 is now given by $\widetilde{s}_1^{syn} = q \cdot (\alpha \cdot R + \theta_1)$. Analogously, CVC_2 provides the nonmonetary support $\widetilde{s}_2^{syn} = q \cdot [(1-\alpha) \cdot R + \theta_2)]$. Given the above modification, a syndicate has to fulfill two classes of constraints to satisfy the criterion of stability: a *participation constraint* (i.e. a syndicate represents a Pareto improvement compared to the equilibrium of the stand-alone setting) and a *feasibility constraint* (i.e. $\alpha \in [0;1]$).

As a preliminary step, I consider the *participation constraint*. Suppose that the equilibrium of the stand-alone setting is characterized by no investment. Hence, CVC_1 obtains the stand-alone utility U_1^{no}. CVC_1 has no strictly profitable deviation from syndication if the following condition is fulfilled:

$$q \cdot (\alpha \cdot R + \theta_1) \cdot (1 + \widetilde{s}_1^{syn} + \widetilde{s}_2^{syn}) - \frac{1}{2} \cdot (\widetilde{s}_1^{syn})^2 - \alpha \geq 0. \tag{13}$$

Condition (13) is satisfied if $\alpha \in [A-B; A+B] \equiv \alpha \in [\underline{\alpha}_1^{no}; \overline{\alpha}_1^{no}]$, where A and B are given by

$$A \equiv 1 + \frac{1}{qR} \cdot \left(1 - \frac{1}{q^2 R}\right) + \frac{\theta_2}{R},$$

$$B \equiv \frac{1}{q^2 R^2} \cdot \sqrt{q^3 R^2 \theta_1 \cdot [2 + q \cdot (2R + \theta_1 + 2\theta_2)] + [1 - qR \cdot (1 + q \cdot (R + \theta_2))]^2}.$$

Thus, CVC_1 is sufficiently motivated to join a syndicate and to exert support if it receives a share above the minimum threshold $max\,\{0, \underline{\alpha}_1^{no}\}$. Indeed, the share can be limited to a maximum threshold $min\,\{1, \overline{\alpha}_1^{no}\}$ because of the investment costs in a syndicate. Hence, for particular investment situations, CVC_1 is better-off to obtain less shares. For CVC_2, I derive analogously, that the *participation constraint* is satisfied if

$\alpha \in [C - D; C + D] \equiv \alpha \in [\underline{\alpha}_2^{no}; \overline{\alpha}_2^{no}]$, where

$$C \equiv \frac{1}{q^2R^2} \cdot \left(1 + q + q^2R\theta_1\right),$$

$$D \equiv \frac{\sqrt{1 - 2qR - q^2R \cdot (R + 2\theta_1) + 2q^3R^2 \cdot (R + \theta_1 + \theta_2) + q^4R^2 \cdot (R + \theta_1 + \theta_2)^2}}{q^2R^2}.$$

CVC_2's minimum threshold is defined by $max\,\{0, \underline{\alpha}_2^{no}\}$ and the maximum threshold is given by $min\,\{1, \overline{\alpha}_2^{no}\}$.

Second, I turn to the case when CVC_1 is the stand-alone investor. Hence, CVC_1 obtains $U_1^1(\widehat{s}_1)$, whereas CVC_2 obtains $U_2^1(\widehat{s}_1)$. For clarity, I skip the particular values of the interval and state that $\alpha \in [max\left\{0, \underline{\alpha}_1^1\right\}, min\left\{1, \overline{\alpha}_2^1\right\}]$, such that CVC_1 has no strictly profitable deviation from syndication. On the other hand, CVC_2 accepts to syndicate if the following interval is fulfilled: $\alpha \in [max\left\{0, \underline{\alpha}_2^1\right\}, min\left\{1, \overline{\alpha}_2^1\right\}]$.

Last, suppose the equilibrium of the stand-alone setting is characterized by a stand-alone investment of CVC_2. Thus, CVC_1 obtains $U_1^2(\widehat{s}_2)$, whereas CVC_2 obtains $U_2^2(\widehat{s}_2)$. CVC_1 has no strictly profitable deviation from syndication if $\alpha \in [max\left\{0, \underline{\alpha}_1^2\right\}, min\left\{1, \overline{\alpha}_1^2\right\}]$. On the other hand, CVC_2 accepts to syndicate if $\alpha \in [max\left\{0, \underline{\alpha}_2^2\right\}, min\left\{1, \overline{\alpha}_2^2\right\}]$

Proposition 3.10 summarizes the results for the *participation constraint* under consideration of the *feasibility constraint*, such that the shareholding is in the interval $\alpha \in [0; 1]$:

Proposition 3.10. *(Syndication for complements with variable shares). There exist unique values $\widehat{R}^{no}$, R_i^{no}, R_i^1 and $R_i^2 \in \mathbb{R}_+$ with $\widehat{R}^{no} < R_1^{no} < R_2^{no}$, $R_1^1 > R_2^1$ and $R_1^2 < R_2^2$ such that the following statements hold:*

(i) Suppose the equilibrium of the stand-alone setting is characterized by no investment. Then a syndicate is stable
  - *for $\alpha \in [0; 1]$ if and only if $R > R_2^{no}$,*
  - *for $\alpha \in [\underline{\alpha}_2^{no}; 1]$ if and only if $R_1^{no} < R \leq R_2^{no}$,*
  - *for $\alpha \in [\underline{\alpha}_2^{no}; \overline{\alpha}_1^{no}]$ if and only if $\widehat{R}^{no} \leq R \leq R_1^{no}$.*

(ii) Suppose the equilibrium of the stand-alone setting is characterized by an investment of CVC_1. Then a syndicate is stable
  - *for $\alpha \in [\underline{\alpha}_1^1; 1]$ if and only if $R \geq R_1^1$,*
  - *for $\alpha \in [0; 1]$ if and only if $R_2^1 < R < R_1^1$,*
  - *for $\alpha \in [\underline{\alpha}_2^1; 1]$ if and only if $R \leq R_2^1$.*

(iii) Suppose the equilibrium of the stand-alone setting is characterized by an investment of CVC_2. Then a syndicate is stable
  - *for $\alpha \in [0; \overline{\alpha}_2^2]$ if and only if $R \geq R_2^2$,*
  - *for $\alpha \in [0; 1]$ if and only if $R_1^2 < R < R_2^2$,*
  - *for $\alpha \in [0; \overline{\alpha}_1^2]$ if and only if $R \leq R_1^2$.*

Otherwise the syndicate is not stable.

To understand the intuition, suppose the equilibrium of the stand-alone setting is characterized by no investment. The results show that a syndicate is stable for all feasible shares (i.e. $\alpha \in [0; 1]$) if the the expected is high enough (i.e. $R > R_2^{no}$). However, if the cash flow decreases, then the interval for stable syndicates becomes limited by both particular shareholding benchmarks (i.e. $\underline{\alpha}_2^{no}$ and $\overline{\alpha}_1^{no}$). Indeed, if the cash flow decreases strongly (i.e. $R < R^{no}$) then the syndicate is blocked for all feasible shares, because the syndication costs are too high. Hence, both investors are better-off not to invest.

Suppose now that at least one of the CVCs finance the venture. Intuitively, the particular investor blocks a syndicate if the cash flow is high enough and the assigned shareholding is only low (i.e. $\alpha < \underline{\alpha}_1^1$ for investor CVC_1 and $\alpha > \underline{\alpha}_2^2$ for investor CVC_2). It is important to point out that a syndicate is also possible if the cash flow decreases strongly. Stand-alone investor CVC_1, for instance, can syndicate with CVC_2 given a cash flow level $R \leq R_2^1$. However, the latter investor blocks a high shareholding for itself (i.e. $\alpha < \alpha_2^1$) due to the investment costs and the low cash flow.

3.4.1. Pareto Efficient Shareholding Allocation

I now check which shareholding agreements represents the *pareto efficient* allocation, in the sense that it is impossible to reallocate the shareholding so as to make one CVC better-off without making the other CVC worse-off. As a preliminary step, I state the following derivations:

$$\alpha_1^{pe} = \underset{\alpha\in[0;1]}{\operatorname{argmax}} \left\{ \widetilde{U}_1^{syn}(\alpha) \right\} \Leftrightarrow \alpha_1^{pe} = 1 + \frac{1+q\theta_2}{qR} - \frac{1}{q^2R^2},$$
$$\alpha_2^{pe} = \underset{\alpha\in[0;1]}{\operatorname{argmax}} \left\{ \widetilde{U}_2^{syn}(\alpha) \right\} \Leftrightarrow \alpha_2^{pe} = \frac{1}{q^2R^2} - \frac{1+q\theta_1}{qR},$$

for CVC_1 and CVC_2, respectively. Consider the first equation that states CVC_1's profit maximizing shareholding. Interestingly, the benchmark α_1^{pe} increases in θ_2. To understand this point, notice that a decrease of θ_2 leads also to decrease of CVC_2's nonmonetary support. Then, CVC_1 prefers to hold less shares, such that CVC_2 obtains a monetary incentive to increase its nonmonetary support again. On the other hand, if θ_1 decreases, then it is clear that CVC_1 obtains a lower utility level. However, this change in the asset's value has no impact on the optimal shareholding. In other words, CVC_1 cannot increase its utility by redistributing the shares. The reverse result applies when I consider the second equation for CVC_2 with the benchmark α_2^{pe}.

Next, I consider the impact of the cash flow on the profit maximizing shareholding. I obtain the following conditions $\forall\alpha \in [0; 1]$:

$$\alpha_1^{pe} > 1 \Leftrightarrow R > \frac{1}{q\cdot(1+q\theta_2)}, \tag{14}$$

$$\alpha_1^{pe} < 0 \Leftrightarrow R < \frac{1}{2q}\cdot\left[\sqrt{4+(1+q\theta_2)^2}-1\right]-\frac{\theta_2}{2}. \tag{15}$$

If condition (14) is fulfilled, then CVC_1 is always better-off to obtain more shares of the syndicate due to the possibility to obtain a high cash-flow. On the other hand, if condition (15) holds, then CVC_1 is always better-off to obtain less shares. However, if both conditions are not fulfilled, then an increase of the shareholding has only a positive impact on the expected utility for a particular range of the feasible shares, i.e. $\alpha \in [0; \alpha_1^{pe}]$.

Second, I turn to CVC_2 and show the following conditions $\forall \alpha \in [0;1]$:

$$\alpha_2^{pe} < 0 \Leftrightarrow R < \frac{1}{2q} \cdot \left[\sqrt{4 + (1 + q\theta_1)^2} - 1\right] - \frac{\theta_1}{2}, \tag{16}$$

$$\alpha_2^{pe} > 1 \Leftrightarrow R > \frac{1}{q \cdot (1 + q\theta_1)}. \tag{17}$$

The intuitions of these conditions are the same as for CVC_1.

Straightforwardly, $\alpha_1^{pe} < (1 - \alpha_2^{pe})$ due to $\theta_1 \geq \theta_2$. This means that the profit maximizing shareholding is lower for CVC_1. Then, I have the following order: if condition (14) holds, then (17) is always fulfilled. I can also state that if condition (15) holds, then (16) is always fulfilled. Moreover, condition (16) cannot hold if (17) holds and if condition (14) holds, then (15) cannot hold, respectively.

Last, I compare condition (15) and (17):

$$\frac{1}{2q} \cdot \sqrt{4 + (1 + q\theta_2)^2} - \frac{1}{2q} - \frac{\theta_2}{2} \geq \frac{1}{q \cdot (1 + q\theta_1)} \Leftrightarrow$$

$$\theta_1 \geq \frac{1}{2q} \cdot \sqrt{4 + (1 + q\theta_2)^2} + \frac{\theta_2}{2} - \frac{1}{2q}. \tag{18}$$

Given this, there exist two different cases for the order of the above cash flow thresholds. I proceed with Proposition 3.11 and summarize these results:

Proposition 3.11. (Pareto efficient shareholding allocation). *I consider a stable syndicate.*

(i) Suppose condition (18) *is not fulfilled, in the sense that the change in CVC_1's asset value is small.*
  - *If condition* (14) *does not hold and* (17) *holds, then every shareholding $\alpha \in [0; \alpha_1^{pe}]$ is pareto efficient.*
  - *If condition* (15) *and* (17) *do not hold, then every shareholding $\alpha \in [min\{\alpha_1^{pe}, \alpha_2^{pe}\}; max\{\alpha_1^{pe}, \alpha_2^{pe}\}]$ is pareto efficient.*
  - *If condition* (15) *holds and* (16) *does not hold, then every shareholding $\alpha \in [0; \alpha_2^{pe}]$ is pareto efficient.*

(ii) Suppose condition (18) *is fulfilled, in the sense that the change in CVC_1's asset value is large.*
  - *If condition* (14) *and* (15) *do not hold, then every shareholding $\alpha \in [0; \alpha_1^{pe}]$ is pareto efficient.*
  - *If condition* (15) *and* (17) *hold, then every shareholding $\alpha = 0$ is pareto efficient.*
  - *If condition* (16) *and* (17) *do not hold, then every shareholding $\alpha \in [0; \alpha_2^{pe}]$ is pareto efficient.*

Otherwise every shareholding $\alpha \in [0;1]$ is pareto efficient.

To understand the intuition of Proposition 3.11, suppose first that condition (14) holds, then both CVCs can obtain a high cash flow. Hence, every shareholding $\alpha \in [0;1]$ is pareto efficient because both investors prefer to obtain more shares. Or in other words, it is impossible to reallocate the shareholding so as to make one CVC better-off without making the other CVC worse-off. On the other hand, if condition (16) holds, then the CVCs obtain a low cash flow. The CVCs prefer to obtain less shares due to the investment costs. Thus, every shareholding $\alpha \in [0;1]$ is pareto efficient.

I turn now to the case, where the change in the asset's value of CVC_1 is smaller (e.g. condition (18) does not hold). If the cash flow becomes lower (e.g. condition (14) does not hold and (17) holds) and CVC_1 has initially a very high shareholding, i.e. $\alpha \in [\alpha_1^{pe};1]$, then the shareholding of CVC_1 can be reallocated so as to make CVC_1 better-off. More precisely, CVC_1 is better-off to obtain a lower shareholding due to the investment cost participation. On the other hand, CVC_2 is better-off to obtain more shares because condition (17) holds. Hence, the reallocation of the shareholding also makes CVC_2 better-off. Given this, the range of pareto efficient shares is limited to the interval $\alpha \in [0;\alpha_1^{pe}]$.

3.4.2. Joint Utility Maximization

I now check which shareholding allocation maximizes the joint utility of a stable syndicate. It takes into account the *participation* and *feasibility constraint* of the CVCs.[24] First, I consider the joint utility of a syndicate, that should be divided between the CVCs:

$$U^{joint} = q \cdot (R + \theta_1 + \theta_2) \cdot (1 + \widetilde{s}_1^{syn} + \widetilde{s}_2^{syn}) - \frac{1}{2} \cdot (\widetilde{s}_1^{syn})^2 - \frac{1}{2} \cdot (\widetilde{s}_2^{syn})^2 - 1.$$

Given this, I show the shareholding allocation among the investors that maximize the joint utility:

$$\alpha^{max} = \underset{\alpha \in [0;1]}{\operatorname{argmax}} \left\{ q \cdot (R + \theta_1 + \theta_2) \cdot (1 + \widetilde{s}_1^{syn} + \widetilde{s}_2^{syn}) - \frac{1}{2} \cdot (\widetilde{s}_1^{syn})^2 - \frac{1}{2} \cdot (\widetilde{s}_2^{syn})^2 - 1 \right\},$$

where

$$\widetilde{s}_1^{syn} = q \cdot (\alpha R + \theta_1) \quad \text{and} \quad \widetilde{s}_2^{syn} = q \cdot [(1-\alpha) \cdot R + \theta_2)] \,.$$

The solution to this problem is given by:

$$\alpha^{max} = \frac{1}{2} + \underbrace{\frac{\theta_2 - \theta_1}{2R}}_{\text{Balancing Effect}} . \tag{19}$$

It is important to point out that the shareholding α^{max} balances the change in the asset's value. In other words, if the innovation advantage of CVC_1 increases, then it obtains a lower share in the cash flow. The same applies if the innovation advantage of CVC_2 decreases. The intuition behind the balancing effect is that both investors provide nonmonetary support and thus, the investor with the lower innovation advantage obtains a higher participation in the cash flow to enable a higher support level. This implies that the establishment of a lead investor (i.e. $\alpha < \frac{1}{2}$) in a syndicate with several CVCs maximize the joint utility if and only if the lead investor has the lower

[24]Note that this shareholding can be denoted by *second best* shareholding due to the *participation* and *feasibility constraint* of the CVCs.

innovation advantage. Intuitively, if the change in the assets' values is equal for both CVCs (i.e. $\theta_1 = \theta_2$), then each investor obtains half of the shares.

An increase in the cash flow reduces the balancing effect. This result occurs because the investment is now more relying on the cash flow rather than the innovation advantage. Consequently, if the cash flow becomes very high, then it is efficient to split the shareholding equally because the importance of the innovation advantage vanishes.

Checking for the *feasibility constraint* of the CVCs, i.e. $\alpha \in [0;1]$, yields

$$\alpha^{max} \in [0;1] \Leftrightarrow \theta_2 \geq \theta_1 - R. \tag{20}$$

The following proposition entails conditions under which the shareholding α^{max} can be achieved given that the syndicate setting satisfies the criterion of stability:

Proposition 3.12. (Second-best shareholding allocation). *Suppose condition* (20) *is fulfilled. Then, the shareholding α^{max} can be established for a stable syndicate if the equilibrium of the stand-alone setting is characterized by*

(i) no investment and $R > R_2^{no}$.
(ii) an investment of CVC_1 and $R_2^1 < R < R_1^1$.
(iii) an investment of CVC_2 and $R_1^2 < R < R_2^2$.

The results show that the shareholding, that maximize the joint utility of a stable syndicate, can be established for all possible equilibria of the stand-alone setting. Indeed, the cash flow has to be suitable such that both investors accept a joint investment.

3.4.3. Nash Bargaining Solution

Finally, I endogenize the shareholding decision of the syndication partners. Following Casamatta and Haritchabalet (2007), I use the *Nash bargaining solution* as negotiation concept for the shareholding allocation.[25]

The *Nash bargaining solution* is an approach for a two-person bargaining problem. In the present model, the CVCs divide the shares of a syndicate to participate in the syndicate surplus. If negotiation succeeds, then the CVCs conclude a contract on the shareholding. Note that the shareholding allocation is restricted, such that the CVCs are better-off compared to the *disagreement point*. This *disagreement point* is the equilibrium of the stand-alone setting or in other words the utility the CVCs can expect to receive if the negotiation breaks down.

Suppose the disagreement point is characterized by no investment, then the *Nash bargaining solution* can be determined for CVC_1 through the following maximization problem:

$$\widehat{\delta} = \underset{\delta \in [0;1]}{\operatorname{argmax}} \{\Delta U_1^{no} \cdot \Delta U_2^{no}\} \Leftrightarrow \widehat{\delta} = \frac{1}{2},$$

where

$$\Delta U_1^{no} = \delta \cdot U^{joint} - U_1^{no} \quad \text{and} \quad \Delta U_2^{no} = (1-\delta) \cdot U^{joint} - U_2^{no}.$$

[25] See, for instance Laengle and Loyola (2012) for a bargaining problem with externalities.

The parameter δ is CVC_1's and $(1-\delta)$ CVC_2's share in the joint profits, respectively. Intuitively, both investors equally divide the joint profits due to the same disagreement point. However, the syndication contract only includes a shareholding on the cash flow and does not cover the innovation components. I have to determine the particular share α for CVC_1:

$$\widetilde{U}_1^{syn} = \frac{1}{2} \cdot U^{joint} \Leftrightarrow \alpha = \frac{q \cdot (R + \theta_2 - \theta_1) \cdot (q \cdot (\theta_1 + \theta_2 + R) + 2) - 2}{2 \cdot (qR \cdot (q \cdot (\theta_1 + \theta_2 + R) + 2) - 2)}$$

I proceed with the case that the disagreement point is characterized by an investment of CVC_1. Then the following utility differences exist: $\Delta U_1^1 = \delta U^{joint} - U_1^1$ and $\Delta U_2^1 = (1-\delta)U^{joint} - U_2^1$, respectively. For clarity, I only state the solution for the shareholding on the cash flow:

$$\alpha = \frac{q \cdot \left[2qR^2 + 2R \cdot (2 + q\theta_1) + q\theta_2 \cdot (\theta_2 - 2\theta_1)\right] - 4}{2 \cdot [qR \cdot (2 + q \cdot (R + \theta_1 + \theta_2)) - 2]}.$$

Last, suppose the disagreement point is characterized by an investment of CVC_2. The same approach holds as for the previous step. Thus, I only show the particular shareholding:

$$\alpha = \frac{q^2\theta_1 \cdot (2R - \theta_1 + 2\theta_2)}{2 \cdot [qR \cdot (2 + q \cdot (R + \theta_1 + \theta_2)) - 2]}$$

Given this, I want to justify the share α^{max} that maximizes the joint surplus of a syndicate by means of bargaining. Hence, I use the analysis for the feasible set of the shareholding (i.e. Proposition 3.10) and the conditions under which the shareholding α^{max} can be established for the feasible set (i.e. Proposition 3.12). In this way, Proposition 3.13 entails conditions under which the shareholding α^{max} can be implemented by the *Nash bargaining solution* for a stable syndicate:

Proposition 3.13. (Nash bargaining solution). *Suppose condition* (20) *is fulfilled. Then, the Nash bargaining solution implements the shareholding α^{max} for a stable syndicate if the equilibrium of the stand-alone setting is characterized by*

(i) no investment, $R > R_2^{no}$ and $\theta_1 = \theta_2$.
(ii) an investment of CVC_1, $R_2^1 < R < R_1^1$ and $\theta_1 = \widetilde{\theta}_1$.
(iii) an investment of CVC_2, $R_1^2 < R < R_2^2$ and $\theta_1 = \check{\theta}_1$.

The unique values $\widetilde{\theta}_1$ and $\check{\theta}_1$ are defined in Appendix A.

It seems worth noting that there exists a positive external effect for the rejecting investor in case of the last two points of Proposition 3.13, due to the costless change in the asset's value. Hence, the possibility to bargain for the shares may be viewed as an internalization of this externality. Henceforth, after bargaining, the formerly rejecting investor joins a syndicate and bears some of the investment costs.

However, Proposition 3.13 states that the *Nash bargaining solution* only achieve the shareholding α^{max} in a few special cases and fails in general, respectively. Clearly, transfer payments between the CVCs may be a possibility to increase the number of solutions.[26] Nevertheless, I view syndicate agreements with transfers as less likely for

[26]See, for instance, Bayar and Chemmanur (2011) for the use of transfer payments in the context of venture

venture capital investments, following Casamatta and Haritchabalet (2007).

Numerical Examples

To study the endogenous shareholding issue, consider the following examples of a possible syndication contract. Suppose the disagreement point is characterized by an investment of CVC_1. For both examples apply $R = 5$, $q = 0.15$ and different couples of $\{\theta_1, \theta_2\}$.[27]

	$\{\theta_1, \theta_2\}$	Feasible Shares	Pareto Efficient Shares	α^{max}
(i)	$\{2.7, 2\}$	$\alpha \in [0.0; 1.0]$	$\alpha \in [0.0; 1.0]$	0.43
(ii)	$\{0.55, 0.5\}$	$\alpha \in [0.07; 1]$	$\alpha \in [0.34; 0.67]$	0.49

In Example (i), both investors obtain a stronger change in the assets values than in Example (ii). However, CVC_1 obtains a stronger increase in θ_1 than CVC_2 in θ_2. Hence, the former investor obtains less shares in a syndicate that maximizes the joint surplus of a syndicate due to equation (19). On the other hand, in Example (ii), CVC_1 obtains more shares than in Example (i) because the change in the assets values is almost similar. Thus, these examples illustrate the balancing effect of the shareholding, in the sense that the change in the asset's value becomes balanced by the syndicate shares.

4. Extensions

4.1. Different Bargaining Configurations

To this point, the CVCs have all bargaining power vis-a-vis of the venture. However, Riyanto and Schwienbacher (2006) emphasizes that ventures usually have significant amount of bargaining power. Hence, I will now relax the strict bargaining assumption and show that my model is robust to alternative bargaining approaches. Moreover, the venture is not a player in my model and thus accepts every offered contract. To analysis a venture with bargaining power, I will also relax this assumption. Given that $\theta_i \in \mathbb{R}_+$, I analysis the following two cases:

- The case in which the CVCs offer a contract to the venture and the latter decides whether to accept or reject the offer. The venture has at least some or all of the bargaining power.
- The case in which the venture offers a contract to one of the CVCs and the latter decides whether to accept or reject the offer. The venture has at least some or all of the bargaining power.

I proceed with the first case. Given the sequential game structure, the results are qualitatively unchanged if the venture obtains some bargaining power. However, the cash flow for the particular investor will decrease because the venture does not obtain zero profits. In comparison with the basic model, I have more equilibria which are characterized by no investment, given a certain value of the cash flow. In the same way, I have more equilibria which are characterized by a stand-alone investment of

capital.

[27] I only focus on the shareholding and do not check if the cash flow of the stand-alone case is lower than the cash flow of the syndicate case. Intuitively, the latter case has a higher cash flow due to the *Nash bargaining approach*.

CVC_2 because CVC_1 decides first on an investment. If I consider the extreme case, where the venture has all bargaining power, then CVC_1 will forgo to finance the venture for all $\theta_1 > 0$ due to $U_1^1 = 0$. Obviously, if I analyze the syndicate setting, then I have also qualitatively unchanged results.

Under Case 2, the venture has the incentive to obtain the highest possible nonmonetary support and thus it prefers to have a syndicate consisting of both investors (see, the *corporate venture capital value-added hypothesis*). However, the venture has no possibility to increase the number of stable syndicates (see, the proof of Proposition 3.5 to check this statement). Nevertheless, the venture is better-off with an investment by CVC_1 than with an investment by CVC_2 due to $\theta_1 \geq \theta_2$. Thus, CVC_2 is no longer a stand-alone investor and the problem stated in Corollary (3.2) vanishes.

4.2. Alternative Investor Types

The second extension concerns other investor types. For the basic model, I suppose that the venture needs some special nonmonetary support and thus requires an investment by at least one of the CVCs. If I relax this assumption and replace CVC_2 by an *IVC*, then I have only to check for θ_1. According to Hellmann (2002), the *IVC*'s nonmonetary support is lower in comparison with a CVC due to the absence of the innovation component. Nevertheless, the results are qualitatively unchanged. CVC_1 has still an incentive to forgo an investment due to the the positive externality effect of θ_1. Note that I obtain for less couples of $\{\theta_1, \theta_2\}$ a stable syndicate because the value-added of a syndicate is now reduced. However, in some cases cost sharing eclipse this effect, so that a syndicate may also established by both investors.

Last, if I add a possible outside option for the venture, in the sense of an IVC and the venture offers a contract to one of the investors (i.g. CVC or IVC), then the results are also qualitatively unchanged. The venture prefers to obtain an investment by a CVC due to the higher nonmonetary support. However, the particular corporate investor will obtain less utility because the venture has a possible outside option.

Therefore, the main insights obtained from the analysis of the basic model can be straightforwardly applied to cases with less extreme bargaining configurations and with different investor types.

5. Empirical Predictions

The findings of the present model allow me to derive a number of interesting empirical predictions about the investment decision of CVCs that are confronted with innovation objectives:

- An original feature of the present model is the combination of the investment decision of CVCs with their innovation objectives. Moreover, I investigate the impact of the cash flow. I predict that CVCs faced with weak complements but high cash flows prefer stand-alone investments. Masulis and Nahata (2009) and Sharifzadeh and Walz (2012) give evidence for this result. By contrast, my model shows that ventures leading to a medium cash flow are financed by a syndicate without any consideration of the innovation objectives.
- I predict that if a substitute is included in the analysis, then stand-alone investments are more likely to occur because of the negative impact of the substitute on the nonmonetary support of the affected investor. Recent studies provide

evidence that CVCs do not want to syndicate with other corporate investors because of their impact on the venture's development (Park and Steensma 2012; Souitaris and Zerbinati 2014). Nevertheless, in my model, syndicates are possible if the cash flow is on a low or medium level. This holds even if the provided nonmonetary support is lower than in the stand-alone case. Similarly, Masulis and Nahata (2009) show with their sample that substitutes are corporate-backed as well.
- Brander, Amit, and Antweiler (2002) emphasize that syndicates consisting of several IVCs have significantly higher cash flows than stand-alone investments because of the nonmonetary support effect (see, the *value-added hypothesis*) by different investors. In line with this study, my model shows that if the venture is a complement for both CVCs, then the investors provide a higher support level (value-added) than in case of a stand-alone investor.

Hence, some of my predictions have already been examined empirically, others are new. In the following, I will state possible empirical implications, which have not been tested so far:

- First, a central prediction of the model is that the possible innovation objectives have a great influence on the investment decision of CVCs. Sharifzadeh and Walz (2012) provide empirical evidence that only a small number of CVCs syndicate with other CVCs. Most of the corporate investments are stand-alone investments.[28] However, they analyze the CVCs' investment behavior without consideration of the innovation objectives. By contrast, Masulis and Nahata (2009) take these objectives into account and stress that CVCs finance by the majority weak complements. Interestingly, their sample demonstrates that substitutes also obtain in a considerable size investments by CVCs. Unfortunately, Masulis and Nahata (2009) do not distinguish between different investment pattern (i.e. syndication and stand-alone investment). To my knowledge, no study so far has ever considered the innovation objectives' impact on the investment pattern of CVCs.
- Hellmann (2002) formulates an extension of his basic model with two corporate investors and one IVC. The model shows that if the venture is a complement for both large companies, only the CVC with the stronger complement allocates funds towards the venture. Some examples of CVC investments show that other results than those by Hellmann are possible. One example is the young fintech firm Gini, that is supported by only one corporate investor, namely, the Main Incubator founded by the Commerzbank. After Gini has succeeded with its banking software for giro accounts, the online bank ING DiBa has established Gini's software before the Commerzbank uses this product for itself (Commerzbank 2014, 2015).[29] Obviously, Gini's product is a stronger complement to online banks than to the Commerzbank, a retail bank. However, only Commerzbank finances the young firm. The present model explains this puzzling behavior of the ING DiBa due to the costless impact on some assets of the incumbent company if another CVC bears the investment costs. However, I predict that such an investment behavior only occurs if the venture has a low cash flow.
- In contrast to Brander, Amit, and Antweiler (2002), I state that syndicates lead

[28] Dushnitsky (2008) gives an example for syndicates, consisting of different corporate investors: the Linux company Red Hat is financed by Compaq, IBM, Intel, Novell, Oracle and SAP.

[29] The bank ING DiBa does not own a subsidiary for corporate venture capital investments. However, investments in young fintechs are realized by the incumbent company itself.

to a support level (value-added) in comparison with a stand-alone investment if one CVC is confronted with a substitute. The investor with the substitute has an incentive to undermine the venture and to protect its parental company. Thus, a lower support level occurs. Masulis and Nahata (2009) stress the undermining motivation of CVCs, but it is still an empirical issue that syndicates with substitutes lead to a lower value-added than stand-alone investments of complementary investors. I call this prediction the *corporate venture capital value-added hypothesis.*

6. Conclusion

I examine the investment decision of two CVCs that are subsidiaries of incumbent companies. The CVCs have to decide whether to finance a wealthless venture or not. Two different investment pattern may occur: a stand-alone investment or a syndicate. In both cases, the CVCs provide nonmonetary support to increase the value of the venture. Hence, the advantages of a syndicate entail cost sharing and also the nonmonetary support of the cooperation partner. However, both CVCs has to take into account that they share the cash flow if they syndicate.

The success of the venture affects some of the parental companies' assets (e.g. a product or process). This change in the asset's value may be positive or negative and differ among the parental companies. Thus, the venture can be a weak complement for a parental company, while it is also a strong complement for the other. I find that a CVC may forgo to finance a complementary venture even if the complementarity is stronger than it is for the other CVC. To understand this point, see that the impact on the assets emerges costless if the venture is financed by the opponent and it succeeds. Given this, the change in the asset's value may be interpreted as a positive external effect due to the absence of a cost contribution. Moreover, if the venture generates a medium cash flow, then it is always financed by a syndicate independently of the change in the asset's value. However, this situation only arises if the venture is a complement for both parental companies due to the beneficial support-effect of several investors.

Indeed, corporate investors do not always have a positive impact on their ventures. If one CVC obtains a positive change, whereas the other obtains a negative change, then a stand-alone investment of the former CVC leads to a higher nonmonetary support. However, in some cases cost sharing eclipse this value-added, so that a syndicate may also established by CVCs with countervailing incentives (complement vs. substitute).

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Appendix A. Proofs

Proof of Proposition 3.3. I consider a syndicate, in which each CVC_i obtains

$$U_i^{syn} = q \cdot \left(\frac{1}{2}R + \theta_i\right) \cdot (1 + s_i + s_j) - \frac{1}{2}s_i^2 - \frac{1}{2}.$$

The optimal support value s_i^{syn} is given by:

$$s_i^{syn} = \underset{s_i \in \mathbb{R}_+}{\operatorname{argmax}} \left\{ q \cdot (\frac{1}{2}R + \theta_i) \cdot (1 + s_i + s_j) - \frac{1}{2}s_i^2 - \frac{1}{2} \right\}.$$

For syndicate member CVC_i this yields:

$$s_i^{syn} = q \cdot \left(\frac{1}{2}R + \theta_i\right).$$

This support level dominates all other support levels, regardless of what CVC_j does, and is hence a best response to the support s_j^{syn}. There is thus a unique equilibrium in nonmonetary support levels.

□

Proof of Lemma 3.4. To proof Lemma 3.4, I characterize different thresholds for the cash flow:

- Start with the case where $\upsilon_2^*(0) \leq 0$:

$$\upsilon_2^*(0) \leq 0 \Leftrightarrow R \geq \widetilde{R} \equiv \frac{2}{3q} \cdot \left(\sqrt{4} - 1\right).$$

- I proceed with the case where $\upsilon_1^{**}(0) \leq \overline{\theta}_2$, $\upsilon_2^{**}(0) \leq \overline{\theta}_1$ and $\upsilon_2^*(\overline{\theta_1}) \leq 0$. Then, I have

$$\upsilon_2^{**}(0) \leq \overline{\theta_1} \Leftrightarrow R \geq \underline{R} \equiv \frac{2}{q} \cdot \left(\sqrt{3} - \sqrt{2}\right).$$

  Equivalently, $\upsilon_1^{**}(0) \leq \overline{\theta}_1$ and $\upsilon_2^*(\overline{\theta_1}) \leq 0$ if and only if $R \geq \underline{R}$.
- Last, I check the case where $\upsilon_1^{***}(\theta_1) \leq 0$

$$\upsilon_1^{***}(\theta_1) \leq 0 \Leftrightarrow R \geq \overline{R} \equiv \frac{2}{q} \cdot \left(\sqrt{2} - 1\right).$$

Straightforwardly, the following order exists: $\underline{R} < \widetilde{R} < \overline{R}$. □

Proof of Proposition 3.5. (i) Suppose that conditions (3) and (5) do not hold, i.e. the equilibrium of the stand-alone setting is characterized by no investment. One checks easily that $\upsilon_2^*(\theta_1) > \upsilon_1^*(\theta_1)\ \forall \theta_1 \geq \theta_2$. In other words, if CVC_2 accepts a syndicate, then the same applies for CVC_1. Also, $0 < \upsilon_2^*(\theta_1) < \overline{\theta}_2$ since $R < \widetilde{R}$. Therefore, a syndicate is stable
  - if $R < \widetilde{R}$ and condition (8) holds,
  - if $R \geq \widetilde{R}$.

  Otherwise the syndicate is not stable.

(ii) Suppose that condition (3) does not hold and (5) holds or that condition (3) and (7) hold, i.e. the equilibrium of the stand-alone setting is characterized by an investment of CVC_1. Hence, I consider $\upsilon_1^{***}(\theta_1)$ and $\upsilon_2^{**}(\theta_1)$. One checks easily that $\varphi(\theta_1) > \upsilon_1^{***}(\theta_1)\ \forall \theta_1 \geq 0$. Therefore, a syndicate is stable
  - if $R < \underline{R}$ and condition (10) holds. I have not to consider (9) due to $\underline{R} < \overline{R}$,
  - if $\underline{R} \leq R \leq \overline{R}$,
  - if $R > \overline{R}$ and condition (9) holds. I have not to consider (10) due to $\underline{R} < \overline{R}$.

  Otherwise the syndicate is not stable.

(iii) Suppose that condition (3) holds and (7) does not hold, i.e. the equilibrium of the stand-alone setting is characterized by an investment of CVC_2. One checks easily that $\varphi(\theta_1) > \upsilon_2^{***}(\theta_1)\ \forall \theta_1 \geq 0$.

  Note that I assume $\theta_1 \geq \theta_2$. Quite naturally, I have to check $\upsilon_1^{**}(\overline{\theta}_1) > \overline{\theta}_2$ due to $\theta_1 \geq \theta_2$:

$$\upsilon_1^{**}(\overline{\theta}_1) > \overline{\theta}_2 \Leftrightarrow R < \frac{2}{3q^2} \cdot \left(-2+\sqrt{3}+\sqrt{-2+2\sqrt{3}}\right).$$

This threshold differs only slightly from $\underline{R}$. Moreover, I have the following order:

$$\frac{2}{3q^2} \cdot \left(-2+\sqrt{3}+\sqrt{-2+2\sqrt{3}}\right) < \underline{R}.$$

Hence, a syndicate is stable

- if $R < \underline{R}$ and condition (11) holds,
- if $R \geq \underline{R}$.

Otherwise the syndicate is not stable.

Consider Figure 4, it summarizes the results depending on the cash flow.

"Insert Figure 4 Here"

□

Proof of Proposition 3.7. I relax the assumption that the venture is a complement for both investors and suppose that CVC_2 is confronted with a substitute, i.e. $\theta_2 < 0$. Furthermore, the venture is a complement for CVC_1, i.e. $\theta_1 \geq 0$.

(i) First, suppose that condition (5) does not hold, i.e. the equilibrium of the stand-alone setting is characterized by no investment. I have only to consider $\upsilon_2^{*}(\theta_1)$ [see, proof of Proposition 3.5]. The syndicate is stable if $R \geq \underline{R}$ and condition (8) holds. Otherwise the syndicate is not stable.

(ii) Suppose that condition (5) holds, i.e. the equilibrium of the stand-alone setting is characterized by a stand-alone investment of CVC_1. I consider $\upsilon_1^{***}(\theta_1)$ and $\upsilon_2^{**}(\theta_1)$. Then a syndicate is stable
   - if $R < \underline{R}$ and conditions (9) and (10) hold,
   - if $\underline{R} \leq R < \overline{R}$ and condition (9) holds.

   Otherwise the syndicate is not stable.

□

Proof of Proposition 3.8. Intuitively, a syndicate leads to a higher value-added than a stand-alone investor if the sum of the syndicate support is higher than the support of a possible stand-alone investor:

$$s_i^{syn} + s_j^{syn} \geq \widehat{s}_i \Leftrightarrow \theta_i + \theta_j \geq \theta_i. \tag{21}$$

If $\theta_i \geq 0$, then condition (21) is only fulfilled if $\theta_j \geq 0$ also applies. Otherwise, syndication lead to a lower value-added than a stand-alone investment of the complementary CVC_i. If $\theta_i < 0$, then condition (21) is only fulfilled if the venture is a complement for the other CVC. However, I show with Proposition 3.6 that the last investment pattern cannot occur.

□

Proof of Proposition 3.9. Henceforth, I show that a syndicate is stable, if CVC_1 provides nonmonetary support ($s_1^{syn} \geq 0$) and CVC_2 undermines the development of the venture ($s_2^{syn} < 0$). It is straightforward to show that $s_2^{syn} < 0$ if $\theta_2 < -\frac{1}{2}R$. Moreover, one checks easily that ${\partial \upsilon_1^{***}}/{\partial R} > 0$ and ${\partial \upsilon_2^{**}}/{\partial R} < 0$.

First, I consider the following equation:

$$\upsilon_1^{***}(\theta_1) = -\frac{1}{2}R \Leftrightarrow R = \frac{1}{q\sqrt{3}}.$$

If $R < \frac{1}{q\sqrt{3}}$, then CVC_1 accepts a syndicate, whereas a possible syndicate member CVC_2 undermines the development of the venture.

Second, I check if CVC_2 is also better-off with a syndicate. I consider the following equation:

$$\upsilon_2^{**}(\theta_1) = \upsilon_1^{***}(\theta_1) = -\frac{1}{2}R \Leftrightarrow R = 0.$$

Therefore, the quantity ${1}/{q\sqrt{3}}$ is the upper and the outside option, i.e. the risk-free cash flow with value 1, is the lower threshold for a stable syndicate, where CVC_2 undermines the development of the venture. Consider Figure 5, it describes the proof of Proposition 3.6 and 3.7.

"Insert Figure 5 Here"

□

Proof of Proposition 3.10. I characterize different thresholds for the cash flow:

(i) Start with the case where the equilibrium of the stand-alone setting is characterized by no investment:

$$\underline{\alpha}_i^{no} < 0 \text{ and } \overline{\alpha}_i^{no} > 1 \Leftrightarrow R > R_2^{no} \equiv \frac{1}{q} \cdot \left[\sqrt{2 + (1 + q\theta_1)^2} - 1 - q \cdot (\theta_1 + \theta_2)\right],$$

$$\underline{\alpha}_1^{no} < 0,\ \underline{\alpha}_2^{no} \geq 0 \text{ and } \overline{\alpha}_i^{no} > 1 \Leftrightarrow R_1^{no} < R \leq R_2^{no} \equiv$$
$$\frac{1}{q} \cdot \left[\sqrt{2 + (1 + q\theta_2)^2} - 1 - q \cdot (\theta_1 + \theta_2)\right] < R \leq R_2^{no},$$

$$\underline{\alpha}_1^{no} < 0,\ \underline{\alpha}_2^{no} \geq 0, \overline{\alpha}_1^{no} \leq 1 \text{ and } \overline{\alpha}_2^{no} > 1 \Leftrightarrow \widehat{R}^{no} \leq R \leq R_1^{no}.$$

Note that $\underline{\alpha}_2^{no} > \overline{\alpha}_1^{no} \Leftrightarrow R < R^{no}$. For clarity, I skip the value of $\widehat{R}^{no}$. This threshold is available from the author upon request.

(ii) I proceed with the case where the equilibrium of the stand-alone setting is characterized by a stand-alone investment of CVC_1:

$$\underline{\alpha}_1^1 \geq 0,\ \underline{\alpha}_2^1 < 0 \text{ and } \overline{\alpha}_i^1 > 1 \Leftrightarrow R \geq R_1^1 \equiv R \geq \frac{1}{q} \cdot \left(\sqrt{3 + 2q^2\theta_1\theta_2} - 1\right)$$

$$\underline{\alpha}_i^1 < 0 \text{ and } \overline{\alpha}_i^1 > 1 \Leftrightarrow R_2^1 < R < R_1^1 \equiv$$
$$\sqrt{\frac{3}{q^2} + \frac{2\theta_1}{q} + (\theta_1)^2 - (\theta_2)^2} - \frac{1}{q} - \theta_1 < R < R_1^1$$

$$\underline{\alpha}_1^1 < 0, \underline{\alpha}_2^1 \geq 0 \text{ and } \overline{\alpha}_i^1 > 1 \Leftrightarrow R \leq R_2^1$$

(iii) I proceed with the case where the equilibrium of the stand-alone setting is characterized by a stand-alone investment of CVC_2:

$$\underline{\alpha}_i^2 < 0,\ \overline{\alpha}_1^2 > 1 \text{ and } \overline{\alpha}_2^2 \leq 1 \Leftrightarrow R \geq R_2^2 = R_2^1$$
$$\underline{\alpha}_i^2 < 0 \text{ and } \overline{\alpha}_i^2 > 1 \Leftrightarrow R_1^2 < R < R_2^2 \equiv$$
$$\sqrt{\frac{3}{q^2} + \frac{2\theta_1}{q} + (\theta_2)^2 - (\theta_1)^2} - \frac{1}{q} - \theta_1 < R < R_2^2$$
$$\underline{\alpha}_i^2 > 0,\ \overline{\alpha}_2^2 > 1 \text{ and } \overline{\alpha}_1^2 \leq 1 \Leftrightarrow R \leq R_1^2$$

One checks easily that the different thresholds for the cash flow have the following order: $\widehat{R}^{no} < R_1^{no} < R_2^{no}$, $R_1^1 > R_2^1$ and $R_1^2 < R_2^2$

□

Proof of Proposition 3.11. The proof of this proposition is straightforward. I have already shown the cash flow benchmarks, i.e. condition (14) up to (17), and the derivations $\partial\widetilde{U}_1^{syn}/\partial\alpha$ and $\partial\widetilde{U}_2^{syn}/\partial\alpha$, respectively. Hence, I only state the following condition to complete the proof:

$$\alpha_1^{pe} \geq \alpha_2^{pe} \Leftrightarrow R \leq \frac{1}{2q} \cdot \left[\sqrt{(8 + (2 + q \cdot (\theta_1 + \theta_2)^2} - 2 - q \cdot (\theta_1 + \theta_2)\right]. \qquad (22)$$

If condition (15), (17) and (22) do not hold, then every shareholding $\alpha \in [\alpha_2^{pe}; \alpha_1^{pe}]$ is Pareto efficient. Otherwise, if condition (22) does not hold, then every shareholding $\alpha \in [\alpha_1^{pe}; \alpha_2^{pe}]$ is Pareto efficient. □

Proof of Proposition 3.12. The proof follows easily from Proposition 3.10, in the sense that $\alpha \in [0; 1]$ is the feasible shareholding interval for the given cash flow values. Thus, if condition (20) holds, then α^{max} can be established for a stable syndicate. □

Proof of Proposition 3.13. I now check under which conditions the shareholding $\alpha^{max} = \frac{1}{2} + \frac{\theta_2 - \theta_1}{2R}$ can be implemented by the Nash bargaining solution for a stable syndicate.

(i) I have already shown the calculation of the shareholding if the disagreement point is characterized by no investment. Hence, I check if the *Nash bargaining solution* can implement the shareholding α^{max}:

$$\frac{q \cdot (R - \theta_1 + \theta_2) \cdot (2 + q8R + \theta_1 + \theta_2) - 2}{2 \cdot [qR \cdot (2 + q \cdot (R + \theta_1 + \theta_2)) - 2]} = \frac{1}{2} + \frac{\theta_2 - \theta_1}{2R} \Leftrightarrow \theta_1 = \theta_2$$

(ii) Suppose the disagreement point is characterized by an investment of CVC_1. Then the following utility difference exist: $\Delta U_1^1 = \delta \cdot U^{joint} - U_1^1$ and $\Delta U_2^1 = (1 - \delta) \cdot U^{joint} - U_2^1$. The *Nash bargaining solution* can be determined for CVC_1 through the following maximization problem:

$$\widetilde{\delta} = \underset{\delta \in [0;1]}{\operatorname{argmax}} \left\{ \Delta U_1^1 \cdot \Delta U_2^1 \right\}.$$

This yields:

$$\widetilde{\delta} = \frac{4q \cdot (R + \theta_1) + 2q^2 R^2 \cdot (1 + \alpha - \alpha^2) + E - 4}{4q \cdot (R + \theta_1 + \theta_2) + 2q^2 R^2 \cdot (1 + 2\alpha - 2\alpha^2) + F - 4},$$

where

$$E = 2\theta_1 \cdot (\theta_1 + \theta_2) + \theta_2^2 + 2R \cdot (3 - \alpha\theta_1 + \alpha\theta_2),$$
$$F = \theta_1 \cdot (\theta_1 + 4\theta_2) + \theta_2^2 + 2R \cdot (2\theta_1 - \alpha\theta_1 + \theta_2 + \alpha\theta_2).$$

I have to determine the particular share α of the cash flow:

$$\widetilde{U}_1^{syn} = \widetilde{\delta} U^{joint} \Leftrightarrow \alpha = \frac{q \cdot \left[2qR^2 + 2R \cdot (2 + q\theta_1) + q\theta_2 \cdot (\theta_2 - 2\theta_1)\right] - 4}{2 \cdot (-2 + qR \cdot (2 + q \cdot (R + \theta_1 + \theta_2)))}$$

Next, I justify the share α^{max} that maximizes the joint surplus of a syndicate by means of bargaining:

$$\frac{q \cdot \left[2qR^2 + 2R \cdot (2 + q\theta_1) + q\theta_2 \cdot (\theta_2 - 2\theta_1)\right] - 4}{2 \cdot (qR \cdot (2 + q \cdot (R + \theta_1 + \theta_2)) - 2)} = \frac{1}{2} + \frac{\theta_2 - \theta_1}{2R} \Leftrightarrow$$
$$\theta_1 = \check{\theta}_1 \equiv \frac{1 - qR + q^2 R \cdot (\theta_2 - R) + \sqrt{1 + q^2 R^2 \cdot (1 + q^2\theta_2^2 - 2qR)}}{q^2 R}.$$

(iii) Suppose the disagreement point is characterized by an investment of CVC_2. The same approach holds as for part (ii). Thus, I only show the particular shareholding:

$$\widetilde{U}_1^{syn} = \check{\delta} U^{joint} \Leftrightarrow \alpha = \frac{q^2\theta_1 \cdot (2R + 2\theta_2 - \theta_1)}{2 \cdot [qR \cdot (2 + q \cdot (R + \theta_1 + \theta_2)] - 2)}$$

Last, I justify the share α^{max} that maximizes the joint surplus of a syndicate by means of bargaining:

$$\frac{q^2\theta_1 \cdot (2R + 2\theta_2 - \theta_1)}{2 \cdot [qR \cdot (2 + q \cdot (R + \theta_1 + \theta_2)] - 2)} = \frac{1}{2} + \frac{\theta_2 - \theta_1}{2R} \Leftrightarrow$$
$$\theta_1 = \widetilde{\theta}_1 \equiv \frac{R + \theta_2 \cdot [qR \cdot (2 + q \cdot (R + \theta_2)) - 2]}{2 \cdot [qR \cdot (1 + q \cdot (R + \theta_2)) - 1]}.$$

□

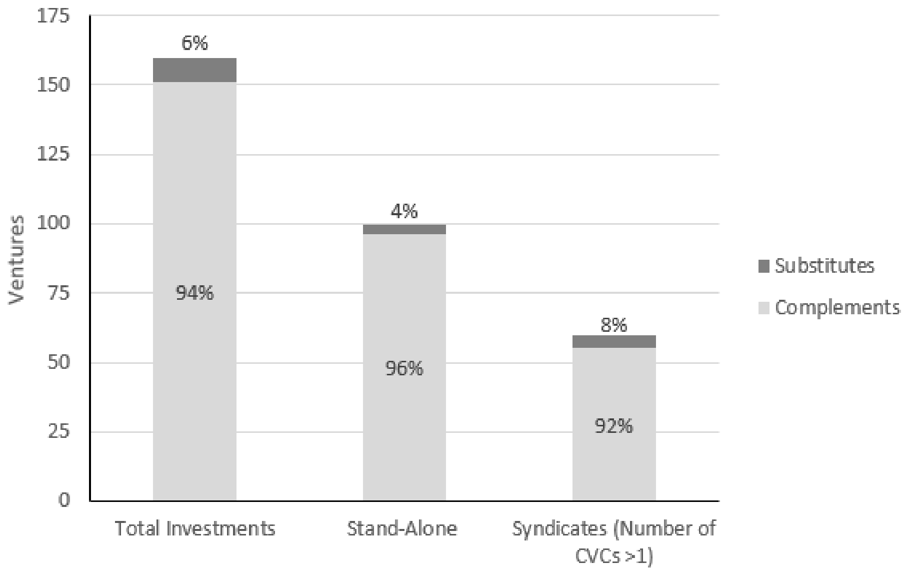

Figure 1. CVC Investments in the USA, 1997-2017, by different investment patterns. Source: Author's calculation based on Thomson Reuters.

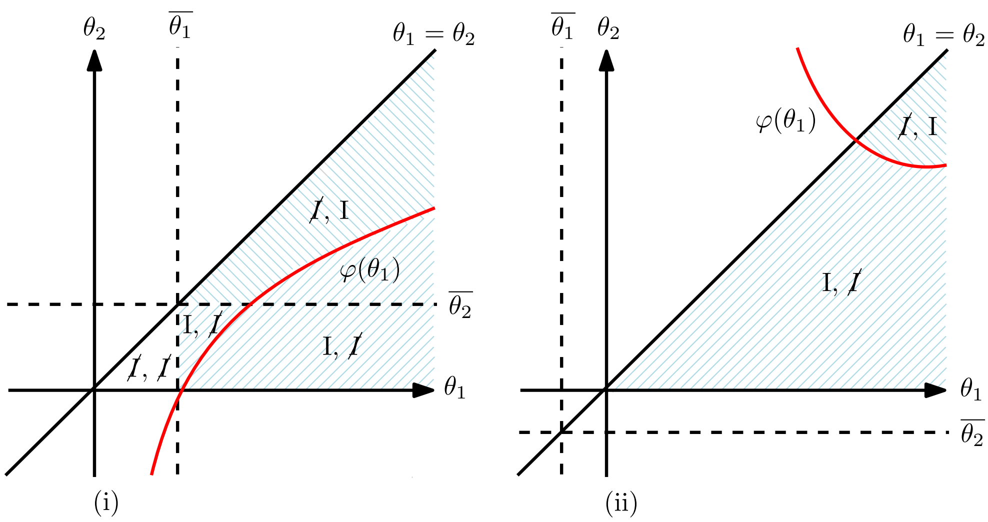

Figure 2. In Illustration (i), I consider a lower cash flow (i.e. condition (4) does not hold), whereas in (ii), I consider a higher cash flow (i.e. condition (4) holds).

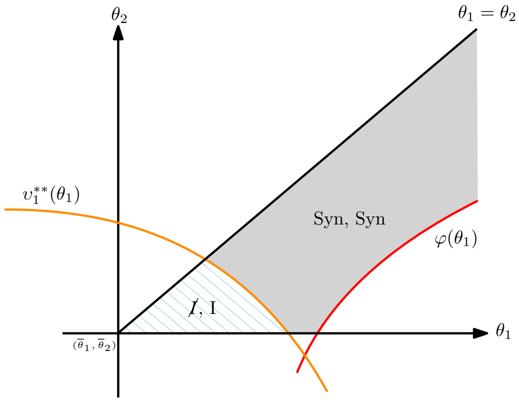

Figure 3. Stability of the syndicate.

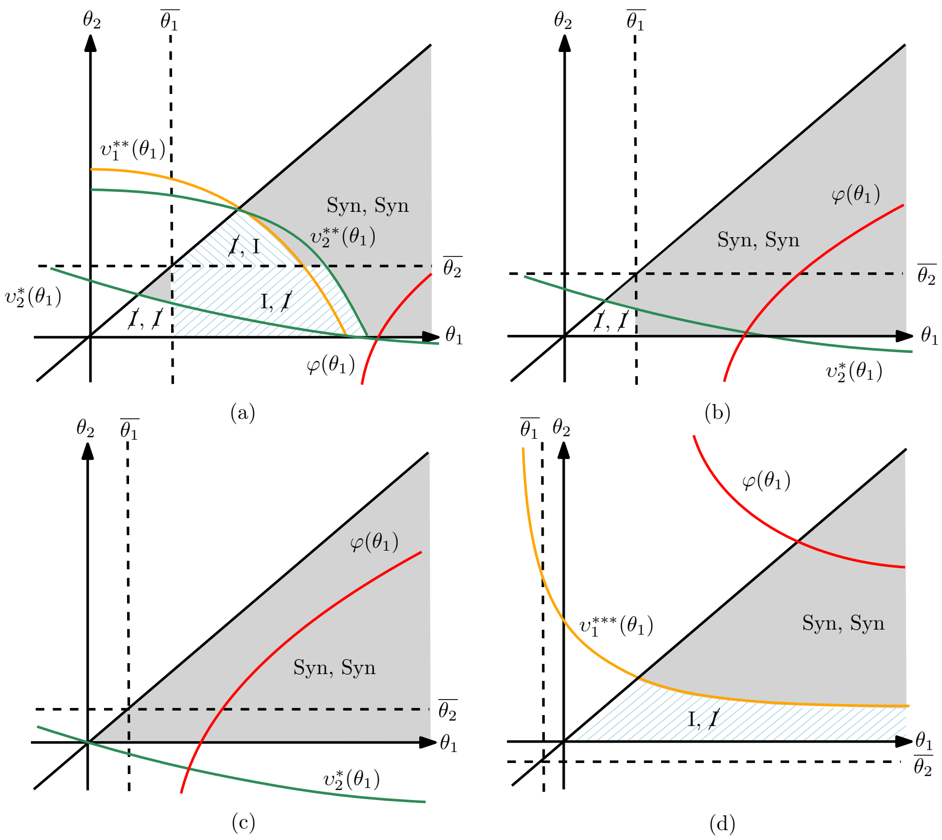

Figure 4. For Illustration (a), $r < R < \underline{R}$, for (b) $\underline{R} \leq R < \widetilde{R}$, for (c) $\widetilde{R} \leq R < \overline{R}$ and for (d) $R \geq \overline{R}$ applies.

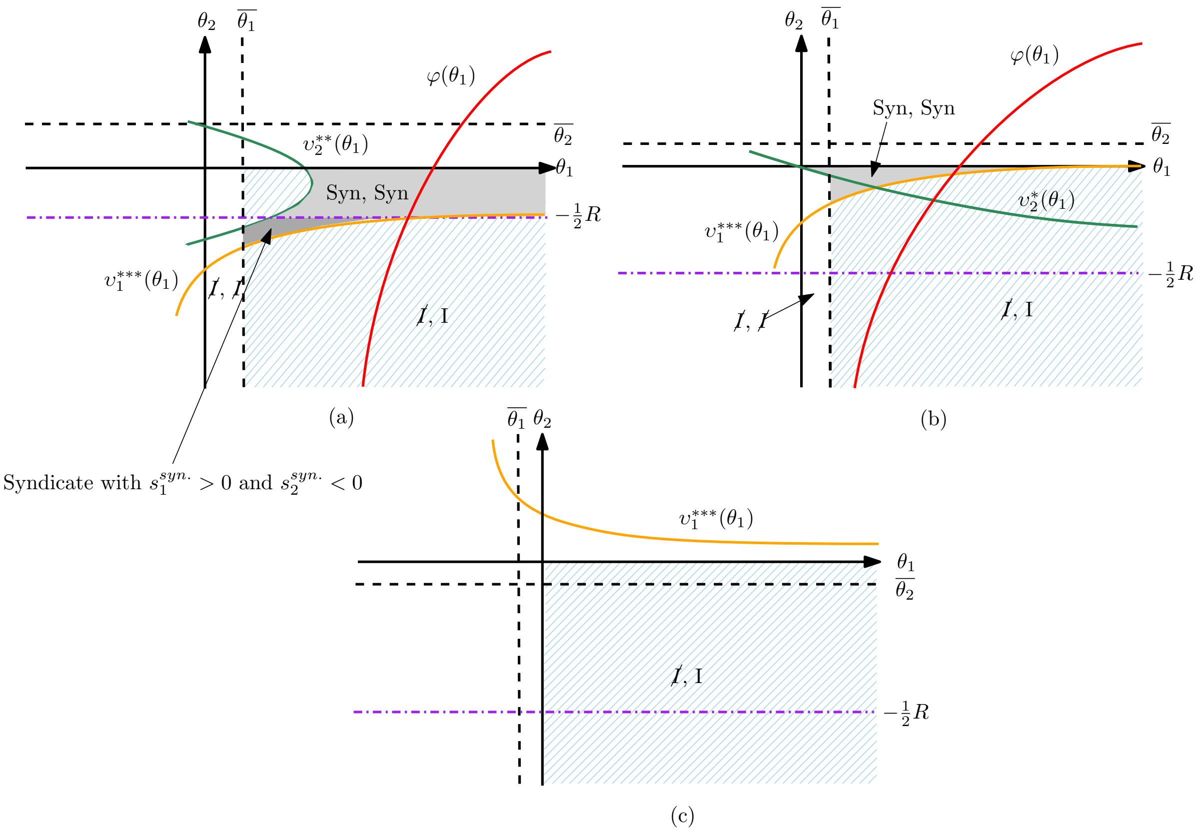

Figure 5. For Illustration (a), $1 < R < \underline{R}$, for (b) $\underline{R} \leq R < \overline{R}$ and for (c) $R \geq \overline{R}$ applies.