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**ORIGINAL PAPER** 



## How do investor characteristics of business angels and venture capitalists predict the occurrence of co-investments?

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## Abstract

Business angels (BAs) and venture capitalists (VCs) play major roles in the early funding stages of a venture. Although a significant proportion of venture funding rounds results from multiple investor types, most existing research takes an isolated view of either BAs or VCs. Research on the conditions and reasons for the formation of co-investments by BAs and VCs remains scarce. This study closes this gap by considering the impact of investor characteristics of BAs and VCs on the likelihood of co-investment. We focus on investor reputation, prior investment ties, and geographic proximity between the new venture and the investor. We address the questions of how these investor characteristics predict the probability of a co-investment between BAs and VCs in the first funding round of a new venture. Relying on the resource-based view and agency theory, we examine conditions that are in place when the two types of investors co-invest. Using a large-scale dataset with more than 7300 funding rounds of US-based ventures between the years 2005 and 2017, we find support for our hypotheses that investor reputation, prior investment ties, and geographical proximity impact the likelihood of co-investment and that these associations differ depending on the investor type.

**Keywords** Co-investment · Business angel · Venture capital · Investor network dyads · Investor location · Resource-based view · Agency theory

JEL Classification L26

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#### 1 Introduction

In the first financing round, new ventures may receive money from bank or government agencies, but the most important sources of funds are typically business angels (BAs) and venture capital firms (VCs). These two types of investors sometimes invest together in a so-called *co-investment* (Block et al. 2017). We define a co-investment as a simultaneous financial equity investment of two or more different investor types in one venture within a certain period of time (Wallmeroth et al. 2018; Cumming et al. 2019). Johnson and Sohl (2012) already show that 55% of the co- investments by BA and VC investors are simultaneous and not sequential. In addition, they state that the antecedents of a co-investment between these two different investor types might be different from the antecedents of a common investment by the same investor types.

Notwithstanding the increase in co-investments between BAs and VCs, previous research has mainly focused on investments by one investor type, either BA or VC (e.g., Barry 1994; Gompers 1994; Gompers and Lerner 1998; Croce et al. 2023) or syndicate investments between the same investor type, BA and BA or VC and VC (Sorenson and Stuart 2001; Bonini et al. 2016; Braune et al. 2021). As such, there are limited insights on co-investments between BAs and VCs. In the present study, we respond to a call from Cumming et al. (2019, p. 257), who state that "more insight is needed into how and in which circumstances different types of investors [...] interact to create value and to minimize principal-principal problems." Motivations for co-investments of BAs and VCs include sharing the risk and increasing the resources that might benefit the new venture (Brander et al. 2002; Wang and Wang 2012). However, such situations involving multiple investors carry specific risks. Conflicts may arise between the two different investor types due to different objectives of the investors (e.g., Van Osnabrugge 2000; Vanacker et al. 2013; Koenig and Burghof 2022; Robinson 2022).

We focus on three research gaps. First, we clarify and examine the role of investor reputation in co-investments of BAs and VCs. Whereas BAs are commonly known as high-net-worth individuals with key capabilities such as profound industry and operations expertise, VCs are described as finance professionals with strong skills in strategy, screening, and monitoring; generally, VCs have greater financial resources than a BA (Maula et al. 2005; Bonnet and Wirtz 2011). The decision of each of these investor types to participate in a co-investment in the first funding round of a new venture is informed by a careful study of the other potential investors. The quality signal that investors send out plays an important role (Hellmann et al. 2021; Koenig and Burghof 2022; Robinson 2022). We know from the VC syndication literature that previous success stories of VC investors can attract others to join their investments (Plagmann and Lutz 2019). The different characteristics and the unequal financial resources of BA and VC investors mean that a good reputation can have different levels of importance for the two investor types.

Second, we consider the role of the investors' possible prior investment ties – that is, the question of whether the BA and VC have previously co-invested,

and, if so, what influence that previous co-investment might have on a potential present one. Investors might think about the extent to which they can enforce their objectives with the other investors and possibly actively intervene if something develops contrary to their expectations (Mason et al. 2016). Investors may minimize such a risk by favoring a co-investor with whom they have prior experience through prior investment ties (e.g., Bellavitis et al. 2020; Edelman et al. 2021; Wallmeroth et al. 2018). Little attention has been paid to prior investment ties of different investor types in a co-investment. The different investor characteristics may lead to different assessments of the relevance of existing prior investment ties.

Third, we examine how geographical proximity to the new venture may favor the occurrence of a co-investment by BAs and VCs. We already know that VCs (Sorenson and Stuart 2001) and BAs (Sohl 1999; Paul et al. 2007; Ibrahim 2008) tend to invest in their local and regional economies, where the opportunity to actively participate is greater (Sorenson and Stuart 2001; Morrissette 2007) and the investor can monitor the new venture more closely (Lerner 1995; Cumming and Dai 2010). Previous research has not addressed the question of how geographical proximity between investors and a new venture might affect the possibility of a co-investment between BA and VC investors.

Consequently, the purpose of our study is to analyze the influence of three investor characteristics –investor reputation, prior investment ties, and geographical proximity – on the decision of whether or not to participate in a co-investment by BAs and VCs in a first funding round of a new venture. Relying on the resourcebased view, we examine the following research question: How do investor reputation, prior investment ties, and geographical proximity enhance the likelihood of the occurrence of a co-investment between BAs and VCs in the first funding round of a new venture? We examine our hypotheses using a large-scale dataset with more than 7,300 founding rounds of US-based new ventures between the years 2005 and 2017. Following entrepreneurship literature, we use the term *new venture* for entrepreneurial firms with limited resources that start from a weak market position (Katila et al. 2012). We find evidence for most of our hypotheses: Reputation and investment ties influence the occurrence of co-investments in the first funding round of a new venture, and they do so differently for BAs and VCs.

With our results, we explain the formation of co-investments between BAs and VCs, even if those arrangements seem problematic because they are multi-principal situations and because of the divergent goals of the two investor types. Thereby, we contribute to the academic literature in three ways. First, prior entrepreneurial finance literature mostly focuses on a single investor type (e.g., Barry 1994; Gompers 1994; Gompers and Lerner 1998; Kaiser and Berger 2021) or a syndication by the same investor type (BA and BA; VC and VC, Sorenson and Stuart 2001; Bonini et al. 2016). With our study, we extend these studies and results by examining the antecedents of co-investments of BAs and VCs, thereby adding to the literature on diverse investor sourcestor sources the relevance of investor reputation but pays less intention to the interplay of multiple investors in a co-investment (Meuleman et al. 2009; Chemmanur et al. 2011; Gu and Lu 2014). We expand this research

by clarifying the significance and the signaling effect of investor reputation for a VC and a BA investor in the context of a co-investment decision. We also add to this research by considering prior investment ties and geographical proximity as investor characteristics that associate with the probability of a co-investment. Third, we find evidence that BA and VC investors are in different power positions. In a co-investment, in contrast to a BA syndication (Johnson and Sohl 2012), the quality signals from the less dominant partner, in this case, the BA, must be strong enough to override the potential risks to co-investment from the VC's perspective.

#### 2 Conceptual framework and hypotheses

#### 2.1 Co-investments and the role of value-adding resources, potential conflicts, and signals

The scope of our analysis is co-investments by BAs and VCs in the first funding round of a new venture. Following existing literature, BAs are defined as high-net-worth individuals who invest a share of their resources in high-risk, high-return entrepreneurial projects (Freear et al. 1994). They follow financial return goals without a fixed time horizon and are often involved in venture operations and day-to-day business (Drover et al. 2017). Existing literature even argues that BAs tend to invest mostly for non-economic reasons, such as the intrinsic motivation to support new venture growth with their time and energy (Baty and Sommer 2002; Kaiser and Berger 2021; Falcão et al. 2023). In general, the interests of BAs are often in line with those of entrepreneurs (Kelly and Hay 2003).

Institutional investors (i.e., VCs) are finance professionals who manage other investors' money (Bonnet and Wirtz 2012). The primary investment motivation of VCs is usually financial returns with timely exits, by taking strategic roles in venture management, such as positions on the board (Berger and Udell 1998). Previous research shows that VCs usually have more capital and possibilities to participate in subsequent rounds than BA investors and therefore often appear more powerful, for example in term sheet negotiations (Harrison and Mason 2000; Hellmann et al. 2021).

Academic literature on both BA and VC investors provides the basis for our study of the phenomenon of co-investment with these two types of investors (Hellmann et al. 2021). We consider three different perspectives to derive our conceptual model of how investor characteristics of BAs and VCs might influence the occurrence of co-investments.

First, we use a resource-based perspective to understand the motivation of BAs and VCs to co-invest in the first funding round of a new venture. Hellmann and Thiele (2015) discuss the interrelated role between BA and VC investors, based on a two-market model with staged financing of the two investor types, where ventures first obtain seed funding from BA investors and follow-up funding by VC investors (Pfleiderer and Admati 1994; Berk et al. 1999). Freear and Wetzel (1990) reveal that the two investor types play complementary roles and the survey-based study of Harrison and Mason (2000) confirms the presence of a beneficial effect for invested

ventures when BAs and VCs have value-adding relationships. Conclusively, a resource-based view mostly supports the fact that complementary skills could be added together and results in good arguments for co-investment compositions (Filatotchev et al. 2006; Ferrary 2010). When investment decisions are taken, it is not clear how good the resources of other potential investors really are; hence, quality signals need to serve as a helpful indication (Colombo 2021; Koenig and Burghof 2022).

Second, existing studies find support for potential misunderstandings between BA and VC investors due to conflicting objectives, such as different expected time horizons of financial returns (Bruton et al. 2010; Wallmeroth et al. 2018). According to the agency theory, equity funding by external stakeholders is necessarily connected to agency costs. This phenomenon derived from information asymmetry and potentially differing interests are independent of the investor type (Jensen and Meckling 1976) and can be managed through appropriate monitoring and control mechanisms (Holmstrom 1982). Therefore, we face a multi-principal situation, where multiple investors of different types (i.e., BAs and VCs) target to achieve their individual goals with their investments. New ventures backed by multiple investors suffer from two sets of agency costs. On the one hand, additional costs of asymmetric information concerning the principal-agent link between the investor and the investee (Arthurs et al. 2008), and further, the principal-principal relationship in-between the investors (Young et al. 2002; Wright and Lockett 2003). Asymmetric information leads to the phenomenon of adverse selection and moral hazard in the investment decision process (Hall and Lerner 2009). Moral hazard refers to the problem of inducing actors to exert effort when their actions cannot be observed and resource investments such as monitoring are needed to overcome the asymmetries (Holmstrom 1982). On the other hand, adverse selection plays a major role in the selection process before the investment decision is taken and refers to a situation that investors face when they select companies, but the quality is not apparent because the assets are highly specialized, and no comparable options are traded on the competitive market. Hence, the interactions between investors and founders will be characterized by negotiations about achieving a balance among differing objectives. Obviously, the more different interests collide, the more difficult this goal achievement becomes.

Third, we assume that the two types of investors, BA and VC, are very different due to their diverse investment motives and opportunities. Hence, there is likely to be a power imbalance in the cooperation between these two investor types. From the investor descriptions and findings in the literature, we find that VC firms tend to take a dominant role over BA investors concerning term sheet negotiations due to their size, organizational structure, and possibilities (Leavitt 2005). For example, VC investors usually have the capital opportunities and intention for participating in follow-on investments, whereas Angel investments remain usually in the very early stages (Wallmeroth et al. 2018).

A first funding round with more than one investor can lead to additional transaction costs and potential problems due to diverging interests and goals of the different investors (Cumming 2006; Meuleman et al. 2009). In an ideal world, contracts would allow to clearly define different investors' rights and obligations. Still, this is

not possible in practice and would be even more challenging to enforce (Hart and Moore 1988; Wright and Lockett 2003; Lockett et al. 2006; Zhelyazkov and Gulati 2015). Consequently, the decision to participate in a co-investment is based on which other investors are involved in the first funding round. This decision of participation does not necessarily depend on the type of investors, as both investor types could either benefit or lose from the joint investment. Instead, the question arises whether it is worthwhile considering the triad of two different investor types and whether the venture itself is worth taking the risks of the multi-principal situation (Bruton et al. 2009). Thus, we follow previous studies arguing that the decision to invest and, hence, the venture-investor matchmaking process is predominantly influenced by the investor, and not the venture (Tian 2012). Following this line of inquire, we consider the investor characteristics of BAs and VCs (i.e., investor reputation, prior investment ties, geographical proximity between investor and investee) on the likelihood of a co-investment in the first founding round of a new venture. Figure 1 provides a schematic structure of the research model which we derive through the following hypotheses.

#### 2.2 Investor reputation and the likelihood of co-investment occurrence

We rely on signaling theory (Spence 1974) to consider how the investor reputation of BAs or VCs is associated with the likelihood of a co-investment occurrence in the first funding round of a new venture. Signaling theory refers to a goal-oriented disclosure and transmission of information to improve the financing conditions of capital borrowers (Spence 1974; Certo 2003; Hopp and Lukas 2014). Following Jensen and Roy (2008) and Wilson (1985), we define reputation as the esteem in which companies are held based on their past performance.

The decision to co-invest with other investors is usually taken under conditions of information asymmetry. This means that the information about the quality of investors in the potential co-investment group is different. To reduce the asymmetry and



Fig. 1 Research model

infer the quality, the actors use observable information (i.e., signals; Colombo 2021) such as the reputation of an investor (Spence 1974; Certo et al. 2001; Certo 2003; Hopp and Lukas 2014).

This situation of information asymmetry can be overcome through the emission of signals that indicate the reputation of an investor. According to signaling theory, the reputation must be freely accessible such as observable (Connelly et al. 2011). We, therefore, consider the experience in the form of previous investments and the investor portfolio performance, which are mostly transparent in the VC market, so that observability may be accomplished (Dimov and Milanov 2010; Koenig and Burghof 2022; Robinson 2022). Due to the unequal power balance between the two investor types (Harrison and Mason 2000; Wallmeroth et al. 2018), we argue that the investor reputation serves as a signal that reduces information asymmetry, and that in the first funding round of a venture, a high BA reputation increases the likelihood that a BA will co-invest with a VC (H1a), while a high VC reputation reduces the likelihood that a VC will co-invest with a BA (H1b).

Due to the greater financial means of VC investors and their usual intention to participate in a follow-on funding round, they can often dictate the term sheets (Van Osnabrugge 2000; Leavitt 2005; Hellmann et al. 2021). This point is supported by Harrison and Mason (2000), who show that VCs benefit from better investment terms and conditions since BA investors bring less money or are unable to participate in further investment rounds (Morrissette 2007; Wallmeroth et al. 2018). Hence, VCs take a dominant partner position in a possible co-investment situation, and the power relationship in a multi-principal investor group is tilted in favor of the VC. Therefore, from the VC perspective, a co-investment with a BA could be riskier than a pure VC investment. Such potential risks from the VC perspective are based on the different characters between BAs and VCs, the different investment time horizons (five or more years for BAs compared to three to five years for VCs), the different exit strategies (i.e., less important for BAs than for VCs due to the long-term investment horizon), and different return on investment expectations (i.e., between 20 and 30% for BAs and 30–50% for VCs) (Morrissette 2007; Bruton et al. 2010). In addition, the resource imbalance between the two investor types may mean that BA investors can not longer participate in later financing rounds. This means that the VC investor loses its partners and is disadvantaged compared to other investors. From the BA perspective, however, a co-investment with a VC could also be riskier than a pure BA investment, since the BA enters into an investment with a stronger partner, and the BA investor has only limited power within the investment. Following this, a co-investment between a VC and a BA could be riskier than a syndicate where only one type of investor makes a co-investment.

Further, risk reduction is particularly important for less dominant investors within an investor composition, in this case, BAs, due to their limited power to influence decisions on venture strategy and operations. Hoberg et al. (2013) support this argument by finding out that BAs investing alongside VCs often invest with weaker rights. The potential for conflicts and the risks to achieving individual goals are higher for BAs and lower for VCs than in syndicates with their type.

We, therefore, assume that it is difficult for BA investors with inferior power and a relatively low reputation to find VCs who are interested in co-investing. In our context, this reasoning is crucial for BA investors, so that from a resource-based view, their quality signal must override the potential risks of the multi-principal situation for the VC investors to join the co-investment. Studying BA syndication, Johnson and Sohl (2012) found that BA investors generally do not have to signal their skills to other BA investors. But when it comes to co-investments with the more powerful investor types, it is important to signal strong skills and extensive resources as a quality heuristic to other potential co-investors to outweigh the risks arising from the multi-principal situation. We, therefore, expect a positive association for the link between investors' reputation and the probability of a co-investment with VCs for BA investors. For VC investors, this argument turns around so that the reputation of this investor type is not decisive for a co-investment with BA investors. Therefore, we hypothesize:

*Hypothesis 1aa:* A BA-VC co-investment in the first funding round of a new venture is more likely for BA investors with a higher level of reputation. *Hypothesis 1b:* A BA-VC co-investment in the first funding round of a new venture is less likely for a VC investor with a higher level of reputation.

#### 2.3 Prior investment ties and the likelihood of co-investment occurrence

Our second hypothesis considers how investors' prior investment ties are associated with the likelihood of a co-investment between BAs and VCs in the first funding round of a new venture. Prior investment ties, in the present sense, means the number of prior investment dyads between an investor and the other investors of the focal investor group (i.e., simultaneous investment) in another venture within the 5 years preceding the investment in question (De Clercq and Dimov 2004; Lei et al. 2017; Bellavitis et al. 2020). To derive our hypotheses, we also use evidence from co-investment literature and look at the differences between the two investor types in terms of the potential for a co-investment in a new venture's first funding round.

To consider the impact of prior investment ties on the likelihood of a co-investment occurrence we have to face the differences between the two involved investor types (Wright and Lockett 2003; Bonnet and Wirtz 2011; Mason et al. 2016). With regard to the unequal power situation (Harrison and Mason 2000) and the riskreducing behavior of the investors (Edelman et al. 2021; Koenig and Burghof 2022), we argue in the following that more prior investment ties enhance the likelihood that BAs will co-invest with VCs (H2a) while they reduce the likelihood that VCs will co-invest with BAs in the first funding round of a venture (H2b).

As with investor reputation, the association of prior investment ties with the likelihood of a co-investment occurrence with BA and VC investors also depends on unequal power distribution between BAs and VCs (Van Osnabrugge 2000). Due to the more powerful position of the VC in this principal-principal situation, we argue that the risk of not reaching the individual goals is even higher for BA investors if conflicts of interests between the two investor types arise (Hoberg et al. 2013).

Prior research indicates that previous collaboration between the investors could act as a signal of trust, which, for both participating investors, reduces the risk of not reaching their individual goals (e.g., Bellavitis et al. 2020; Edelman et al. 2021;

Wallmeroth et al. 2018). Hellmann et al. (2021) show that serial angels, who invest in multiple companies, are more connected to the VC community than single-investment angels. Based on this finding, we argue that a BA investor who has made many investments with VCs in the past has a lot of experience in co-investments with this investor type. In this case, the BA has a high level of prior investment ties. Sorenson and Stuart (2001) note the significance of prior investment ties in paving the way for current collaborations; we argue that the individual risk for the BA investor in a new co-investment situation might be reduced by previous experiences with co-investment situations with VC investors. The uncertainty of the BA investor might be lower so that the probability of a co-investment between the BA and a VC investor increases. Thus, we argue that for BA investors with a higher level of prior investment ties, the probability of co-investments with VCs are more likely.

In contrast and due to its dominant position, a VC investor can usually enforce the achievement of its goals vis-à-vis a BA even against the BA's will, which makes the VC's risk appear much lower than that of the BA (Leavitt 2005). Therefore, we argue that a BA-VC co-investment in the first funding round of a new venture is more likely for a BA investor with prior investment ties than it is for a VC investor with prior investment ties. For VCs, a high level of prior investment ties does not enhance the probability of a co-investment.

*Hypothesis 2a:* A BA-VC co-investment in the first funding round of a new venture is more likely for a BA investor with more prior investment ties. *Hypothesis 2b:* A BA-VC co-investment in the first funding round of a new venture is less likely for a VC investor with more prior investment ties.

#### 2.4 Geographical proximity and the likelihood of co-investment occurrence

An important factor in the investor's investment decision is geographic proximity, that is, the distance between the investor's location and the new venture's location (Bjørgum and Sørheim 2015). Drawing on the findings of Li and Chi (2013), we consider geographical proximity as given if the investor operates in the same US state as the venture. Sohl (1999), Paul et al. (2007), and Ibrahim (2008) found evidence that BA investors tend to invest in their local economies. Sorenson and Stuart (2001) find similar results for VC investors, who tend to either invest in local ventures or establish proximity by proxy to more distant new ventures by syndicating with a local VC (Tykvová and Schertler 2014). Researchers find two reasons for investors' preference for geographic proximity: interpersonal human psychology and monitoring (Cumming and Dai 2010). For our hypotheses, we argue that with geographical proximity (i.e., the investor operates in the same state as the new venture), it is more likely that BAs will co-invest with VCs (H3a) and that VCs will co-invest with BAs (H3b) in the first funding round of a new venture.

First, we will consider interpersonal human psychology. Investors prefer regular in-person meetings both before and after a funding round the funding round (Morrissette 2007). Between three and eight face-to-face meetings are typically held on a regular basis from the submission of the business plan to the closing of the financing. (Cumming and Dai 2010). For reasons intrinsic to human psychology,

BA (Morrissette 2007) and VC investors (Sorenson and Stuart 2001) prefer to invest in familiar entrepreneurs and in new ventures that have a high level of visibility to them. VCs are normally more informed about funding opportunities in their geographic proximity (Huberman 2001; Franke et al. 2016), and this knowledge makes them feel safer when funding local ventures.

Second, an investor's ability – regardless of the investor type – to closely monitor new ventures is much higher when the physical distance between the investor and the new venture is low (Lerner 1995; Cumming and Dai 2010). Chemmanur et al. (2016) find that proximity allows investors to track the progress of new ventures and, thus, the progress of their investments. Dai et al. (2012) find that proximity enhances investors' ability to select and supervise portfolio firms Accordingly, a nearby investor is better able to attend board meetings, which reduces the moral hazard problem between the principal (investor) and agent in in the area of the management of the venture (Lerner 1995; Cumming and Dai 2010). As Lerner (1995) has shown, the greater the physical distance between a VC and the new venture, the lower the representation of VCs on new venture boards. This lack of representation can lead to a significantly lower return on investments in geographically distant new ventures than those nearby (Coval and Moskowitz 1999a, b). Croce et al. (2018) obtain similar results for BA investors: Geographical proximity leads to advantages in dealing with asymmetric information and agency problems that may arise from conflicting interests.

Based on our reasoning, we conclude that the likelihood of co-investment between BAs and VCs in a new firm's first round of financing is high when an investor (whether BA or VC) is geographically close. Thus, we hypothesize:

*Hypothesis 3a*: A BA-VC co-investment in the first funding round of a new venture is more likely for a BA investor with greater geographical proximity. *Hypothesis 3b*: A BA-VC co-investment in the first funding round of a new venture is more likely for a VC investor with greater geographical proximity.

#### 3 Methodology

#### 3.1 Data description and sample selection

To examine our research questions, we collected data on venture and investor characteristics as well as market-level information. In the first step, we used, as the main source for our sample, TechCrunch's Crunchbase, a comprehensive and regularly updated database that compiles information on ventures, investors, and investments (Homburg et al. 2014; Ter Wal et al. 2016). In a second step, to double-check and complement the information, we added data from Refinitiv Eikon (data as of Dec 2017) on the venture and investor level (Kwon et al. 2020), such as the investor type classification and the industry-level classification based on Standard Industrial Classification (SIC) codes. Finally, we used the Compustat database to add macroeconomic data on the industry level. We took several steps to define our final sample of analysis. First, we specified relevant funding rounds with BA and/or VC participation as the first equity investment (i.e., the first funding round) of a new venture, and redefined them by grouping individual investment events within 90 days into one funding round together (Guler 2007; Hellmann et al. 2021). We included financing rounds with a minimum of two and a maximum of ten different investors, since we do not consider individual investments in our analysis. Also, many investors make it difficult to observe and interpret individual criteria in an investor group. We excluded co-investment rounds in which one type is represented at least three times as often within an investor composition (e.g., three VC investors and one BA investor), as well as rounds with a single investor or with more than ten investors. Furthermore, we restricted our sample to US-based ventures because the US is the world's largest and most active technology start-up ecosystem. Finally, we excluded ventures whose first funding round was before 2005.

The raw data from Crunchbase contains 270,660 funding rounds (including all ventures and investments, worldwide), of which 77,100 remain after focusing on US-based venture investments and matching with Eikon and Compustat. After removing funding rounds before 2005, as well as records with missing data such as investment volume, founder team size, and geographical location, 2706 (with BA participation) and 4653 (with VC participation) funding rounds of new ventures remain. Due to our focus on the first funding round, new ventures are only included once in our dataset. Very few observations are dropped due to the formation of industry groups with fixed effects in the logistic regression. Table 1 shows the details of the sample selection and mergingprocess and Table 2 displays the sample description.

#### 3.2 Measures

To test our proposed hypotheses, we used established measures based on previous investment research in entrepreneurial finance literature. Our analysis considers the first funding round of a new venture. To determine the likelihood that a BA or a VC will co-invest, we operationalized the independent variables (i.e., investor reputation, prior investment ties, geographical proximity) for both investor types. Thus, we determined the probability of a co-investment between BAs and VCs for each investor type.

#### 3.3 Dependent variable

#### 3.3.1 Co-investment occurrence

Following the syndication literature in entrepreneurial finance, we used a binary variable for the co-investment of VCs and BAs in the first funding round which equals 1 if a new venture receives funding with the simultaneous participation of both BAs and VCs, and 0 if the venture receives funding from only one investor type (Ter Wal et al. 2016; Colombo and Murtinu 2017; Lei et al. 2017; Plagmann and Lutz 2019). This means that for the analysis of BAs, the value 0 takes into account

	ignig process	
Sample selection and merging process	Funding round level	Note
Initial sample of Crunchbase database	270,660	Using Crunchbase Export data with data until July 2019 (merging investments.csv, funding_rounds.csv, ipos.csv, acquisition.csv, organisations.csv, organization_descriptions.csv, investors.csv)
Dropouts	193,560	Dropouts due to missing data entries (e.g., investor type) and data exclusion (e.g., US ventures only, no debt/grant funding rounds)
Merging with Refinitiv EIKON, Compustat data, and variable definition	77,100	Merge on investor and new venture level using a fuzzy logic approach with Jaro distance function; e.g., industry SIC code, industry competitiveness, investor classification, M&A/IPO conditions, industry experience)
Dropouts	20,395	Filter data for startups founded in/after the year 1995 and with first investment in/after 2000, exclude investments with just one investor
Reduced data sample	56,705	Composition: 6,524 BA-only investments, 39,965 VC-only investments, 10,216 co-investments
Dropouts	51,275	Filter data for the first funding round per venture only, exclude data with missing information (e.g., venture age, investment volume, founder team size), drop data with dominance of one investor type and more than 10 investors per funding round
Remaining data sample	5430	Composition: 2,732 with BA participation (775 BA-only investments, 1,957 co-investments); 4,655 with VC participation (2,698 VC-only investments, 1,957 co-investments)
Final data sample in regression models (BAs) Final data sample in regression models (VCs)	2706 4653	Few observations dropped due to statistical reasons (building of industry groups with fixed effects)

Table 2 Sample description				
	Funding rounds with BA particip:	ation	Funding rounds with VC particil	pation
Investment volume	Ν	%	Ν	%
Less than or equal to 500 K USD	200	26	735	27
500 to 1000 K USD	549	20	635	23
1000 to 2000 K USD	707	26	1044	38
2000 to 4000 K USD	419	15	846	31
4000 to 7500 K USD	188	7	613	22
More than 7500 K USD	169	6	782	29
Total	2732	100	4655	100
Percentages of investor constel- lations	BA		VC	
BA- or VC-only investments	775	28	2698	58
Co-investment by BA & VC	1957	72	1957	42
Total	2732	100	4655	100
Number of investors in funding round	BA		VC	
2	713	26	1721	63
3	572	21	1011	37
4 to 5	752	28	1119	41
5 to 10	392	14	486	18
More than 10	303	11	318	12
Total	2732	100	4655	100

co-investments by BAs only, and for the analysis of VCs, co-investments by VCs only.

#### 3.4 Independent variables

#### 3.4.1 Investor reputation

To measure a BA's or VC's investor reputation, we used an economic measure to determine the investor's past activities, rather than the sociological concept of status capturing the social status of the investor based on external affiliations (Dimov and Milanov 2010).

Since there is no consensus in the academic literature on how to measure an investor's reputation (Plagmann and Lutz 2019), we establish a multi-item index. To establish the index, we followed and modified the method used by Dimov and Milanov (2010) to build a multi-item index. For the items, we used the three variables of Hahn and Kang (2017), which are widely used in entrepreneurship literature (e.g., Bellavitis et al. 2020), and we applied them to each BA and VC. First, we determined the number of investments the investor had made in the five years before the focal funding round. Second, we determined the investor's age at the time of the funding round (Nahata 2008). For a BA, we used the real age, and for a VC, the date of incorporation or their first investment registered in Crunchbase or Eikon. Third, we determined the number of ventures with IPOs or acquisitions the investor had backed in the five years before the focal investment (Lee et al. 2011; Amor and Kooli 2020). This last component of the multiitem index is an especially direct indication of the previous reputation of an investor. We z-standardized all items for each corresponding year to obtain a comprehensible classification for each investor type. We then summed up all three components and calculated the average value to create a reputation index for each investor. A higher index represents a higher level of reputation. We also used the operationalization by Hahn and Kang (2017) as an alternative variable for investor reputation, and, as we show in our robustness tests section, validated the robustness of our results.

#### 3.4.2 Prior investment ties

Our second independent variable counts the number of prior investment dyads between an investor and the other investors of the focal investor group (i.e., co-investment of BAs and VCs in the first funding round of a new venture). Based on previous studies (De Clercq and Dimov 2004; Lei et al. 2017; Bellavitis et al. 2020), we considered the prior investment dyads within the five years preceding the investment in question. Following the literature, for each pair of investors, this measure takes a value of 0 if they have never invested together before, or 1 if they have invested together one or more times (Sorenson and Stuart 2001, 2008; Hochberg et al. 2007; Hallen 2009). The variable *prior investment ties* is calculated as the quotient of the number of prior investment dyads and the number of potential dyads in the relevant investor group. This variable is dynamic and can change over time for

each investor with investment activities. At the level of the first funding round of a new venture, we used the average value and grouped it for each investor type, that is, BA and VC.

We used a dummy count (value 0 or 1) for each investor pair because we want to determine how many other investors in an investor group are familiar with a focal investor from previous investment activities. We kept our definition of a co-investment as a simultaneous event due to the intensive contact points during the mutual funding process. The calculation is as follows:

$$X_{ijt} = k_{ijt} * \left(\frac{n_{jt} * (n_{jt} - 1)}{2}\right)^{-1}$$

1

In the formula,  $k_{ijt}$  reflects the number of investors with a joint investment within the last 5 years in the investor group of investors *i* and in funding round *j*;  $n_{jt}$  refers to the number of investors in the focal funding round, and *t* to the funding round year.

For example, one funding round in the year 2010 is composed of three investors: A, B, and C. If A and B invested together in 2008, but none of them invested together with C, the variable *prior investment ties on investor level* will equal the value 1/2 for investors A and B. Similarly, if the three investors invest again in the year 2011, each investor has a tie ratio of 1 (two out of two).

Finally, we calculated the average value of the prior investment tie for each investor type on the funding round level.

#### 3.4.3 Geographical proximity

Our third independent variable reflects the distance between the investor location related to the new venture. Following Li and Chi (2013), we created a binary variable that equals 1 if the investor operates in the identical state as the new venture and 0 otherwise. The variable reflects the fact that the investor is familiar with the local landscape and might have personal contact with the founders of the new venture; this second factor has also been used as a measure for risk reduction (Li and Chi 2013). We employed the average value of geographical proximity of each investor (i.e., BA or VC) on the first funding round level.

#### 3.5 Control variables

We used several control variables in our analysis, since several additional factors may affect the likelihood of a co-investment by BAs and VCs in the first funding round of a new venture. Therefore, we employed control variables at the investor level, venture level, and macro level.

To control for investment deal-specific characteristics that can determine the probability of a co-investment, we included several variables on multiple levels, such as *investor group size*, a metric variable that counts the number of investors investing together within one funding round of a new venture (Lei et al. 2017; Block et al. 2019; Plagmann and Lutz 2019). As stated earlier, a funding round can be

interpreted as simultaneous equity financing, and we assume that the probability of a co-investment by different types increases with the number of investors participating in any focal round. We have included financing rounds with a minimum of two and a maximum of ten different investors because, on the one hand, we do not consider individual investments in our analysis, and, on the other hand, a high number of investors makes it difficult to observe and interpret individual criteria in an investor group.

Moreover, we control for the *investment volume* per funding round because this factor is seen in the existing literature as driving the formation of co-investments and syndicates (Lockett et al. 2006; Croce et al. 2018). The reason for this is simply the distribution of the necessary capital among several resource providers. Since we assume that the investment value might also affect our analysis, we employed this variable using the natural logarithm. Also, previous research used this variable to control for different initial start-up conditions, such as the perceived quality of the business model (Ter Wal et al. 2016). Further, we employed a binary variable, *CVC participation*, which takes a value of 1 if a corporate venture capital (CVC) investor is a participant in the focal funding round, and a value of 0 otherwise. Previous studies reveal that a CVC behaves differently from an independent venture capital (IVC) firm. CVC investors often have more strategic goals in gaining technological knowledge, and provide particular resources, such as extensive access to industry contacts, which could influence the investment behavior of other investors (Park, H. D. & Steensma 2013; Colombo and Murtinu 2017).

At the level of the venture, we controlled for the *founder team size*, since the team size usually influences the venture's investment decisions (Mason and Stark 2004; Cumming et al. 2016). We obtained the number of founders from the Crunchbase database. We further controlled for the venture's age (i.e., *venture age*), because older ventures are usually more established and have proven their survival without failure, thus reducing uncertainty, which could influence their attractiveness for different investor types (Dimov and De Clercq 2006; Cumming et al. 2010; de Vries and Block 2011). We also used a binary variable to control for accelerator program participation (i.e., *previous accelerator round*) of the new venture, which takes a value of 1 if the venture participated in an accelerator program before the focal funding round and a value of 0 otherwise (Hochberg 2016; Cohen et al. 2019).

Another factor at the macro level that might influence the funding round is the ecosystem in which the start-ups operate. Hence, we control for the *venture's geographical location* with a binary variable that takes a value of 1 if the venture operates in an entrepreneur-friendly state and a value of 0 otherwise. According to Lee and Masulis (2011), California and Massachusetts are the most entrepreneur-friendly states, with high-class entrepreneurial universities, established accelerators, and high numbers of investors. The venture's geographical location in one of these states could influence the probability of co-investment (Lee and Masulis 2011; Chahine et al. 2012; Falconieri et al. 2019). Similarly, we assume that the competition in the segment where a start-up operates can influence the probability of investor funding, as existing literature finds the role of the competitive surroundings of a new venture to be important in the investment decision process (Moritz et al. 2020). Thus, following the well-established measure of Kwoka (1977), we calculated the *industry competitiveness (HHI)* of each industry for each year with the Herfindahl-Hirschmann index (HHI), defined as the sum of squared market shares in the industry.

Finally, we included dummy variables for the *investment year* and the *venture industry*. Existing research indicates that both factors can influence investment behavior due to different competitive intensities and growth perspectives over time (De Clercq and Dimov 2008; Gu and Lu 2014; Ter Wal et al. 2016). As is common in the entrepreneurial finance literature, we employed a set of binary variables for each year within our period of observation (2005–2019). They equal 1 for an investment in that specific year and 0 otherwise (Nahata 2008; Plagmann and Lutz 2019). We controlled for the new venture's industry based on the Crunchbase industry category list and a subsequent matching logic with SIC codes. We also used a set of binary variables for each industry, 1 if the venture operates in a specific industry, 0 otherwise (Nahata 2008).

Table 3 reports our variables and important descriptions such as mean, minimum, and maximum values. Since we needed to perform the analysis on the funding round level separately for the two types of investors, the data are presented for the BA and VC investors.

#### 3.6 Analysis

Because our dependent variable is binary and therefore the most extreme form of a discrete variable, we used logistic regression to analyze the likelihood of a co-investment occurrence of BA and VC investors in the first funding round of a new venture. Our unit of analysis is a funding round where BAs and VCs invest simultaneously in a venture.

To test our hypotheses and verify the robustness of our results, we apply multiple regression models using STATA 17. Based on previous studies, we account for the outcome as a binary variable and use logit regression models including firm and investment year fixed effects (Cumming and Zhang 2019; Plagmann and Lutz 2019). We used STATA's xtlogit regression model for the Hausman test (Hausman 1978) and get strong support for the random effects. Thus, we estimated the following latent model equation in the main logistic model:

$$Co\_Investment_{it} = \beta_0 + \beta_1 Inv\_reputation_{it} + \beta_3 Inv\_prior\_tie\_ratio_{it} + \beta_4 Inv\_location_{it} + \sum_{j=4}^{14} \beta_j X_{j,it} + \varepsilon_{it}$$

 $Co\_Investment_{it}$  describes the co-investment funding round with BA and VC investors,  $Inv\_reputation_{it}$  is the investors' reputation,  $Inv\_prior\_tie\_ratio_{it}$  captures the prior investment ties of an investor and  $Inv\_location_{it}$  denotes the geographical proximity. The control variables are described in  $x_{j,it}$ , whereby *i* denotes the individual company in a particular industry, *t* the year of the funding round, and  $\varepsilon_{it}$  the joint error term.

of variables and descriptive statistics on funding round level	escription Mean SD Min Max Mean SD Min Max	BA VC		inary variable 0.72 0.45 0.00 1.00 0.42 0.49 0.00 1.00 that equals 1 if a new venture	receives fund- ing with the	simultaneous	participation of both inves-	tor types, BAs,	and VCs, 0 if	the venture	receives	funding from	co-investments	of one investor	
w of variables a	Description			Binary variable that equals 1 i a new venture	receives fund- ing with the	simultaneous	participation of both inves-	tor types, BAs	and VCs, 0 if	the venture	receives	funding from	co-investment	of one investo	
Table 3 Overvie	Variable		Dependent vari- able	Co-investment of BA & VC investor											

Table 3 (conti	nued)								
Variable	Description	Mean	SD	Min	Max	Mean	SD	Min	Мах
Independent variables									
Investor reputation	<ul> <li>Group average of investor reputation values (i.e., the number of investor has made in the last five years before the funding round the investor's age at the time of the funding round the number of backed ventures with IPOs or acqui sitions in the last five years before the investment)</li> </ul>	- 0.07	0.70	- 0.58	5.34	- 0.08	0.64	- 0.87	3.34 4

Table 3 (continu	(pər								
Variable	Description	Mean	SD	Min	Max	Mean	SD	Min	Max
Prior invest- ment ties	Group average of prior invest ment ties ratio (i.e., the num- ber of prior investment dyads between an investor and the other investors of the focal investor group)	0.10	0.24	0.00	1.00	0.25	0.35	0.00	00
Geographical proximity	Binary variable that equals 1 if the investor operates in the same state as the new venture and 0 otherwise	0.49	0.43	0.00	1.00	0.52	0.42	0.00	1.00
Control vari- ables Investor level Active VC investor (in thousands)	Number of VC investors with at least one investment per year	2.07	0.50	0.98	2.64	I	1	I	I

	Max	3.15	10.00	20.11	1.00
	Min	0.16	2.00	8.52	0.00
	SD	0.89	1.98	1.54	0.32
	Mean	2.22	3.71	14.46	0.11
	Max	1	10.00	19.22	1.00
	Min	I	2.00	8.52	0.00
	SD	1	2.19	1.34	0.27
(pen)	Description Mean	Number of BA – investors with at least one investment per year	<ul> <li>Number of 4.25 investors participating in the focal fund- ing round</li> </ul>	Investment 13.88 ) amount of the funding round in USD (logarithmic value)	<ul> <li>Binary vari- able taking the value of 1 if a CVC is partici- pating in the focal funding round and 0 otherwise</li> </ul>
Table 3 (continu	Variable	Active BA investor (in thousands)	Investor group size	Investment volume (log)	CVC participa tion

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lable 3 (contin	nea)								
Variable	Description	Mean	SD	Min	Max	Mean	SD 1	Min 1	Max
Venture level									
Founder team size	Count variable describing the number of venture founders	1.77	0.87	1.00	00.6	1.77	0.87	1.00	9.00
Venture age (years)*	The time between the venture founding date and the focal funding round in years	1.47	1.16	0.00	4.95	1.63	91.1	0.00	4.99
Previous accel erator round	- Binary vari- able taking the value 1 if the venture was in an accelerator program and 0 otherwise	0.07	0.25	0.00	1.00	0.06	0.24	0.00	1.00

3 (continu	(pen								
0	Description	Mean	SD	Min	Max	Mean	SD	Min	Max
level									
re's graphical ttion	Binary vari- able taking th value of 1 if the venture is located in one of the two most entrepreneur- friendly state. (Massachuset or California) and 0 other- wise	o 0.53 s c c c c c c c c c c c c c c c c c c	0.50	0.00	0.1	0.57	0.50	0.00	1.00
try com- tiveness II)	Herfindahl- Hirschmann index of each industry and year	0.04	0.04	0.02	0.49	0.04	0.04	0.01	0.49
-				· ·					

Note: The table displays the description, operationalization, and statistics for the variables used in our models. The dummy variables for the investment year and the ven-ture industry are not displayed. \*Unstandardized value

IdDIE 4 Fair WISE COLIEIAUIOIIS (DA III	vestor												
Variables	(1)	(2)	(3)	(4)	(5)	(9)	(1)	(8)	(6)	(10)	(11)	(12)	(13)
(1) Co- investment of BA & VC	1.00												
(2) Investor reputation	$0.21^{*}$	1.00											
	(0.00)												
(3) Prior investment ties	$0.14^{*}$	0.38*	1.00										
	(0.00)	(0.00)											
(4) Geographical proximity	0.12*	0.20*	0.13*	1.00									
	(0.00)	(0.00)	(0.00)										
(5) Active VC investors	0.03	0.02	0.03	-0.05*	1.00								
	(0.18)	(0.31)	(0.12)	(0.00)									
(6) Investor group size	0.32*	0.01	- 0.03	0.06*	0.03	1.00							
	(0.00)	(0.54)	(0.18)	(0.00)	(0.00)								
(7) Investment volume (log)	$0.36^{*}$	$0.12^{*}$	0.02	0.08*	$0.06^{*}$	0.23*	1.00						
	(0.00)	(0.00)	(0.27)	(0.00)	(0.00)	(0.00)							
(8) CVC participation	0.07*	0.00	-0.04*	-0.01	0.03	0.17*	$0.16^{*}$	1.00					
	(0.00)	(0.95)	(0.05)	(0.62)	(0.08)	(0.00)	(0.00)						
(9) Founder team size	0.03	- 0.03	-0.01	-0.01	$0.13^{*}$	0.05*	-0.01	-0.01	1.00				
	(0.0)	(0.10)	(0.72)	(0.73)	(0.00)	(0.01)	(0.55)	(0.74)					
(10) Venture age (log)	0.08*	0.09*	0.04*	- 0.02	$0.13^{*}$	-0.01	0.19*	0.02	- 0.02	1.00			
	(0.00)	(0.00)	(0.03)	(0.21)	(0.00)	(0.68)	(0.00)	(0.32)	(0.33)				
(11) Previous accelerator round	$0.06^{*}$	$0.04^{*}$	0.03	0.01	0.05*	$0.11^{*}$	-0.04*	-0.01	0.08*	0.09*	1.00		
	(0.00)	(0.04)	(0.14)	(0.54)	(0.01)	(0.00)	(0.03)	(0.70)	(0.00)	(0.00)			
(12) Venture's geographical location	*60.0	$0.04^{*}$	0.03	0.15*	- 0.02	$0.11^{*}$	0.08*	$0.04^{*}$	0.03	-0.08*	-0.02	1.00	
	(0.00)	(0.02)	(0.11)	(0.00)	(0.32)	(0.00)	(0.00)	(0.04)	(0.07)	(0.00)	(0.21)		
(13) Industry competition (HHI)	0.00	0.02	0.00	-0.01	0.01	0.01	0.01	0.00	0.01	0.02	0.00	0.00	1.00
	(0.85)	(0.43)	(0.85)	(0.56)	(0.54)	(0.45)	(0.51)	(06.0)	(0.65)	(0.34)	(0.96)	(0.98)	
Note: $N=2,732$ . This table reports th by * with $p < 0.1$	ie correlatic	n coefficie	ents of the	main varial	bles; <i>p</i> -val	ues are rep	ported bene	eath the co	rrelations i	n parenthe	ses; signifi	cance is	marked

Table 5         Pairwise correlations (VC inv	vestor)												
Variables	(1)	(2)	(3)	(4)	(5)	(9)	(7)	(8)	(6)	(10)	(11)	(12)	(13)
(1) Co- investment of BA & VC	1.00						-						
(2) Investor reputation	-0.10*	1.00											
	(0.00)												
(3) Prior investment ties	-0.17*	0.35*	1.00										
	(0.00)	(0.00)											
(4) Geographical proximity	0.02	$0.16^{*}$	0.14*	1.00									
	(0.0)	(0.00)	(0.00)										
(5) Active BA investors	$0.16^{*}$	0.01	-0.01	-0.03*	1.00								
	(0.00)	(0.66)	(0.68)	(0.02)									
(6) Investor group size	0.42*	0.00	-0.08*	0.02	$0.14^{*}$	1.00							
	(0.00)	(0.92)	(0.00)	(0.21)	(0.00)								
(7) Investment volume (log)	-0.15*	0.25*	- 0.02	0.03*	-0.17*	0.08*	1.00						
	(0.00)	(0.00)	(0.11)	(0.02)	(0.00)	(0.00)							
(8) CVC participation	-0.07*	0.05*	-0.03*	- 0.03	0.04*	0.15*	$0.16^{*}$	1.00					
	(0.00)	(0.00)	(0.05)	(0.08)	(0.00)	(0.00)	(0.00)						
(9) Founder team size	0.02	0.02	0.00	-0.01	$0.17^{*}$	0.05*	-0.02	-0.01	1.00				
	(0.17)	(0.15)	(0.87)	(0.43)	(0.00)	(0.00)	(0.09)	(0.65)					
(10) Venture age (log)	-0.04*	-0.04*	$-0.11^{*}$	-0.05*	0.01	- 0.02	$0.24^{*}$	0.07*	-0.03*	1.00			
	(0.02)	(0.01)	(0.00)	(0.00)	(0.58)	(0.20)	(0.00)	(0.00)	(0.04)				
(11) Previous accelerator round	0.07*	-0.04*	- 0.02	-0.03*	0.09*	$0.11^{*}$	-0.08*	- 0.02	$0.06^{*}$	0.08*	1.00		
	(0.00)	(0.01)	(0.11)	(0.04)	(0.00)	(0.00)	(0.00)	(0.15)	(0.00)	(0.00)			
(12) Venture's geographical location	- 0.02	$0.21^{*}$	$0.05^{*}$	$0.28^{*}$	-0.03*	0.05*	$0.13^{*}$	$0.05^{*}$	0.01	- 0.05*	- 0.02	1.00	
	(0.24)	(0.00)	(0.00)	(0.00)	(0.03)	(0.00)	(0.00)	(0.00)	(0.73)	(0.00)	(0.13)		
(13) Industry competition (HHI)	0.00	0.00	-0.01	-0.01	-0.01	0.02	0.03*	- 0.02	0.00	0.02	0.00	0.00	1.00
	(0.93)	(06.0)	(0.54)	(0.69)	(0.65)	(0.20)	(0.04)	(0.25)	(0.89)	(0.12)	(0.91)	(0.80)	
Note: $N = 4,655$ . This table reports th by * with $p < 0.1$	e correlatio	n coefficiei	nts of the r	nain variab	les; <i>p</i> -valu	es are repo	rted bene	th the cor	relations in	n parenthes	es; signific	ance is 1	marked

Table 6Variance inflationfactors	Variable	BA	VC
	Investor reputation	1.23	1.29
	Prior investment ties	1.18	1.25
	Geographical proximity	1.15	1.18
	Active VC investors	1.11	-
	Active BA investors	-	1.13
	Investor group size	1.09	1.11
	Investment volume	1.08	1.11
	CVC participation	1.05	1.10
	Founder team size	1.05	1.08
	Venture age	1.04	1.06
	Previous accelerator round	1.04	1.04
	Venture's geographical location	1.03	1.04
	Industry competitiveness (HHI)	1.00	1.00
	Average	1.09	1.11

#### 4 Results

Table 4 (BA) and Table 5 (VC) report the matrix with Pearson's correlation coefficients of all variable constructs in our dataset.

To ensure that multicollinearity does not bias our calculation models, following Kalnins (2018), we examined each pairwise correlation value above 10.31 in two steps. First, we checked whether the two variables had regression coefficients (cf. regression result tables) of opposite signs if correlated positively, or of the same sign if correlated negatively. Second, we checked the variables within the regressions more thoroughly.

Based on this approach, only one variable pair of our research model demonstrates a pairwise correlation value above 10.31 and needs to be further examined. Prior investment ties and investor reputation show correlations of 0.38 for BAs and 0.35 for VCs. However, the prior investment ties and the investor reputation for BA investors are positively correlated and have both a positive regression coefficient (i.e., same sign). For VCs, the variables are correlated positively and both show negative regressions coefficients (i.e., same sign). Following Kalnins (2018), we assume that multicollinearity might not unduly bias our results. The low average variance inflation factors (Table 6) strengthen our assumption that multicollinearity is unlikely to be a major concern since all VIFs are below the acceptable limit of 15.01 (O'Brien 2007) and confirm our perceptions.

The estimation results for all regression stages are presented in two separate tables, Table 7 for the BA and Table 8 for the VC investor. The first model considers only the control variables. We then included the independent variables. Lastly, we included all variables in the full model. All regression models are statistically significant and the quality increases step-by-step, as the calculated pseudo-R<sup>2</sup> and other quality values indicate.

Table / Main results of logistic regre	ssion for BA	investors			
Dependent variable: Co-investment of BA & VC in first funding round*	(1)	(2)	(3)	(4)	(5)
Control variables					
Investor level					
Active VC investors	- 0.536	-0.687	- 0.623	- 0.569	- 0.729
	(0.506)	(0.508)	(0.507)	(0.512)	(0.513)
	0.290	0.176	0.219	0.266	0.155
Investor group size	0.360	0.366	0.364	0.358	0.367
	(0.030)	(0.030)	(0.030)	(0.030)	(0.031)
	0.000	0.000	0.000	0.000	0.000
Investment volume (log)	0.547	0.520	0.559	0.537	0.528
	(0.041)	(0.041)	(0.042)	(0.041)	(0.042)
	0.000	0.000	0.000	0.000	0.000
CVC participation	-0.220	-0.184	- 0.169	-0.185	- 0.143
	(0.209)	(0.212)	(0.210)	(0.211)	(0.214)
	0.291	0.385	0.421	0.380	0.502
Venture level					
Founder team size	0.061	0.077	0.064	0.066	0.077
	(0.057)	(0.058)	(0.058)	(0.058)	(0.058)
	0.285	0.181	0.266	0.254	0.188
Venture age	0.043	0.013	0.027	0.048	0.012
	(0.050)	(0.051)	(0.051)	(0.050)	(0.051)
	0.386	0.796	0.593	0.342	0.812
Previous accelerator round	0.484	0.431	0.453	0.470	0.416
	(0.219)	(0.224)	(0.222)	(0.220)	(0.225)
	0.027	0.054	0.041	0.033	0.065
Macro level					
Venture's geographical location <sup>a</sup>	0.213	0.188	0.188	0.172	0.158
	(0.097)	(0.100)	(0.099)	(0.098)	(0.100)
	0.029	0.059	0.056	0.079	0.116
Industry competitiveness (HHI)	2.726	3.132	1.801	2.847	2.457
	(6.901)	(6.954)	(6.926)	(6.884)	(6.935)
	0.693	0.652	0.795	0.679	0.723
Independent variables (BAs)					
(H1a) Investor reputation		0.828			0.666
		(0.098)			(0.101)
		0.000			0.000
(H2a) Prior investment ties			1.540		0.962
			(0.232)		(0.246)
			0.000		0.000
(H3a) Geographical proximity				0.447	0.256
				(0.112)	(0.116)
				0.000	0.027

- 7.057

- 6.304

- 7.095

- 7.015

 Table 7 Main results of logistic regression for BA investors

Constant

- 6.439

Table 7 (continued)					
Dependent variable: Co-investment of BA & VC in first funding round*	(1)	(2)	(3)	(4)	(5)
	(1.565)	(1.577)	(1.572)	(1.580)	(1.591)
	0.000	0.000	0.000	0.000	0.000
Chi-square test	596.8	691.5	648.8	612.8	713.4
Pseudo R2	0.184	0.213	0.200	0.189	0.220
Log likelihood	- 1321.32	- 1273.94	- 1295.31	- 1313.32	- 1263.01
AIC	2724.64	2631.87	2674.62	2710.63	2614.02
BIC	2966 68	2879.81	2922 56	2958 57	2873 76

Note: N=2,706 funding rounds. Standard errors in parentheses. *p*-values below. Coefficients for calendar year and industry dummy variables not reported. \*Binary variable that considers the probability of a co-investment occurrence of BA and VC investors in the first funding round (value 1). The probability of this analysis is predicted against receiving an investment from BAs (value 0). <sup>a</sup>Binary variable that takes a value of 1 if the venture operates in Massachusetts and California, states with especially entrepreneur-friendly ecosystems and a value of 0 otherwise

#### 4.1 Hypotheses testing

Model 1 in Table 7 and 8 display the effect of the control variables. Consistent with our knowledge about the common investment behaviors of the two investor types, the probability of co-investment increases with the investment volume for the BA investor, whereas it decreases for the VC investor. Not surprisingly, the likelihood of co-investment increases with the investor group size. Furthermore, previous participation in an accelerator program seems to enhance to chances for a co-investment. The other variable constructs and their impact depend on the investor type and are shown in the main regression results tables.

The effects of the main variables are interpreted with the full model (Model 5 in Table 7 and 8), where most of the hypotheses to explain the occurrence of co-investments between VCs and BAs in the first funding round are confirmed. Based on the main regression results and the marginal effects, we discuss our findings concerning our hypotheses in the following.

H1a posits that the occurrence of a co-investment of BAs and VCs in the first funding round of a new venture is more likely for a BA investor with a high reputation. The regression results of Table 7, Model 5 provide high significance, and, therefore, our Hypothesis 1a of a positive correlation is confirmed over the full data range for the BA investor ( $\beta$ =0.666, p=0.000). This result shows that for a one-unit increase in BA's reputation (the unit for reputation is 1.0), we expect a 0.666 increase in the log odds of the probability of a co-investment. H1b argues that the occurrence of a co-investment is less likely for VC investors with high reputation. Table 8, Model 5 shows a negative association at a significant level threshold at p < 0.1 with the probability of a co-investment ( $\beta$ =-0.011, p=0.065). Thus, we expect for each one-unit increase in a VC's reputation, a decrease of 0.011 in the log odds of the probability of a co-investment. This provides at least a weak support for

Table 8 Main results of logistic regre	able 8 Main results of logistic regression for VC investors								
Dependent variable: Co-investment of BA & VC in first funding round*	(1)	(2)	(3)	(4)	(5)				
Control variables									
Investor level									
Active VC investors	0.246	0.252	0.283	0.248	0.292				
	(0.161)	(0.162)	(0.161)	(0.161)	(0.162)				
	0.127	0.120	0.080	0.122	0.071				
Investor group size	0.603	0.600	0.598	0.603	0.598				
	(0.023)	(0.023)	(0.024)	(0.023)	(0.024)				
	0.000	0.000	0.000	0.000	0.000				
Investment volume (log)	- 0.231	- 0.211	- 0.246	- 0.232	-0.247				
	(0.025)	(0.026)	(0.026)	(0.025)	(0.026)				
	0.000	0.000	0.000	0.000	0.000				
CVC participation	- 1.019	- 1.011	- 1.025	- 1.014	- 1.015				
	(0.123)	(0.123)	(0.123)	(0.123)	(0.123)				
	0.000	0.000	0.000	0.000	0.000				
Venture level									
Founder team size	-0.068	- 0.066	-0.070	- 0.067	- 0.069				
	(0.041)	(0.041)	(0.041)	(0.041)	(0.041)				
	0.095	0.107	0.088	0.098	0.094				
Venture age	0.062	0.049	0.023	0.064	0.026				
	(0.037)	(0.037)	(0.038)	(0.037)	(0.038)				
	0.095	0.187	0.536	0.085	0.498				
Previous accelerator round	- 0.093	- 0.102	- 0.102	- 0.089	- 0.095				
	(0.148)	(0.148)	(0.150)	(0.148)	(0.150)				
	0.532	0.493	0.498	0.548	0.526				
Macro level									
Venture's geographical location <sup>a</sup>	- 0.059	- 0.012	- 0.029	-0.087	- 0.079				
	(0.071)	(0.072)	(0.072)	(0.073)	(0.075)				
	0.400	0.863	0.684	0.231	0.292				
Industry competitiveness (HHI)	5.273	5.200	5.456	5.300	5.523				
	(2.906)	(2.928)	(2.948)	(2.905)	(2.948)				
	0.070	0.076	0.064	0.068	0.061				
Independent variables (VCs)									
(H1b) Investor reputation		- 0.219			- 0.011				
· · · ·		(0.061)			(0.065)				
		0.000			0.860				
(H2b) Prior investment ties			- 1.186		- 1.221				
			(0.115)		(0.122)				
			0.000		0.000				
(H3b) Geographical proximity				0.134	0.261				
~									

-0.546

-0.882

 Table 8 Main results of logistic regression for VC investors

Constant

(0.088)

0.003

-0.196

(0.086)

- 0.592

0.121

-0.082

792

(1)	(2)	(3)	(4)	(5)
(0.661)	(0.670)	(0.673)	(0.661)	(0.683)
0.409	0.188	0.903	0.371	0.774
1345	1358	1463	1347	1472
0.212	0.214	0.231	0.213	0.232
- 2494.81	- 2487.12	- 2434.71	- 2492.60	- 2430.35
5075.61	5064.23	4959.43	5075.21	4954.70
5359.21	5354.27	5249.46	5365.25	5258.63
	<ul> <li>(1)</li> <li>(0.661)</li> <li>0.409</li> <li>1345</li> <li>0.212</li> <li>- 2494.81</li> <li>5075.61</li> <li>5359.21</li> </ul>	(1)       (2)         (0.661)       (0.670)         0.409       0.188         1345       1358         0.212       0.214         - 2494.81       - 2487.12         5075.61       5064.23         5359.21       5354.27	(1)         (2)         (3)           (0.661)         (0.670)         (0.673)           0.409         0.188         0.903           1345         1358         1463           0.212         0.214         0.231           - 2494.81         - 2487.12         - 2434.71           5075.61         5064.23         4959.43           5359.21         5354.27         5249.46	(1)         (2)         (3)         (4)           (0.661)         (0.670)         (0.673)         (0.661)           0.409         0.188         0.903         0.371           1345         1358         1463         1347           0.212         0.214         0.231         0.213           -2494.81         -2487.12         -2434.71         -2492.60           5075.61         5064.23         4959.43         5075.21           5359.21         5354.27         5249.46         5365.25

Note: N = 4,653 funding rounds. Standard errors in parentheses. p-values below. Coefficients for calendar year and industry dummy variables not reported. \*Binary variable that considers the probability of a coinvestment occurrence of BA and VC investors in the first funding round (value 1). The probability of this analysis is predicted against receiving an investment from VCs (value 0). <sup>a</sup>Binary variable that takes a value of 1 if the venture operates in Massachusetts and California, states with especially entrepreneurfriendly ecosystems and a value of 0 otherwise

our argument that a VC's reputation plays a role in the probability of a co-investment with a BA.

H2a argues that the occurrence of a co-investment of BAs and VCs in the first funding round of a new venture is more likely for a BA investor with more prior investment ties. Table 7, Model 5 shows that this hypothesis is confirmed by a significant, positive association ( $\beta = 0.962$ , p = 0.000). The coefficient leads to the interpretation that a one-unit increase in BA's prior investment ties (unit of 1.0) leads to an 0.962 increase in the log-odds of the probability of a co-investment. H2b argues that the occurrence of a co-investment of BAs and VCs in the first funding round of a new venture is less likely for a VC investor with more prior investment ties; this hypothesis is supported ( $\beta = -1.221$ , p = 0.000). For the VC, the results demonstrate that for each one-unit increase in prior investment ties, the log-odds of the probability of a co-investment decrease by 1.221.

H3a derives that the occurrence of a co-investment of BAs and VCs in the first funding round of a new venture is more likely for a BA investor with a higher geographical proximity. Table 7, Model 5 shows that this hypothesis is confirmed  $(\beta = 0.256, p = 0.027)$ . We expect that for a one-unit increase in geographical proximity for the BA (in other words, switching from operating in a different state to operating in the same state as the new venture), the log-odds of the probability of a co-investment increase by 0.256. H3b argues that the occurrence of a co-investment of BAs and VCs in the first funding round of a new venture is more likely for a VC investor with higher geographical proximity. As shown in Table 8, Model 5 we can also confirm this hypothesized association ( $\beta = 0.261$ , p = 0.003). For the VC, we can expect a 0.261 increase in the log-odds of the probability of a co-investment.

Thus, most of our hypotheses are confirmed at a high significance level in our main regression results. For full transparency, Fig. 2 presents the marginal effects of the variables concerning the probability of the co-investment of VCs and BAs in the first funding round of a new venture.

Plot 1a: Investor reputation (BAs)

Libration (BAO)

Plot 1b: Investor reputation (VCs)





Plot 2b: Prior investment ties (VCs)



**Fig. 2** Effects of BAs' and VCs' characteristics on the probability of a co-investment. Note: The plots present predictive margins for BAs' and VCs' investor reputation (Plots 1a and b), prior investment ties (Plots 2a and b), and geographical proximity (Plots 3a and b). The margins are predicted with STA-TA's margins command. We estimated the margins at specified values of covariates (i.e., margins at (0(0.05)1)) based on the independent variables' value range (min, max)

#### 4.2 Robustness tests

To further ensure the validity of our findings and to examine potential biases, we employed additional regressions and robustness tests using subsamples,

Dependent variable: Co-investment of BA & VC in first funding round*	(6)	(7)	(8)	(9)	(10)
Control variables					
Investor level					
Active VC investors	-0.710	- 0.672	- 0.704	- 0.720	- 0.695
	(0.515)	(0.511)	(0.511)	(0.513)	(0.510)
	0.168	0.188	0.168	0.160	0.173
Investor group size	0.449	0.229	0.358	0.370	0.358
	(0.030)	(0.022)	(0.030)	(0.030)	(0.030)
	0.000	0.000	0.000	0.000	0.000
Investment volume (log)	0.532	0.544	0.536	0.525	0.536
	(0.042)	(0.041)	(0.042)	(0.041)	(0.042)
	0.000	0.000	0.000	0.000	0.000
CVC participation	- 0.196	0.031	-0.138	-0.150	-0.142
	(0.212)	(0.204)	(0.213)	(0.214)	(0.212)
	0.356	0.878	0.517	0.481	0.505
Venture level					
Founder team size	0.068	0.093	0.076	0.080	0.076
	(0.058)	(0.057)	(0.058)	(0.058)	(0.058)
	0.234	0.101	0.188	0.168	0.189
Venture age	0.000	0.015	0.028		0.028
	(0.051)	(0.050)	(0.051)		(0.051)
	0.997	0.766	0.585		0.589
Previous accelerator round	0.388	0.522	0.439		0.439
	(0.225)	(0.216)	(0.225)		(0.225)
	0.085	0.016	0.050		0.051
Macro level					
Venture's geographical location <sup>a</sup>	0.157	0.172	0.138	0.151	0.139
	(0.100)	(0.097)	(0.100)	(0.100)	(0.100)
	0.117	0.076	0.167	0.131	0.163
Industry competitiveness (HHI)	1.424	0.781	2.529	2.402	
	(6.743)	(6.700)	(6.898)	(6.941)	
	0.833	0.907	0.714	0.729	
Variables used for robustness tests					
Alternative variable for investor reputation			0.561		0.560
			(0.104)		(0.104)
			0.000		0.000
Investment stage				0.174	
				(0.174)	
				0.316	
Independent variables (BAs)					
(H1a) Investor reputation	0.663	0.690		0.669	
	(0.100)	(0.102)		(0.101)	
	0.000	0.000		0.000	

 Table 9
 Robustness tests on funding round level for BA investors

(6)	(7)	(8)	(9)	(10)
0.975	1.000	1.060	0.964	1.063
(0.245)	(0.250)	(0.245)	(0.246)	(0.245)
0.000	0.000	0.000	0.000	0.000
0.243	0.279	0.294	0.257	0.293
(0.115)	(0.114)	(0.115)	(0.116)	(0.115)
0.035	0.015	0.011	0.027	0.011
- 6.605	-6.773	-6.576	-6.612	-6.441
(1.585)	(1.571)	(1.585)	(1.598)	(1.541)
0.000	0.000	0.000	0.000	0.000
3123	2963	2706	2706	2706
889.3	743.9	696.5	710.7	696.4
0.254	0.215	0.215	0.219	0.215
- 1304.05	- 1354.26	- 1271.43	- 1264.37	- 1271.50
2696.09	2797.51	2630.86	2614.73	2628.99
2962.14	3060.24	2890.60	2868.57	2882.83
	(6) 0.975 (0.245) 0.000 0.243 (0.115) 0.035 - 6.605 (1.585) 0.000 3123 889.3 0.254 - 1304.05 2696.09 2962.14	(6)         (7)           0.975         1.000           (0.245)         (0.250)           0.000         0.000           0.243         0.279           (0.115)         (0.114)           0.035         0.015           -6.605         -6.773           (1.585)         (1.571)           0.000         0.000           3123         2963           889.3         743.9           0.254         0.215           -1304.05         -1354.26           2696.09         2797.51           2962.14         3060.24	(6)         (7)         (8)           0.975         1.000         1.060           (0.245)         (0.250)         (0.245)           0.000         0.000         0.000           0.243         0.279         0.294           (0.115)         (0.114)         (0.115)           0.035         0.015         0.011           -6.605         -6.773         -6.576           (1.585)         (1.571)         (1.585)           0.000         0.000         3123           2963         2706           889.3         743.9         696.5           0.254         0.215         0.215           -1304.05         -1354.26         -1271.43           2696.09         2797.51         2630.86           2962.14         3060.24         2890.60	(6)         (7)         (8)         (9)           0.975         1.000         1.060         0.964           (0.245)         (0.250)         (0.245)         (0.246)           0.000         0.000         0.000         0.000           0.243         0.279         0.294         0.257           (0.115)         (0.114)         (0.115)         (0.116)           0.035         0.015         0.011         0.027           -6.605         -6.773         -6.576         -6.612           (1.585)         (1.571)         (1.585)         (1.598)           0.000         0.000         0.000         0.000           3123         2963         2706         2706           889.3         743.9         696.5         710.7           0.254         0.215         0.219         -1304.05         -1354.26         -1271.43         -1264.37           2696.09         2797.51         2630.86         2614.73         2630.86         2614.73           2962.14         3060.24         2890.60         2868.57         -1264.37

Explanation for models and estimates robustness checks

Model 6: Without the condition of dominance in the ownership of the investment compositions

Model 7: Without limiting the number of investors per funding round to 10

Model 8: Alternative variable for investor reputation by using prior ventures with IPO or M&A event

Model 9: Alternative variable for venture age and accelerator participation by using the investment stage of the funding round

Model 10: Excluding industry competitiveness (HHI)

Note: Standard errors in parentheses. p-values below. Coefficients for calendar year and industry dummy variables not reported. \*Binary variable that considers the probability of a co-investment occurrence of BA and VC investors in the first funding round (value 1). The probability of this analysis is predicted against receiving an investment from BAs (value 0). <sup>a</sup>Binary variable that takes a value of 1 if the venture operates in Massachusetts and California, states with especially entrepreneur-friendly ecosystems and a value of 0 otherwise

well-established guidance procedures, and alternative variables. First, and for both investor types, we took six steps to conduct variations in our models. Tables 9 and 10 present the results.

First, we challenged our restriction of balanced ownership in co-investments and removed the condition of dominance in the ownership of the investment compositions to account for a potential selection bias (Model 6). However, we checked the impact on the co-investment probability of our main variables by including the funding rounds with an unbalanced power situation. In a second step, we did not limit the number of investors per funding round to 10 (Model 7). We took advantage of this limitation, as we assume that there are unclear power structures and personal relationships within very large investor groups. Removing this condition increased the data sample while still allowing us to demonstrate the main direct effects in our results.

Dependent variable: Co-investment of BA & VC in first funding round*	(6)	(7)	(8)	(9)	(10)
Control variables					
Investor level					
Active VC investors	0.306	0.291	0.292	0.299	0.317
	(0.163)	(0.161)	(0.161)	(0.161)	(0.161)
	0.061	0.071	0.070	0.064	0.049
Investor group size	0.687	0.586	0.598	0.597	0.597
	(0.024)	(0.023)	(0.024)	(0.024)	(0.024)
	0.000	0.000	0.000	0.000	0.000
Investment volume (log)	-0.247	- 0.248	- 0.254	- 0.242	- 0.247
	(0.026)	(0.026)	(0.027)	(0.025)	(0.026)
	0.000	0.000	0.000	0.000	0.000
CVC participation	- 1.084	- 1.006	- 1.017	- 1.010	- 1.014
	(0.121)	(0.123)	(0.123)	(0.123)	(0.123)
	0.000	0.000	0.000	0.000	0.000
Venture level					
Founder team size	-0.065	- 0.066	-0.070	-0.070	- 0.069
	(0.040)	(0.041)	(0.041)	(0.041)	(0.041)
	0.105	0.110	0.089	0.091	0.095
Venture age	0.017	0.030	0.029		0.025
	(0.037)	(0.038)	(0.038)		(0.038)
	0.647	0.435	0.446		0.509
Previous accelerator round	- 0.135	- 0.079	- 0.093		-0.092
	(0.149)	(0.149)	(0.150)		(0.150)
	0.366	0.595	0.533		0.539
Macro level					
Venture's geographical location <sup>a</sup>	-0.089	-0.076	-0.094	- 0.083	-0.078
	(0.074)	(0.074)	(0.075)	(0.075)	(0.075)
	0.230	0.305	0.213	0.268	0.295
Industry competitiveness (HHI)	5.068	5.468	5.535	5.497	
	(2.835)	(2.935)	(2.945)	(2.950)	
	0.074	0.062	0.060	0.062	
Variables used for robustness tests					
Alternative variable for investor reputation			0.053		
			(0.054)		
			0.324		
Investment stage				- 0.109	
				(0.116)	
				0.348	
Independent variables (BAs)					
(H1a) Investor reputation	0.002	- 0.013		-0.015	- 0.013
	(0.063)	(0.065)		(0.065)	(0.065)
	0.979	0.838		0.812	0.845

 Table 10
 Robustness tests on funding round level for VC investors

lable 10 (continued)					
Dependent variable: Co-investment of BA & VC in first funding round*	(6)	(7)	(8)	(9)	(10)
(H2a) Prior investment ties	- 1.200	- 1.211	- 1.266	- 1.227	- 1.219
	(0.121)	(0.122)	(0.123)	(0.122)	(0.122)
	0.000	0.000	0.000	0.000	0.000
(H3a) Geographical proximity	0.267	0.264	0.251	0.258	0.259
	(0.087)	(0.088)	(0.089)	(0.088)	(0.088)
	0.002	0.003	0.005	0.003	0.003
Constant	-0.440	- 0.146	- 0.059	- 0.149	0.106
	(0.678)	(0.681)	(0.683)	(0.688)	(0.663)
	0.517	0.830	0.932	0.828	0.873
Observations (N; funding rounds)	5077	4897	4653	4653	4653
Chi-square test	1969	1832	1473	1472	1468
Pseudo R2	0.281	0.272	0.233	0.232	0.232
Log likelihood	- 2524.76	- 2452.22	- 2429.88	- 2430.30	- 2432.15
AIC	5143.41	4998.44	4953.76	4952.61	4956.30
BIC	5450.44	5303.77	5256.69	5249.09	5252.79

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Explanation for models and estimates robustness checks

Model 6: Without the condition of dominance in the ownership of the investment compositions

Model 7: Without limiting the number of investors per funding round to 10

Model 8: Alternative variable for investor reputation by using prior ventures with IPO or M&A event

Model 9: Alternative variable for venture age and accelerator participation by using the investment stage of the funding round

Model 10: Excluding industry competitiveness (HHI)

Note: Standard errors in parentheses. p-values below. Coefficients for calendar year and industry dummy variables not reported. \*Binary variable that considers the probability of a co-investment occurrence of BA and VC investors in the first funding round (value 1). The probability of this analysis is predicted against receiving an investment from VCs (value 0). "Binary variable that takes a value of 1 if the venture operates in Massachusetts and California, states with especially entrepreneur-friendly ecosystems and a value of 0 otherwise

Third, we checked the robustness of our analysis and potential threats of reverse causality by using an alternative variable construct for investor reputation. Following Hahn and Kang (2017), we measured investor reputation by referring to prior ventures with IPO or M&A events (Model 8). In Model 9, we used an alternative variable construct for venture age and accelerator participation and added instead the investment stage of the funding round, based on (Nahata 2008), with an ordinal variable that depicts the venture's funding stage, starting from zero for the first funding round. We still found evidence for our results.

Fourth, to reduce potential concerns of industry bias (Ko and McKelvie 2018), we excluded the market variable of industry competitiveness in Model 10, since we already included the industry fixed effects and got strong support for our results. We conclude that despite extensive checks, our results are robust against variations in our model and variable constructs.

Fifth, we employed a different regression approach to account for heterogeneity and autocorrelation and to address the threats of a potential small-sample bias when using logistic regression with maximum likelihood estimation (King and Zeng 2001). In addition to the main regression model, we conducted panel generalized estimating equations (GEEs). We used the investor identifier as a panel variable and examined the respective investor characteristics on the probability of a coinvestment to control for the effects of autocorrelation. Hereby, we constructed all variables for each investor per funding round and took a more detailed view of the investor level. The GEE regression results support our main regression results (cf. Tables 11 and 12). Using this analytical approach, and switching to an investor perspective, we find that the results at the funding round level of our main regression with averaged variables are not biased by outliers.

Sixth, we examined the simultaneous effects of the investor characteristics of both BAs and VCs in a pooled data set. For this purpose, we adapted our dependent variable as follows. As in our main analysis, the variable took a value of 1 if a new venture received funding with the simultaneous participation of both investor types. But unlike in our main analysis, the variable took a value of 0 if the venture received funding from only one type of investor, that is, either from one or more BAs only, or from one or more VCs only. Thus, we included both pure BA co-investments and pure VC co-investments. The results for the pooled data set are displayed in the new Table 13. The results of all hypotheses, 1a to 3b, remain robust, showing the same effects as our main analysis. The results also reduce potential concerns of a sample selection bias and enhance the validity of our findings.

#### 5 Discussion

#### 5.1 Implications for theory and practice

This study offers several contributions to the literature. First, we extend prior studies on entrepreneurial finance, which mostly focuses on a single investor type (e.g., Barry 1994; Gompers 1994; Gompers and Lerner 1998) or a syndication by the same investor types (i.e., BA and BA, VC and VC; Bonini et al. 2016; Sorenson and Stuart 2001) by studying the antecedents for co-investments by BAs and VCs in the first founding round of a new venture.

Based on the different power positions of the two investor types in a co-investment, we show that the investor reputation serves as a signal to reduce information asymmetry, but with different effects for the two investor types. For a BA investor, we extend the findings of Johnson and Sohl (2012) and show that a BA with a high investor reputation is more likely to co-invest with a VC in the first founding round of a new venture. The investor reputation of a BA is, therefore, a relevant factor to enable a diverse investor portfolio in a first funding round. Meanwhile, a VC with a higher reputation is less likely to co-invest with a BA in the first funding round. Thus, the investor reputation of a BA is a relevant factor to enable a diverse investor portfolio in a first funding round.

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Dependent variable: Co-investment of BA & VC in first funding round*	(1)	(2)	(3)	(4)	(5)
Control variables					
Investor level					
Active VC investors	0.053	- 0.117	0.004	0.061	- 0.107
	(0.284)	(0.296)	(0.291)	(0.287)	(0.297)
	0.851	0.693	0.990	0.832	0.718
Investor group size	0.169	0.189	0.161	0.170	0.177
	(0.014)	(0.015)	(0.014)	(0.014)	(0.015)
	0.000	0.000	0.000	0.000	0.000
Investment volume (log)	0.510	0.509	0.528	0.508	0.514
	(0.025)	(0.026)	(0.025)	(0.025)	(0.026)
	0.000	0.000	0.000	0.000	0.000
CVC participation	0.271	0.271	0.281	0.282	0.284
	(0.127)	(0.140)	(0.136)	(0.129)	(0.142)
	0.033	0.054	0.039	0.029	0.046
Venture level					
Founder team size	0.140	0.150	0.142	0.141	0.152
	(0.035)	(0.037)	(0.036)	(0.035)	(0.037)
	0.000	0.000	0.000	0.000	0.000
Venture age	0.016	0.006	0.014	0.020	0.006
	(0.031)	(0.033)	(0.032)	(0.031)	(0.033)
	0.605	0.866	0.670	0.521	0.863
Previous accelerator round	0.682	0.712	0.720	0.691	0.719
	(0.123)	(0.136)	(0.132)	(0.125)	(0.138)
	0.000	0.000	0.000	0.000	0.000
Macro level					
Venture's geographical location <sup>a</sup>	0.190	0.194	0.204	0.164	0.183
	(0.061)	(0.064)	(0.063)	(0.062)	(0.064)
	0.002	0.002	0.001	0.008	0.005
Industry competitiveness (HHI)	3.861	4.145	4.273	3.697	3.935
	(4.287)	(4.711)	(4.540)	(4.325)	(4.756)
	0.368	0.379	0.347	0.393	0.408
Independent variables (BAs)					
(H1a) Investor reputation		0.803			0.663
		(0.073)			(0.073)
		0.000			0.000
(H2a) Prior investment ties			0.162		0.125
			(0.021)		(0.023)
			0.000		0.000
(H3a) Geographical proximity				0.203	0.122
				(0.061)	(0.065)
				0.001	0.058
Constant	- 8.253	- 7.665	-8.400	- 8.283	- 7.819

Table 11 (continued)					
Dependent variable: Co-investment of BA & VC in first funding round*	(1)	(2)	(3)	(4)	(5)
	(0.936)	(0.981)	(0.963)	(0.944)	(0.987)
	0.000	0.000	0.000	0.000	0.000
Wald chi (2)	966.34	1009.84	976.93	970.62	1017.03

Note: N = 6,068 investors. Standard errors in parentheses. *p*-values below. Coefficients for calendar year and industry dummy variables not reported. \* Binary variable that considers the probability of a coinvestment occurrence of BA and VC investors in the first funding round (value 1). The probability of this analysis is predicted against receiving an investment from BAs (value 0). <sup>a</sup>Binary variable that takes a value of 1 if the venture operates in Massachusetts and California, states with especially entrepreneurfriendly ecosystems and a value of 0 otherwise

Regarding the relevance of prior investment ties, we also get different results for the investor types. We contribute to Sorenson and Stuart's (2001) findings by showing that for a BA investor, prior investment ties enhance the likelihood to co-invest with a VC investor in the first funding round of a new venture. Otherwise, for a VC investor, the likelihood to invest in a first funding round with a BA investor is reduced. For BAs, as with investor reputation, strong prior investment ties enhance the chance to enable a diverse portfolio at the early stage of new venture financing. Both results indicate that BAs with a strong reputation and investment ties are a key factor for achieving diverse investor portfolios, a finding that is of high interest for BAs and new ventures (Schwienbacher 2007; Antretter et al. 2020).

In addition, we confirm prior studies on an investor's geographical proximity (Lerner 1995; Croce et al. 2018), demonstrating that geographical proximity has the same relevance for both investor types in a co-investment, as proposed in Hypotheses 3a and 3b.

Second, we contribute to the understanding of the signaling effect in the context of co-investments. We expand the research of Meuleman et al. (2009), Chemmanur et al. (2011), and Gu and Lu (2014) by clarifying the relevance and the signaling effect of investor reputation for VC and BA investors in the context of a co-investment decision. Our results demonstrate that the signaling effects develop differently for BA and VC investors. The results of Hypothesis 1a show that a BA's reputation is a quality signal for the potential resources a BA can provide after the investment (Hoberg et al. 2013) and that these signals from the subordinate BA must be strong enough to override the potential risks of multi-principal conflicts from the VC's perspective. In contrast, the reputation of VC investors is less relevant, as shown in Hypothesis 1b. Considering prior investment ties in the context of the signaling effect, we expand prior research indicating that prior contact - that is, prior investment ties - between the investors could act as a signal of trust, which reduces the risk that the investors will not reach their individual goals (e.g., Bellavitis et al. 2020; Edelman et al. 2021; Wallmeroth et al. 2018). We demonstrate that prior investment ties with a VC could act as a signal of trust for the subordinate BA investor in a co-investment situation, as we argue in Hypothesis 2a. By contrast, sending quality signals is less necessary for the VC,

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Dependent variable: Co-investment of BA & VC in first funding round*	(1)	(2)	(3)	(4)	(5)
Control variables					
Investor level					
Active VC investors	0.279	0.307	0.295	0.279	0.312
	(0.124)	(0.128)	(0.126)	(0.124)	(0.128)
	0.025	0.017	0.019	0.025	0.015
Investor group size	0.554	0.552	0.574	0.554	0.572
	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)
	0.000	0.000	0.000	0.000	0.000
Investment volume (log)	-0.821	-0.807	-0.804	- 0.819	- 0.792
	(0.077)	(0.077)	(0.077)	(0.077)	(0.077)
	0.000	0.000	0.000	0.000	0.000
CVC participation	- 0.315	-0.307	- 0.317	- 0.315	- 0.312
	(0.018)	(0.019)	(0.019)	(0.018)	(0.019)
	0.000	0.000	0.000	0.000	0.000
Venture level					
Founder team size	-0.070	-0.070	-0.076	-0.070	- 0.076
	(0.027)	(0.027)	(0.027)	(0.027)	(0.027)
	0.010	0.011	0.005	0.011	0.005
Venture age	0.042	0.036	0.031	0.043	0.030
	(0.026)	(0.026)	(0.026)	(0.026)	(0.026)
	0.106	0.158	0.234	0.097	0.239
Previous accelerator round	-0.057	- 0.063	-0.047	- 0.056	- 0.050
	(0.092)	(0.092)	(0.092)	(0.092)	(0.092)
	0.532	0.493	0.606	0.542	0.589
Macro level					
Venture's geographical location <sup>a</sup>	-0.005	0.010	- 0.003	- 0.020	- 0.020
	(0.049)	(0.050)	(0.050)	(0.050)	(0.051)
	0.921	0.835	0.952	0.689	0.701
Industry competitiveness (HHI)	5.842	5.861	5.906	5.827	5.891
	(1.836)	(1.848)	(1.844)	(1.836)	(1.847)
	0.001	0.002	0.001	0.002	0.001
Independent variables (BAs)					
(H1a) Investor reputation		-0.182			- 0.103
		(0.044)			(0.047)
		0.000			0.028
(H2a) Prior investment ties			- 0.022		- 0.021
			(0.003)		(0.003)
			0.000		0.000
(H3a) Geographical proximity				0.065	0.102
				(0.050)	(0.051)
				0.196	0.046
Constant	0.758	0.541	0.746	0.732	0.585

 Table 12
 Robustness test using generalized estimation equation (GEE) logistic analysis for VC investors

Table 12 (continued)					
Dependent variable: Co-investment of BA & VC in first funding round*	(1)	(2)	(3)	(4)	(5)
	(0.493)	(0.506)	(0.498)	(0.493)	(0.507)
	0.124	0.285	0.134	0.138	0.249
Wald chi(2)	2049.45	2030.42	2055.01	2050.32	2042.11

Note: N=10,851 investors. Standard errors in parentheses. *p*-values below. Coefficients for calendar year and industry dummy variables not reported. \*Binary variable that considers the probability of a co-investment occurrence of BA and VC investors in the first funding round (value 1). The probability of this analysis is predicted against receiving an investment from VCs (value 0). <sup>a</sup>Binary variable that takes a value of 1 if the venture operates in Massachusetts and California, states with especially entrepreneur-friendly ecosystems and a value of 0 otherwise

due to its dominant position, as we argue in Hypothesis 2b. These results are in line with existing literature that demonstrates that VC investors have very strong competence in hedging investment risks through detailed contracts and in following them through strict monitoring (Van Osnabrugge 2000). We assume that for a co-investment with a BA, the VC investor might have an advantage over the BA investor, and therefore feels fundamentally more secure and is less dependent on additional risk reduction measures by prior investment ties in the investor composition.

Third, prior research (Van Osnabrugge 2000; Leavitt 2005) finds that BA and VC investors are in different power positions in a co-investment. We add to these studies by showing the different power positions in a co-investment and demonstrating that the quality signals from the less dominant partner, in this case, the BA, must be strong enough to override the potential risks to co-investment from the VC's perspective. This point is demonstrated by the fact that BAs' investor reputation and prior investment ties enhance the probability of a co-investment with a VC, whereas for VCs, their reputation and prior investment ties are less relevant for a co-investment with a BA. In contrast to a syndication between two investors of the same type, in a co-investment, the difference in power between BAs and VCs leads to the need for the BA to send out signals so strong that they override the potential risks of a co-investment from the VC's point of view.

Our research offers practical insights for both investors and new ventures. First, our results enhance investors' understanding of the importance of their capabilities relative to other investors and their influence on investments. For the BA it is crucial to send strong quality signals to override the potential risks of multi-principal conflicts from the VC's perspective if the BA wants to participate in a co-investment with a VC.

Second, our results support investors in deciding if and with whom to partner in the light of their characteristics when investing in new ventures. For a BA investor, it is advantageous to invest with a VC with whom prior investment ties exist, because this investor is already known. Considering Hellmann and Thiele's (2015) findings, in which BA and VC investors in a co-investment can turn from friends to foes in later founding rounds, less-protected BA investors must consider and evaluate their

Table 13         Robustness test using pooled data	a		
Dependent variable: Co-investment of BA VC in first funding round*	& (1)	(2)	(3)
Control variables			
Investor level			
Active BA investors	1.233	1.103	0.847
	(0.436)	(0.455)	(0.488)
	0.005	0.015	0.083
Active VC investors	- 1.353	- 1.232	-0.806
	(0.658)	(0.684)	(0.735)
	0.040	0.072	0.273
Investor group size	0.517	0.495	0.466
	(0.020)	(0.020)	(0.022)
	0.000	0.000	0.000
Investment volume (log)	- 0.039	- 0.011	-0.018
	(0.023)	(0.025)	(0.027)
	0.093	0.650	0.512
CVC participation	-0.781	- 0.662	- 0.590
	(0.116)	(0.119)	(0.131)
	0.000	0.000	0.000
Venture level			
Founder team size	- 0.030	-0.021	- 0.011
	(0.037)	(0.039)	(0.043)
	0.425	0.586	0.797
Venture age	0.017	- 0.015	0.076
	(0.034)	(0.036)	(0.039)
	0.625	0.683	0.055
Previous accelerator round	0.057	0.073	0.141
	(0.137)	(0.144)	(0.156)
	0.677	0.611	0.365
Macro level			
Venture's geographical location <sup>a</sup>	0.053	0.003	- 0.395
	(0.066)	(0.069)	(0.078)
	0.420	0.971	0.000
Industry competitiveness (HHI)	4.443	3.011	4.225
	(2.844)	(2.926)	(3.213)
	0.118	0.303	0.188
Independent variables			
(H1a) Investor reputation (BAs)	0.454		
	(0.062)		
	0.000		
(H1b) Investor reputation (VCs)	- 0.455		
· · ·	(0.064)		
	0.000		
(H2a) Prior investment ties (BAs)		4.987	

Table 13 (continued)			
Dependent variable: Co-investment of BA & VC in first funding round*	(1)	(2)	(3)
	,	(0.287)	
		0.000	
(H2b) Prior investment ties (VCs)		- 1.561	
		(0.149)	
		0.000	
(H3a) Geographical proximity (BAs)			2.904
			(0.098)
			0.000
(H3b) Geographical proximity (VCs)			1.038
			(0.092)
			0.000
Constant	-2.056	- 2.085	- 3.662
	(0.873)	(0.899)	(0.987)
	0.018	0.020	0.000
Chi-square test	1289	1726	2413
Pseudo R2	0.182	0.243	0.340
Log likelihood	- 2903.66	- 2685.05	- 2341.61
AIC	5899.32	5462.11	4775.21
BIC	6202.89	5765.67	5078.77

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Note: N = 5,427 funding rounds. Standard errors in parentheses. p-values below. Coefficients for calendar year and industry dummy variables not reported. \*Binary variable that considers the probability of a coinvestment occurrence of BA and VC investors in the first funding round (value 1), and a value 0 if the venture receives funding from one investor type. <sup>a</sup>Binary variable that takes a value of 1 if the venture operates in Massachusetts and California, states with especially entrepreneur-friendly ecosystems and a value of 0 otherwise

investment ties with VC investors. In addition, we show that investors' general preference to invest in new ventures with high geographical proximity (e.g., Sohl 1999; Paul et al. 2007; Ibrahim 2008 for the BA investor; Sorenson and Stuart 2001 for the VC investor) is specifically present in co-investments. This finding may influence the likelihood of a co-investment, for instance if a BA and a VC are both close to the new venture.

Additionally, new venture founders can learn from the present paper about what characteristics are desirable in investors so as to achieve a broad and stable portfolio of investors (Schwienbacher 2007; Antretter et al. 2020). For the BA, a strong reputation could serve as an argument during the contract negotiation process, strengthening the BA's position in relation to the VC investor.

#### 5.2 Limitations and further research

Our study has multiple limitations that offer opportunities for future research. Our first limitation concerns our database, which is limited to the US market. Although the US market is certainly the largest ecosystem for entrepreneurship, an expansion to other regions would be interesting. Other venture and investor characteristics such as ethics or cultural differences could be included. Furthermore, due to the limitations of the data sources, Crunchbase and Eikon, not all investments in the US market are included, especially those by BAs, because their investments are often done without public attention.

Second, we chose to investigate three investor characteristics – reputation, prior investment ties, and geographical proximity to the new venture – because their importance with regard to investment decisions is known from prior literature regarding single investors or syndications of the same investor type. Other investor characteristics, such as professional and managerial background, educational level, and gender, might be of interest.

Third, investor networks could be investigated in terms of quality and quantity measures (Ter Wal et al. 2016). Along with prior investment ties, mutual affiliations in networks could be another way to trace co-investment opportunities.

Fourth, the decision to participate in a co-investment is likely influenced by the characteristics of the new venture. Hence, future research might include distinctive new venture characteristics for a deeper understanding of how new ventures decide on the compositions of their investor portfolios. In this regard, other variables such as the number of interested investors per funding round would also be interesting to examine.

Fifth, regarding possible time effects, we consider investors' behavior only in the first funding round of a new venture. Future research could study the behavior of the same investors in subsequent funding rounds of the same new venture. Also, the development of investors' behavior across different funding rounds with different new ventures might be interesting to study to understand investors' experience and learning effects.

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#### Declarations

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