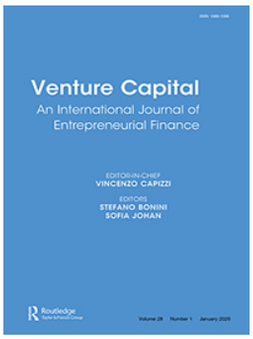

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Social and knowledge brokerage by venture capitalists and co-patenting by portfolio startups

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ABSTRACT

Startups rely on external resource providers when seeking collaborative arrangements for their inventive activities. Venture capitalists (VCs) often act as brokers for their portfolio startups, facilitating their collaboration for co-inventive activities. We suggest that independent venture capitalists (IVCs) act as social brokers who increase the frequency of co-inventing activities among their portfolio startups. In contrast, corporate venture capitalists (CVCs) act as knowledge brokers who may selectively connect their portfolio startups into collaborative co-inventing activities; when they do, firms connected through CVCs tend to produce more impactful but less novel inventions. We corroborate these predictions using a sample of 677 startups in the U.S. semiconductor sector that received funding from 570 IVCs and/or 90 CVCs between 2000 and 2014. In doing so, this study provides new insights into how different types of brokers facilitate or inhibit inventive outcomes of ventures to which they are connected and the characteristics of inventions that result from the brokerage.

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Brokerage; corporate venture capital; innovation; knowledge search; structural hole

Introduction

Startups are often important sources of inventions that fuel economic and scientific progress, yet they lack resources of their own to develop their businesses (Stinchcombe 1965). As a result, startups must rely on external investors, such as venture capitalists (VCs), who can connect them to other resource holders from the external environment (Hsu 2006; Lindsey 2008). However, different types of VCs vary in terms of their investment objectives and resource endowments (Drover et al. 2017). For instance, independent venture capitalists (IVCs) invest in startups to achieve capital gains and have a wide array of contacts that they could connect with their portfolio startups and help with the professionalization of those startups (Amit, Brander, and Zott 1998; Hellmann and Puri 2002), whereas corporate venture capitalists (CVCs) invest in startups primarily for strategic objectives that can benefit their parent firms and provide complementary assets to their portfolio startups (Jeon and Maula 2022). These differences in investment objectives

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and resources provided by different types of VCs may influence various outcomes for startups, including exit events (Kim and Park 2017), alliance relationships (Dushnitsky and Lavie 2010), and innovation outputs (Alvarez-Garrido and Dushnitsky 2016).

Although this stream of research has provided valuable insights into the heterogeneous effects of different types of VCs on startup outcomes, a few aspects require further attention. VCs may play a pivotal role in connecting their portfolio startups with other firms (Hsu 2006; Lindsey 2008). Such a brokerage role provided by VCs can be particularly important to startups' inventive outcomes because startups often lack internal knowledge stocks and often collaborate with others for inventive activities (Baum, Calabrese, and Silverman 2000). However, the effects of different types of VCs on enhancing or inhibiting collaborative activities with other firms, and the subsequent impact on inventive outputs, remain poorly understood. Indeed, although the involvement of both IVCs (Kortum and Lerner 2000) and CVCs (Alvarez-Garrido and Dushnitsky 2016; Park and Steensma 2013) may enhance startups' inventive outputs, how such VC investors influence the quantity and attributes of inventive outputs from the R&D collaborations of their portfolio firms is not clear. Because startups are important creators of novel inventions, understanding the role that VCs play in enhancing or inhibiting their portfolio startups' inventive outputs and the type of inventions that they create can provide nuanced insights into the literature on technology entrepreneurship (Drover et al. 2017). Moreover, because the initial position of startups in the network of collaborators within an entrepreneurial ecosystem is path-dependent, such an evolutionary perspective may influence how startups can overcome obstacles to their business success (Noelia and Rosalia 2020).

Theoretically, we develop the concept of social and knowledge brokerage provided by IVCs and CVCs, respectively, and how each type of brokerage affects the co-inventing outcomes of a pair of alter startups connected through a common IVC or CVC. Co-inventing activities require the sharing and exchange of advanced knowledge elements that must be recombined to create new knowledge (Grigoriou and Rothaermel 2017). We consider connections between two portfolio firms made by IVCs as *social brokerage* because IVCs tend to possess a wide set of contacts that could be connected with each other and act as brokers for their portfolio companies, but they often do not have a detailed understanding of the content of the knowledge elements that may be exchanged when a connection between portfolio firms is established. Moreover, the inventions of their portfolio startups are merely a vehicle to achieve financial return, but those inventions per se do not provide other private benefits to the IVCs. This concept of social brokerage is related to the notion of *tertius jungens* (i.e., "third who joins") orientation, developed by social network theorists, in that this type of brokerage focuses on facilitating connections between their network alters (Obstfeld 2005; Quintane and Carnabuci 2016).

In contrast, we consider connections between two portfolio firms made by CVCs as *knowledge brokerage* because corporate investors are often engaged in inventing in related knowledge domains. As a result, inventive outcomes by portfolio startups may have greater strategic ramifications for the corporate investors. Consequently, CVCs are more likely to selectively and strategically connect their portfolio startups that may, in turn, collaborate with each other. This type of brokerage is related to the concept of *tertius gaudens* (i.e., "third who enjoys") orientation in that CVCs strategically maneuver the connection of their portfolio firms to their advantage by allowing them to be connected

only indirectly, through the structural hole position of the corporate investors. Indeed, CVCs are often directly involved in the co-inventing activities of their portfolio firms, leveraging their in-depth knowledge of the technologies in their industry (Rossi et al. 2022). As a result, they enjoy private benefits from the inventions resulting from those co-inventing activities, beyond capital gains from the enhanced value of their portfolio startups. By examining the different brokerage roles played by IVCs and CVCs, this study provides novel insights into the extant social network literature that has traditionally overlooked heterogeneity in types of brokers influencing various outcomes of their alters (Quintane and Carnabuci 2016), i.e., startups that are tied by common a VC investor in our context.[1]

We collected data on 677 startups that received IVC/CVC funding in the 2000–2014 period, along with their subsequent inventive outcomes. We conducted a dyadic analysis between pairs of all possible startups in our sample to predict the likelihood of co-patenting and its subsequent effect on startup firms' knowledge impact and novelty. We report several findings. First, we find that social brokerage provided by IVCs tends to increase the likelihood of co-patenting by portfolio startups connected through the same IVCs, compared to a control group of dyads with no common investor. In contrast, knowledge brokerage provided by CVCs tends to reduce the likelihood of co-patenting by portfolio firms connected through the same CVCs, compared to the control group. More interestingly, the inventive impact of a startup's inventions, measured by forward citations of patents produced following the co-inventive activities, is superior for startups facilitated by knowledge brokerage compared to that facilitated by social brokerage. The expertise provided by CVCs in the focal knowledge domain enables CVCs to broker collaborations between portfolio startups that lead to the subsequent creation of highly impactful inventions. In contrast, the novelty of startup inventions enabled through knowledge brokerage by CVCs is lower compared to those enabled through social brokerage by IVCs, due to the strategic and path-dependent nature of knowledge recombination activities facilitated through knowledge brokerage.

By examining the different brokerage roles provided by IVCs/CVCs on startups' co-inventive outcomes, this study contributes to three streams of literature. First, it contributes to the literature focused on the role of VCs in nurturing startups (Huang and Madhavan 2021; Jeon and Maula 2022). Prior research has demonstrated how IVCs and CVCs affect innovation and other outcomes for their portfolio startups (Alvarez-Garrido and Dushnitsky 2016; Chemmanur, Loutskina, and Tian 2014; Park and Steensma 2013). However, these studies have focused on the direct effect of VCs on the innovation outcomes of portfolio firms. In contrast, studies focusing on the brokerage role of VCs (Hsu 2006; Lindsey 2008) have not distinguished the different roles that IVCs and CVCs may play in fostering or inhibiting collaborative relationships among their portfolio firms. Our study provides novel insights into how different types of investors can influence co-inventive outcomes by startups through social or knowledge brokerage. Second, by unpacking the role that different types of VCs play in forming collaboration links between startups and subsequent inventive outcomes, this study contributes to the rapidly growing literature on technology entrepreneurship by providing novel insights into the evolution of the co-inventive network influenced by IVCs and CVCs. Such an understanding complements the literature focusing on the evolutionary aspects of the entrepreneurial ecosystem in technology sectors (Noelia and Rosalia 2020). Third, this study contributes

to the stream of research taking a network perspective in studying inventive outcomes. Recent research in this stream has provided important nuances into the role and evolution of brokers influencing inventive outcomes (Balachandran and Hernandez 2018; Soda et al. 2021). However, limited attention has been paid to different types of brokers and how their differences influence the role that they play in promoting or inhibiting inventive outcomes. We develop the concept of social and knowledge brokerage employed by different types of VCs to predict inventive outcomes of their alters. Through this effort, we seek to enhance our understanding of how entrepreneurs manage their network resources through their VC investors (Wang 2020).

Background literature

The role of venture capitalists

The literature on entrepreneurial finance suggests that VCs act as brokers for startups and provide them access to resources elsewhere (Drover et al. 2017). However, research on this brokerage role has largely focused on the role that IVCs play in nurturing startups. For instance, IVCs connect startups to other firms (Hsu 2006) or among their portfolio firms (Lindsey 2008) to form alliance relationships. Likewise, IVCs introduce professional managers to startups to help with the professionalization of those firms (Hellmann and Puri 2002). Overall, IVCs act as brokers connecting their portfolio firms to other resource holders for business development. In general, IVCs tend to possess a wide range of contacts and facilitate connections with their portfolio firms when needed for business development purposes. They offer endorsement or certification to third parties by providing risky financial capital to their portfolio firms (Hsu 2004; Stuart, Hoang, and Hybels 1999).

In contrast, literature focusing on the role of corporate venture capitalists (CVCs) has largely focused on the role of CVCs in providing resources directly to their portfolio startups (Jeon and Maula 2022). For instance, CVCs provide the necessary complementary assets, such as manufacturing and marketing infrastructure, to support technology commercialization by startups (Park and Steensma 2012). Furthermore, CVCs and startups often benefit from learning and knowledge transfer from each other, enhancing their respective innovation capabilities (Dushnitsky and Lenox 2005; Kim and Park 2017). As a result, startups funded by CVCs tend to exhibit greater inventive outputs compared with those solely funded by IVCs (Alvarez-Garrido and Dushnitsky 2016; Park and Steensma 2013). In general, CVCs tend to have greater industry and technical expertise compared to their IVC counterparts, because their corporate parents are often leading firms in their industry domains. Additionally, CVC units can draw on their knowledge and expertise from other business units when needed (Kim, Steensma, and Park 2019). On the other hand, there are potential sources of conflict between startups and corporate investors, particularly the threat of misappropriation of intellectual property (IP) assets owned by startups (Katila, Rosenberger, and Eisenhardt 2008) as well as competitive concerns between startups and their corporate investors (Dushnitsky and Shaver 2009). However, the literature on CVC investment has not yet examined how CVCs influence their portfolio firms' tendency to work with other firms in collaborative relationships for inventive activities and the types of inventions that such relationships produce.

The role of brokers

Studies taking a network perspective have suggested that brokers, or network actors spanning structural holes (Burt 2004), connect two entities that are not directly connected to each other. Brokers occupy favorable network positions in terms of access to information and resources (Burt 2007; Kwon et al. 2020). Non-redundant information, enabled through a brokerage position, provides organizations with a variety of benefits (Rhee and Leonardi 2018). They tend to enjoy advantages in growth and market share (Batjargal et al. 2013; McEvily, Jaffee, and Tortoriello 2012), greater profitability (Bae and Gargiulo 2004), and tend to close more business transactions (Mizruchi and Stearns 2001).

The benefits of occupying a brokerage position within a network stem from the considerable options available to brokers in managing interactions between entities. Studies adopting a social network perspective have discussed distinct orientations that brokers may take in connecting their alters: *tertius jungens* and *tertius gaudens* orientation (Obstfeld 2005; Quintane and Carnabuci 2016). Spanning otherwise unconnected actors, the former type of brokers may choose to facilitate new connections for alters' and their own benefit (Bidwell and Fernandez-Mateo 2010; Obstfeld 2005), generally adopting a strategic orientation toward cooperation in managing their network ties (Llopis, d'Este, and Díaz-Faes 2021). Alternatively, the latter type of broker may selectively control information and resource sharing or directly play alters against each other to extract value for themselves (Burt 2021; Cook and Emerson 1978). Understanding the actions and potential impact of brokers is thus more important in contexts where information is vital to competitive outcomes or success.

Information brokerage plays an important role in the knowledge and innovation domain. Knowledge brokerage provides a path for innovation, enabled by *"the recombinant nature of innovations and the fragmented nature of the larger social structure"* (Hargadon 2002, 43). Individuals working within collaborative innovation networks tend to have greater innovative productivity through brokerage positions (Obstfeld 2005). Although scholars have explored the effects of connected organizations in the orchestration of innovation networks (Dhanaraj and Parkhe 2006), prior research has not distinguished how the presence and simultaneous interaction of *different types of brokers* within an innovation network may shape outcomes for them and the external organizations to which they are connected.

Hypotheses development

The effects of social and knowledge brokerage on the likelihood of inventive outputs

We first consider the influence of IVCs and CVCs on the likelihood of co-inventing activities by portfolio startups. To compare the role of IVCs and CVCs with respect to a control group of startups with no brokerage, we first distinguish the role of the two types of investors as brokers in connecting their portfolio startups. We refer to the brokerage provided by IVCs as *social brokerage* because IVCs have extensive contacts with many different types of startups (Wang 2020). Indeed, IVCs often work closely with various types of collaborators such as patent attorneys who could help with intellectual property (IP) strategies or investment bankers who could help with exit events, such as an initial public

offering (IPO) or merger and acquisition (M&A) deals for their portfolio firms (Gompers and Lerner 1999). However, although IVCs play an advisory role in helping their portfolio firms develop their business, they typically lack scientific expertise in the specific knowledge that might flow between their portfolio firms, at least to the extent that they do not directly participate in the R&D and invention activities of the industries in which they invest. As a result, the network resources that IVCs may bring could be far-reaching yet are not likely to be focused on a specific domain of actors in a network. In general, social brokerage facilitates the frequency and reach of their alters being connected with each other. However, social brokerage may be subject to greater commission errors (Csaszar 2013), i.e., false positives, in that the frequently facilitated connections may not result in value-creating inventions, because the facilitator may lack an in-depth understanding of the possible value created from the exchange.

In contrast, we refer to CVCs as *knowledge brokers* because CVCs possess expertise in the domain of knowledge that flows between their portfolio startups, even though their contacts may not be as diverse as those possessed by IVCs because of the focused, strategic nature of venture investing by the former. For instance, many CVC managers are former R&D scientists from other business units of their corporate parent and tend to possess in-depth knowledge about the specific technologies of their parent firms (Dushnitsky and Shapira 2010; Rossi et al. 2020). As a result, CVCs can quickly become highly central in the network of VC firms, taking advantage of the resources and reputation that their corporate parents possess (Keil, Maula, and Wilson 2010). However, CVC managers may possess limited reach in terms of their private network compared to their IVC counterparts, and their resources could quickly wind down once outside their domain of expertise (Dushnitsky and Shapira 2010). In sum, the expertise and resources that CVCs can bring tend to be more focused on the specific domain and strategic in nature compared to those offered by their IVC counterparts. However, knowledge brokerage may incur greater omission errors (Csaszar 2013), i.e., false negatives, because it may miss possible value creation opportunities that could be realized due to the overly strategic and infrequent connections of their alters.

These contrasting characteristics of IVCs as social brokers and CVCs as knowledge brokers are general in nature, yet they have ramifications for the likelihood of co-patenting activities between their portfolio startups. We suggest that two portfolio firms are more likely to co-invent when they are connected through IVCs, compared to a pair of startups with no common VC investor, because IVCs will actively attempt to connect their investees. IVCs possess a wide range of diverse investments, and their cost of connecting their investees is not high, given that their connections will not result in any strategic ramifications for the IVCs. Indeed, IVCs will seek to benefit from possible co-inventing outputs that may result from the collaboration between their two portfolio firms because the financial market highly values inventive outputs (Kogan et al. 2017), and IVCs could enjoy higher valuation of their portfolio firms resulting from those inventions when IVCs eventually attempt to exit their investments.

In contrast, CVCs will be more selective in connecting their portfolio firms for co-inventing activities for several reasons. First, CVCs invest in startups primarily for strategic purposes (Jeon and Maula 2022). An important strategic goal for CVCs is to learn from their portfolio firms (Wadhwa, Phelps, and Kotha 2016). However, if their investees are directly connected for co-inventing activities, part of the learning benefits will be

diminished for CVCs because knowledge spillovers resulting from direct collaborative efforts by their portfolio startups would be limited. Indeed, CVCs will generally prefer to sustain their structural hole position to gain bargaining power against their portfolio firms (i.e., act as *tertius gaudens* instead of *tertius jungens*) and have low incentive to relinquish such a position.

Second, due to the strategic nature of their investments, CVCs face low incentives in increasing the financial value of their portfolio firms compared with their IVC counterparts (Dushnitsky and Shapira 2010). Although CVCs can benefit from the increased value of their portfolio firms by producing inventive outputs, the most important yardstick for measuring the success of CVC investments is the strategic value that those investments could generate and deliver to the core business of their parent firms (Ma 2020). Therefore, unless co-inventing activities by their portfolio firms could directly produce tangible benefits to the corporate investor (e.g., enhanced quality of complementary products or increased sales of those products), CVCs have little incentive to connect their portfolio firms to encourage co-inventing activities.

Third, CVCs often possess more in-depth expertise on the knowledge their portfolio firms attempt to create. This expertise has two ramifications: (a) CVCs may sometimes engage in co-inventing activities directly with one of their portfolio firms, resulting in fewer opportunities for other alters to be connected with a portfolio firm, and (b) CVCs would be more selective in connecting their portfolio firms because they are aware of possible pitfalls in pursuing the co-inventing activities by their portfolio firms, due to their greater likelihood of spotting flaws in the potential collaborative opportunities. This possibility arises because new knowledge creation is a highly risky endeavor and is prone to failure, where experts are more likely to identify potential risks associated with an invention project and are more hesitant to connect their portfolio firms when they perceive a greater risk of failure (Park and Tzabbar 2016). Thus, such strategic interactions with their alters may result in infrequent connections facilitated by CVCs.

Taken together, these arguments suggest that, compared to two startups that are not connected through a common investor, startups that are connected through social brokerage by IVCs will be more likely to engage in co-inventing activities, whereas startups that are connected through knowledge brokerage by CVCs will be less likely to engage in co-inventing activities.

Hypothesis 1a: Two startups connected by a common IVC are more likely to co-patent compared with two startups not connected by a common IVC.

Hypothesis 1b: Two startups connected by a common CVC are less likely to co-patent compared with two startups not connected by a common CVC.

The influence of social and knowledge brokerage on the impact of knowledge created by co-inventing portfolio firms

We further examine the impact of subsequent knowledge created by co-inventing start-ups brokered by IVCs and CVCs. We consider the firm-level knowledge stock created by the startups, rather than focusing solely on the patents filed by pairs of startups

connected by IVCs and CVCs. The influence of brokerage by IVCs and CVCs is likely to span across all inventive activities that focal firms engage in, and not just on co-patenting outcomes established through IVCs or CVCs, because the knowledge accessed externally through (social and knowledge) brokerage will likely be transferred to other knowledge creation activities. This is particularly the case with startups, because these firms are small with a simple organizational structure (i.e., less likely to have multi-unit R&D teams) and knowledge transfer would be more immediate and consequential, compared with larger firms with organizational frictions from intra-organizational boundaries inherent in multi-unit R&D teams.

We first argue that social brokerage provided by an IVC is unlikely to lead to impactful knowledge creation. Because IVCs have less expertise in the technical domain in which their portfolio firms invent, they have limited capability to judge the potential impact of the prospective projects. As a result, they are more likely to take a "spray and pray" approach (Ewens, Nanda, and Rhodes-Kropf 2018), in which they connect their portfolio firms unselectively and promote experimentation by creating a greater permutation of knowledge recombination among their portfolio firms. However, such an approach is more likely to result in relatively modest inventive outcomes in terms of impact.

In contrast, although CVCs acting as knowledge brokers are less likely to connect their portfolio firms to collaborate for inventive activities due to reasons cited above, startups connected through knowledge brokerage will be more likely to produce highly impactful inventions for two reasons. First, as knowledge brokers, CVCs are more likely to recognize impactful inventions and selectively connect startups that have the potential to develop those inventions, which in turn could benefit their corporate investors as part-owners of the portfolio firms. Indeed, although high financial returns from their startup investments would be less consequential for CVC investors, strategic benefits (e.g., learning from startup technologies or enhanced quality of complementary products) could be substantial to their core business.

Second, CVCs may actively provide complementary assets for the inventive activities by their portfolio firms that they connected with other startups. Examples of these complementary assets for inventive activities include laboratory equipment, access to knowledge databases, patent attorneys, and other resources often required for scientific endeavors. Corporate investors could provide these resources to enhance the productivity and efficacy of inventing activities by their portfolio firms. This provision may be even more forthcoming when more than one startup portfolio firm is involved in inventive activities. Indeed, corporate investors often seek to build an ecosystem through their venture investment activities (Dushnitsky and Kang 2018). Impactful knowledge developed in the wake of co-inventing collaborations among their portfolio firms would help corporate investors achieve this goal. This acts as a strong incentive for corporate investors to provide their portfolio startups with the necessary complementary assets that may lead to impactful inventions. In exchange, corporate investors can benefit from these inventions by creating an ecosystem around their influence and privately benefit from these inventive outcomes.

Taken together, conditional on two portfolio firms being connected by common IVCs or CVCs, unlike IVCs that often promote frequent yet less impactful inventions by their portfolio co-investors, CVCs have strong incentives and may provide the necessary resources for their portfolio firms to generate impactful inventions. As a result, we suggest

that inventions created by startups brokered by CVCs will be more impactful compared with those created by startups brokered by IVCs.

Hypothesis 2: The impact of inventions created following co-patenting activities between two startups sharing common CVC investors will be higher compared with that created following co-patenting activities between two startups sharing common IVC investors.

The influence of social and knowledge brokerage on the novelty of knowledge created by co-inventing portfolio firms

Although inventions by a pair of startups connected through a common CVC investor may be more impactful on average, we argue that such inventions will be less novel on average. Inventive novelty refers to the extent to which a pattern of knowledge re-combinations in a given industry has not been made prior to the invention (Fleming 2001; Park and Tzabbar 2016). That is, inventive novelty is high when different knowledge pieces are recombined in a manner that has not been tried before. We suggest that inventions created by two startups connected through a common CVC investor are less likely to be novel compared with those jointly developed by two startups connected through a common IVC investor. The cognitive boundaries of CVC investors are often limited to meeting their strategic goals (Maula, Keil, and Zahra 2013). Indeed, CVC investments are more effective in creating value when they can provide unique synergies from their existing resource pools to startups (Park and Steensma 2012). Given this strategic goal, new inventions created by startups with a common CVC investor are more likely to revolve around the domain of interest that could benefit from the resources provided by their CVC investor. New inventions created in such a domain would be less likely to be novel because they are more likely to follow the path of existing search activities of their corporate investors. Indeed, a startup's knowledge search domain tends to become closer to the domain of expertise of its corporate investor following a CVC investment (Ma 2020; Polidoro and Yang 2021).

The knowledge search by two startups connected through a common CVC investor is likely to be in a domain of interest to their corporate investors. CVC investors would encourage such search activities and provide the necessary resources that could result in successful outputs. Although such an effort may result in inventions that could create value for both corporate investors and connected startups, they are less likely to be novel, because those inventions are more likely to use the existing knowledge base and search prototypes applied to prior inventions by the corporate investors. In sum, inventive activities by startups connected by a common CVC investor are more likely to proceed through a directed search effort and be path-dependent. In contrast, startups connected through an IVC investor would face more freedom to pursue inventions in knowledge domains with fewer cognitive restrictions. Because these startups need to engage in less guided search activities, they are more likely to discover knowledge recombinations that have not been utilized before, and inventions resulting from such an effort would be more likely to be novel on average. Therefore, we suggest that novelty exhibited in inventions by startups connected by a common IVC investor will generally be higher compared to that by two startups connected by a common CVC investor.

Hypothesis 3: The novelty of inventions created following co-patenting activities between two startups sharing common CVC investors will be lower compared with that created following co-patenting activities between two startups sharing common IVC investors.

Methods

Sample and data sources

We focus on social and knowledge brokerage through common investors, specifically IVC and CVC investors, respectively. Although our conceptualization of social and knowledge brokerage does not always perfectly match with the brokerage role provided by IVCs and CVCs, there is ample evidence that brokerage provided by IVCs closely resembles our conceptualization of social brokerage, whereas that provided by CVCs resembles knowledge brokerage (e.g., Dushnitsky and Shapira 2010). We examine IVC and CVC investments in startups in the semiconductor industry that received their first round of investment between 2000 and 2014, inclusive. We choose the semiconductor industry because it (a) exhibits relatively high levels of patenting and co-patenting activities (Hagedoorn 2003; Hall and Ziedonis 2001; Howard, Withers, and Tihanyi 2017; Shapiro 2001), (b) is among the most invested sectors by venture capitalists each year (Pitchbook 2022), and (c) has been used in prior research on the relationship between venture capital and knowledge exchange (Di Lorenzo and van de Vrande 2019). We close the sample window in 2014 to account for the time typically required for a patent to be granted by the USPTO and an additional 5 years to measure forward citations.

We use the Refinitiv Workspace database, a proprietary source of panel data for venture capital investments in startups. We focus on U.S.-based startups and U.S.-based investment firms to control for the institutional environment. Following the database's classification system, we select equity-based IVC and CVC investments ranging from the seed stage through the expansion stage up to the late stage. This sample selection yielded a pool of 875 startups and 939 investment firms. Furthermore, we filter out startups with no patenting activity, resulting in a sample of 677 startups. For these 677 startups, we construct a panel dataset indexed by dyad-years. We pair each startup with every other startup in our sample, observing these dyadic relationships from the years 2000 to 2014. This process yielded approximately 6.9 million dyad-year observations.

Data on patents filed during the years 2000–2014, including assignee information and cooperative patent classification (CPC) codes, are obtained from the US Patent and Trademark Office (USPTO) database. We disambiguate patent assignee names using a combination of automatic and manual techniques; we compute the 5-year forward citations for patents filed in 2014 and granted thereafter.

Dependent variables

H1a focuses on the influence of social brokerage through IVCs on the extent of co-patenting activity between two startups in a dyad. For a particular dyad-year, *Co-patenting Activity* is measured as a binary variable that indicates whether (1) or not (0)

the two startups in a dyad are both listed as assignees on one or more patents filed in the observation year. Owners of a patent are those whose (disambiguated) names match those listed as the assignees of that patent in USPTO data. H1b focuses on the influence of knowledge brokerage through CVCs on the extent of co-patenting activity between two startups in a dyad.

H2 focuses on the impact of the co-patenting activity arising out of (a) social brokerage through IVCs and (b) knowledge brokerage through CVCs. For a particular dyad-year, *Focal Firm Invention Impact* is a count-based measure equal to or greater than 0, computed as the sum of the standardized 5-year forward citations for patents filed in the observation year by the focal firm, following prior research (e.g., Basu et al. 2015; Trajtenberg 1990; Yayavaram and Ahuja 2008).

H3 focuses on the novelty of the co-patenting activity arising out of (a) social brokerage through IVCs and (b) knowledge brokerage through CVCs. For a particular dyad-year, *Focal Firm Invention Novelty* is a count-based measure equal to or greater than 0. To compute this measure, we first identify – across the US patent database for all years, including and up to 2021 – those combinations of Cooperative Patent Classification (CPC) codes that are "novel", i.e., instances where a patent used a combination of two CPC codes for the first time. Second, for each firm in our sample, we identify patents that were (a) assigned to that firm and (b) had such novel CPC combinations. Third, for a particular dyad-year and a particular focal firm, we identify those patents assigned to the focal firm that have (a) at least one novel CPC combination and (b) an application year that matched the observation year. Finally, we compute the novelty measure for each dyad-year and focal firm by counting the number of unique novel CPC combinations across the identified patents. In doing so, we follow prior research that has used patent CPCs (Fleming 2001; Park, Howard, and Gomulya 2018; Sorenson, Rivkin, and Fleming 2006).

Explanatory variables

We measure social brokerage through IVCs as a count-based measure, *Shared Independent VC Investors*, which indicates the number of IVCs common to both startups in a dyad. We count only those IVCs who invested in each startup during or prior to the observation year. We similarly measure knowledge brokerage through CVCs, *Shared Corporate VC Investors*, as a count-based measure that indicates the number of CVCs common to both startups in a dyad. We count only those CVCs that invested in each startup during or prior to the observation year. We note that a small fraction of patents in our sample list the CVC itself as a direct co-assignee. Consistent with prior work suggesting that CVCs sometimes participate directly in inventive activities (Rossi et al. 2022), we retain these observations in our main analyses; excluding them does not alter our substantive findings.

Control variables

Our model includes a number of control variables that may influence the hypothesized knowledge exchange between startups with common IVC or CVC investors. At the startup level, we control for *Focal Firm Cumulative Rounds* and *Alter Firm Cumulative Rounds*, the count of investment rounds in each dyad's focal and alter startups, respectively. Similarly,

we control for *Focal Firm Cumulative Amount* and *Alter Firm Cumulative Amount*, the sum of equity investment amounts in each dyad's focal and alter startups, respectively. A higher intensity of venture capital investment, manifesting as a larger number of rounds and/or investment amounts, may increase the odds of knowledge exchange.

We also control for *Focal Firm Cumulative Patents* and *Alter Firm Cumulative Patents*, the count of US-granted patents assigned to each dyad's focal and alter startups, respectively. Other commonalities between two startups in a dyad may influence the likelihood of knowledge exchange. *Venture Pair Located in Same Zip Code* is a binary variable coded as 1 (0) if the two ventures are located in the same (different) postal zip code; geographic proximity may be associated with a greater likelihood of engaging in intellectual property co-ownership (Crescenzi, Nathan, and Rodríguez-Pose 2016). *Startup Pair in Same Industry SubGroup* is a binary variable coded as 1 (0) if the two ventures operate in the same (different) industry subgroup; industrial proximity may influence the likelihood of co-patenting (Belderbos et al. 2014).

Study design and estimation model

Our test for H1a focuses on social brokerage between two startups by a common IVC, whereas our test for H1b focuses on knowledge brokerage between two startups by a common CVC, compared to a counterfactual set of startups with no common investor as a control group. Because the commonality of IVCs or CVCs between a given focal-alter dyad is exceedingly rare – occurring in less than 0.1% of 6.9 million dyad-year observations – we use rare events logistic regression to address the likelihood of small sample bias (King and Zeng 2001). This method is designed to correct for such bias and was used via the "relogit" command in Stata. These explanatory variables, social brokerage and knowledge brokerage, are lagged by 2 years relative to the year of the dependent variable, because inventive projects in semiconductor industries often last between 1 and 2 years. Given that the presence of common investors likely requires time to influence co-patenting behavior in startup dyads, we investigated different time lags, finding that 2 years of elapsed time demonstrated the most meaningful effect for both the IVC and CVC measures. The two-year lag is also a reasonable duration based on prior research into knowledge sharing and transfer (Barra and Zotti 2018; Kotabe et al. 2007).

H2 focuses on the influence of the interaction between common IVC/CVC ownership and co-patenting activity on invention impact. This dependent variable is a count variable, making the Poisson distribution an appropriate choice for the model specification (Wooldridge 2010). Moreover, we use the Poisson Quasi-Maximum Likelihood Estimation (PQMLE) method to conduct a fixed effects analysis of our dyad-year data because the explanatory variables are discrete and exhibit an over-dispersion towards zero (Allison and Waterman 2002; Carnahan and Somaya 2013). We use the "xtpqml" command in Stata to implement the model to test H2.

H3 focuses on the influence of the interaction between common IVC/CVC ownership and co-patenting activity on invention novelty. This dependent variable is a count variable, making the Poisson distribution an appropriate choice for the model specification (Wooldridge 2010). Therefore, our analysis for H3 is similar to that for H2; we used the Poisson Quasi-Maximum Likelihood Estimation (PQMLE) method to conduct a fixed-effects analysis of our dyad-year data.

Results

Table 1 presents the descriptive statistics and bivariate correlations for the dyadic dataset.

Table 2 presents the results of the rare events logistic regression models predicting the influence of social brokerage via IVCs and knowledge brokerage via CVCs. Model 1 includes all control variables that characterize focal and alter startups. Most control variables are statistically significant; focal and alter startups (a) having greater venture capital investment, (b) having greater patenting activity, and (c) being in the same industry or geographic location are likely to have relatively higher levels of co-patenting activities. We add the primary explanatory variables, social brokerage via IVCs and knowledge brokerage via CVCs, in Model 2 of Table 2. Variance inflation factors (VIF) calculated for covariates in Model 2 are 2.05 or lower in all cases, suggesting that multi-collinearity is not a concern in this analysis.

We find a significant positive association between common IVC ownership and co-patenting activity ($\beta = 1.33$, $p < 0.001$). This finding provides support for H1a. In terms of effect size, the presence of a common IVC investor increases the likelihood of co-patenting between startups by 279%. We also find a significant negative association between common CVC ownership and co-patenting activity ($\beta = -2.83$, $p = 0.005$). This finding provides support for H1b. The effect size calculations show that the presence of a common CVC investor decreases the likelihood of co-patenting by 94%.[2]

Table 3 presents the results of H2, which focuses on the influence of common IVC/CVC ownership and co-patenting on the impact of inventive outcomes. Model 3 of Table 3 includes only the control variables, most of which are statistically significant. Focal and alter startups (a) having greater venture capital investment (in terms of amount or the number of rounds) and (b) having greater patenting activity are likely to have a relatively higher impact of inventive outcomes. We note that Industry and Zip code controls are not included in Table 3 analysis, given that these are time-invariant measures in our sample (i.e., startups are not observed to change their physical location or core industry subsegment within the time horizon of our study). Model 4 tests the direct effect of the primary explanatory variables – common IVC/CVC ownership – as well as co-patenting activity on invention impact. The coefficients for social brokerage ($\beta = -0.28$, $p < 0.001$) and knowledge brokerage ($\beta = -0.43$, $p < 0.001$) are negative and statistically significant, whereas that for co-patenting activity is not ($\beta = 0.28$, $p = 0.260$). Common IVC ownership results in a 35% reduction in knowledge impact, whereas common CVC ownership results in an 86% reduction.

Finally, we examine the influence of the interaction between common IVC/CVC ownership and co-patenting activity on invention impact. Model 5 tests the interaction between common IVC ownership and co-patenting activity; the coefficient for the interaction is not statistically significant ($\beta = -0.17$, $p = 0.557$). Model 6 tests the interaction between common CVC ownership and co-patenting activity; the coefficient for this interaction is positive and statistically significant ($\beta = 1.16$, $p < 0.001$). This finding, coupled with the lack of significance for the interaction between co-patenting and shared IVC investors, provides support for H2.

To provide more intuition regarding the interaction effects, we plotted the patent knowledge impact of sampled startups to illustrate the presence or absence of both

Table 1. Descriptive statistics and bivariate correlations.

Variable		Mean	S.D.	Min.	Max.	1	2	3	4	5	6	7	8	9	10	11	12
1	Startup Co-Patenting	2.16E-05	4.64E-03	0	1												
2	Focal Firm Invention Impact	0.37	1.09	0	18	.0008											
3	Focal Firm Invention Novelty	47.79	126.43	0	2776	.0015	.3655										
4	Shared IVC Investors, 2- year lag	0.01	0.12	0	5	.0125	.0059	.0215									
5	Shared CVC Investors, 2- year lag	0.01	0.07	0	2	.0007	−.0004	−.0014	.0213								
6	Focal Firm Cumulative Number of Investment Rounds	2.09	2.31	0	16	.0020	.0719	.1142	.1022	.0556							
7	Alter Firm Cumulative Number of Investment Rounds	2.09	2.31	0	16	.0015	.0026	.0720	.1022	.0556	.2445						
8	Focal Firm Cumulative Amount of Investment	13.97	23.93	0	313	.0032	.0913	.1319	.1023	.0518	.6981	.1436					
9	Alter Firm Cumulative Amount of Investment	13.97	23.93	0	313	.0031	.0015	.0414	.1023	.0518	.1436	.6981	.0836				
10	Focal Firm Cumulative Number of Patents	9.33	24.73	0	605	.0067	.2937	.4513	.0458	.0225	.2686	.0631	.3672	.0370			
11	Alter Firm Cumulative Number of Patents	9.33	24.7	0	605	.0168	.0000	.0132	.0458	.0225	.0631	.2686	.0370	.3672	.0169		
12	Binary – Venture Pair in Same Industry	0.34	0.5	0	1	.0043	.0341	.0265	.0286	.0115	.0405	.0405	.0557	.0557	.0544	.0544	
13	Binary – Startup Pair Located in Same Zip Code	0.01	0.10	0	1	.0061	.0065	.0000	.0312	.0030	.0079	.0079	.0173	.0173	.0170	.0170	.0365

Correlations of 0.002 or higher are significant at the $p < .01$ level; correlations of 0.0015 or higher are significant at the $p < .05$ level.

Table 2. The effect of social and knowledge brokerage on co-patenting activities by startups.

Model Type	Rare Events Logistic Regression					
Outcome Variable	Venture Co-Patenting					
	Model 1			Model 2		
	β	SE	*p*-value	β	SE	*p*-value
Independent Variables						
Shared IVC Investors, 2-year lag	–			1.333	(0.156)	.000
Shared CVC Investors, 2-year lag	–			−2.834	(1.009)	.005
Control Variables						
Focal Firm Cumulative Number of Investment Rounds	−0.015	(0.031)	.614	−0.014	(0.034)	.670
Alter Firm Cumulative Number of Investment Rounds	−0.166	(0.051)	.001	−0.142	(0.055)	.010
Focal Firm Cumulative Amount of Investment	0.006	(0.001)	.000	0.005	(0.002)	.003
Alter Firm Cumulative Amount of Investment	0.009	(0.002)	.000	0.007	(0.003)	.007
Focal Firm Cumulative Number of Patents	0.009	(0.001)	.000	0.009	(0.001)	.000
Alter Firm Cumulative Number of Patents	1.26E-02	(4.75E-04)	.000	0.012	(5.04E-04)	.000
Binary – Startup Pair in Same Industry	1.915	(0.219)	.000	1.985	(0.257)	.000
Binary – Startup Pair Located in Same Zip Code	2.380	(0.243)	.000	2.133	(0.278)	.000
Constant	−12.386	(0.236)	.000	−12.587	(0.281)	.000
Model Wald Chi^2	4,852***			4,470***		
Sample Size - # of Venture Dyad-Years	6,864,780			6,864,780		
(Robust standard errors reported in parentheses; two-tailed tests of significance)						

startup co-patenting and shared CVC investors. The results of this plot are provided in Figure 1.

As shown, startups with a shared co-patenting relationship with another startup as well as common CVC investors demonstrate higher invention impact. All other conditions (e.g., lacking one or both of co-patenting and shared CVC relationships) result in external citations of their patents at one or lower. For shared CVC and co-patenting, invention impact more than doubles, illustrating the strong interactive effect of these startup relationships among the firms in our sample.

Table 4 reports the results of H3, which focuses on the influence of brokerage and co-patenting on the novelty of inventive outcomes. Model 7 of Table 4 includes only the control variables, many of which are statistically significant; focal startups (a) having greater venture capital investment (amount or the number of rounds) and (b) having greater patenting activity are likely to have a relatively higher novelty of inventive outcomes. Industry and Zip code controls are not included in Table 4 analysis, given that these are time-invariant measures in our sample (i.e., ventures are not observed to change physical location or core industry subsegment within the time horizon of our study). Model 8 tests the direct effect of the primary independent variables – social and knowledge brokerage – as well as co-patenting activity on invention novelty. The coefficients for common IVC ownership ($\beta = -0.10$, $p < 0.001$) and common CVC ownership ($\beta = -0.17$, $p < 0.001$) are negative and statistically significant, whereas that for co-patenting activity is not ($\beta = 0.28$, $p = 0.236$). The presence of common IVC ownership results in a 15% reduction in knowledge novelty, and the presence of common CVC ownership results in a 50% reduction.

Finally, we examine the influence of the interaction between common IVC/CVC ownership and co-patenting activity on invention novelty. Model 9 tests the interaction

Table 3. The effect of social and knowledge brokerage on the impact of inventive outcomes by co-patenting activities.

Model Type	Poisson Quasi-Maximum Likelihood Estimation											
Outcome Variable	Focal Firm Knowledge Impact											
	Model 3			Model 4			Model 5			Model 6		
	β	SE	*p*-value	β	SE	*p*-value	β	SE	*p*-value	β	SE	*p*-value
Independent Variables												
Shared IVC Investors, 2-year lag	–			−0.281	(0.035)	.000	−0.281	(0.035)	.000	−0.282	(0.035)	.000
Shared CVC Investors, 2-year lag	–			−0.425	(0.031)	.000	−0.425	(0.031)	.000	−0.425	(0.031)	.000
Startup Pair Co-patenting	–			0.278	(0.247)	.260	0.405	(0.244)	.098	0.261	(0.248)	.293
Shared IVC Investors X Co-patenting	–			-			−0.169	(0.287)	.557	–		
Shared CVC Investors X Co-patenting	–			-			-			1.158	(0.212)	.000
Control Variables												
Focal Firm Cumulative Number of Investment Rounds	0.038	(0.002)	.000	0.051	(0.002)	.000	0.051	(0.002)	.000	0.051	(0.002)	.000
Alter Firm Cumulative Number of Investment Rounds	−0.143	(0.004)	.000	−0.140	(0.004)	.000	−0.140	(0.004)	.000	−0.140	(0.004)	.000
Focal Firm Cumulative Amount of Investment	−0.005	(1.73E-04)	.000	−0.006	(1.95E-04)	.000	−0.006	(1.95E-04)	.000	−0.006	(1.95E-04)	.000
Alter Firm Cumulative Amount of Investment	0.001	(3.97E-04)	.040	0.001	(4.65E-04)	.115	0.001	(4.65E-04)	.115	0.001	(4.65E-04)	.115
Focal Firm Cumulative Number of Patents	0.005	(8.04E-05)	.000	0.005	(9.31E-05)	.000	0.005	(9.31E-05)	.000	0.005	(9.31E-05)	.000
Alter Firm Cumulative Number of Patents	2.27E-04	(2.57E-04)	.378	4.87E-04	(2.68E-04)	.069	4.87E-04	(2.68E-04)	.069	4.87E-04	(2.68E-04)	.069
Model Wald Chi^2	47,833***			45,365***			45,366***			43,365***		
Sample Size – Venture Dyad-Years	1,840,748			1,840,748			1,840,748			1,840,748		

(Robust standard errors reported in parentheses; two-tailed tests of significance)

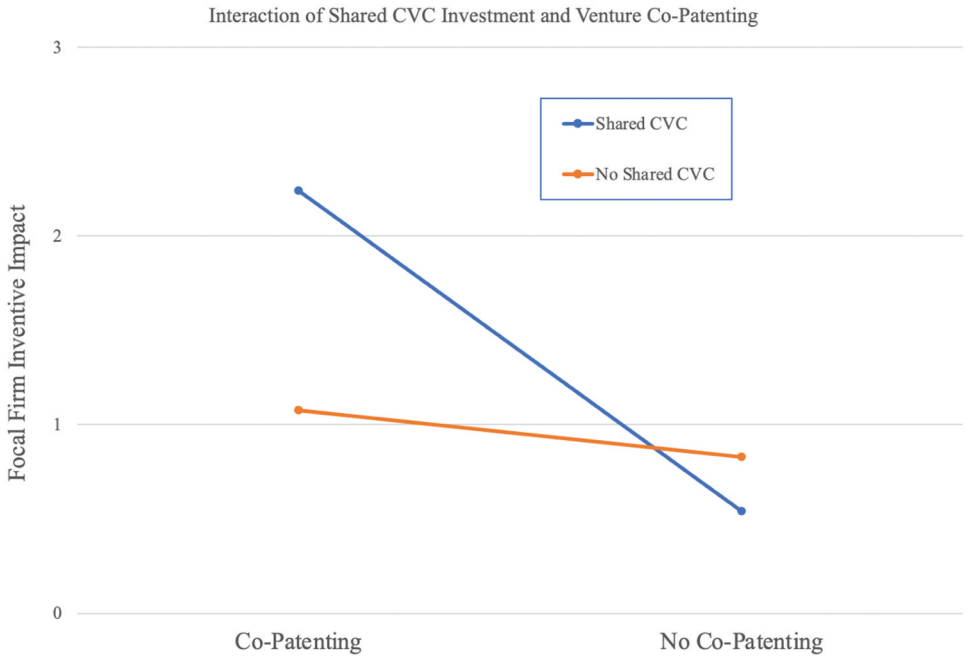

Figure 1. Interaction Effects on Invention Impact

between common IVC ownership and co-patenting activity; the coefficient for the interaction is not statistically significant ($\beta = -0.23$, $p = 0.148$). Model 10 tests the interaction between CVC ownership and co-patenting activity; the coefficient for this interaction is negative and statistically significant ($\beta = -3.17$, $p < 0.001$). This finding, coupled with the lack of significance for the interaction effect between co-patenting and shared IVC investors, provides support for H3; co-patenting ventures that share a common CVC have lower subsequent invention novelty.

To provide more intuition regarding the interaction effects, we plotted the invention novelty of sampled startups to illustrate the presence or absence of both venture co-patenting and shared CVC investors. The results of this plot are provided in Figure 2.

As shown, startups with a shared co-patenting relationship with another startup as well as common CVC investors demonstrate much lower invention novelty. For shared CVC and co-patenting, invention novelty more than halves, illustrating the strong interactive effect of these startup relationships in our sample.

We conduct additional tests to examine the potential that endogeneity may undermine our results, perhaps through unobserved factors that are related to both the presence of shared investor ties and the likelihood of co-patenting between startups. Specifically, we employ the Impact Threshold of a Confounding Variable (ITCV) analysis method. This technique measures how much an omitted variable would need to be correlated with the predictor and outcome variables to result in sufficient bias in the results that it would overturn our causal inferences (Busenbark et al. 2022). We implement this test using the "konfound" command in Stata. The results of this analysis indicate that an unobserved variable would need to be correlated at 0.053 with co-patenting to

invalidate our findings for common IVC investment and at 0.020 to invalidate our findings for common CVC investment. Both of these exceed the correlation values between co-patenting and any of our control variables (in fact, the highest correlation with co-patenting and any other variable in Table 1 is 0.017). This result suggests that it is highly unlikely that an omitted variable is present that would change our inference.

Robustness tests

We conduct robustness tests to examine the possibility of selection effects, specifically the possibility of unobserved variables that may influence the likelihood of a common CVC or a common IVC between any two startups in our sample. To address this concern, we use two instrumental variables, one for each type of investment. Using data from Refinitiv Workspace, we first compute the total investment made by IVCs made in each observation year in the semiconductor industry, regardless of whether the investees were in our final sample. Similarly, we compute the total investment made by CVCs in each observation year in the semiconductor industry. We expect that the total IVC and CVC investment available may, respectively, influence the likelihood of a common IVC or CVC between two startups in our sample, but not the likelihood of co-patenting, making these instruments relevant and exogeneous (Park and Steensma 2012; Semadeni, Withers, and Trevis Certo 2014).

We use the two instrumental variables in Models 11 and 12 (Table 5) to predict the likelihood of a common IVC or CVC between two startups, respectively. The predicted likelihoods of shared IVC and CVC investment were then used in Model 13 with co-patenting as the dependent variable to test H1a and H1b. Models 11 and 12 are statistically significant, as are the relationships between the instrumental variables and corresponding focal variables, i.e., the likelihood of shared IVC or CVC investment.

Compared with Tables 2, 5 (Model 13) shows support for Hypothesis 1b ($\beta = -0.047$, $p = 0.014$) but *not* for Hypothesis 1a ($\beta = 0.101$, $p = 0.101$). That is, when selection effects are accounted for using our choice of instrumental variables, we find that a common CVC between two startups is likely to decrease the likelihood of co-patenting but a common IVC between two startups may not influence the likelihood of co-patenting between them. Given that our instrumental variables (*Availability IVC and CVC*) are highly significant, we interpret this result as some evidence that our results may be subject to selection effect on the availability of IVC in the entrepreneurial finance market.

Further, we test the robustness of the time lag chosen in our study. We choose a two-year time lag because semiconductor development projects typically last 1–2 years to plan, develop, and test new inventions before filing for a patent. Upon testing for other time lags, we find that statistically significant effects are observable for one-year lag for IVCs but not CVCs. This is consistent with the notion that CVCs tend to have a longer time horizon for their investment compared with IVCs. We also found significant effects for a three-year lag for both IVCs and CVCs (Table 6). For lags of 4 years or longer, the effect dissipates.

Another robustness test involves testing for potential confounding by the impact and novelty of the co-patents between the focal firm and the alter firm. Because H2 and H3 focus on the focal firm's patents, we add control variables for co-patent impact (Table 7)

Table 4. The effect of social and knowledge brokerage on the novelty of inventive outcomes by co-patenting activities.

Model Type	Poisson Quasi-Maximum Likelihood Estimation											
Outcome Variable	Focal Firm Knowledge Novelty											
	Model 7			Model 8			Model 9			Model 10		
	β	SE	*p*-value	β	SE	*p*-value	β	SE	*p*-value	β	SE	*p*-value
Independent Variables												
Shared IVC Investors, 2-year lag	–			−0.099	(0.028)	.000	−0.099	(0.028)	.000	−0.099	(0.028)	.000
Shared CVC Investors, 2-year lag	–			−0.168	(0.031)	.000	−0.169	(0.031)	.000	−0.168	(0.031)	.000
Startup Pair Co-patenting	–			0.281	(0.237)	.236	0.473	(0.323)	.143	0.289	(0.236)	.222
Shared IVC Investors X Co-patenting	–			-			−0.231	(0.160)	.148	–		
Shared CVC Investors X Co-patenting	–			-			-			−3.172	(0.161)	.000
Control Variables												
Focal Firm Cumulative Number of Investment Rounds	0.098	(0.002)	.000	0.105	(0.003)	.000	0.105	(0.003)	.000	0.105	(0.003)	.000
Alter Firm Cumulative Number of Investment Rounds	0.001	(0.003)	.764	0.008	(0.004)	.037	0.008	(0.004)	.037	0.008	(0.004)	.037
Focal Firm Cumulative Amount of Investment	−0.003	(2.18E-04)	.000	−0.004	(2.69E-04)	.000	−0.004	(2.69E-04)	.000	−0.004	(2.69E-04)	.000
Alter Firm Cumulative Amount of Investment	0.000	(3.96E-04)	.984	0.000	(4.37E-04)	.853	0.000	(4.37E-04)	.854	0.000	(4.37E-04)	.853
Focal Firm Cumulative Number of Patents	0.004	(5.29E-05)	.000	0.004	(5.40E-05)	.000	0.004	(5.40E-05)	.000	0.004	(5.40E-05)	.000
Alter Firm Cumulative Number of Patents	−7.07E-04	(2.71E-04)	.009	−5.99E-04	(2.75E-04)	.029	−5.99E-04	(2.75E-04)	.029	−5.99E-04	(2.75E-04)	.029
Model Wald Chi^2	10,993***			9,744***			9,744***			1.1E + 08***		
Sample Size – Startup Dyad-Years	1,840,748			1,840,748			1,840,748			1,840,748		

(Robust standard errors reported in parentheses; two-tailed tests of significance)

and co-patent novelty in the respective models (Table 8). This inclusion did not change our previous findings.

Supplementary analyses

To test whether IVCs focusing on a particular sector in their investment portfolio may act as knowledge brokers, we add "semiconductor focus" as a control variable in testing H1. Here, we compute the "semiconductor focus" of each IVC as the fraction of its investments in the semiconductor industry (i.e., the same industry as our sample of 677 ventures) versus IVC's investments across all industries. We find that IVCs with *low* semiconductor focus are more likely to facilitate co-patenting between their portfolio firms compared to IVCs with high semiconductor focus (Table 9). Thus, IVCs focused on a particular sector may act more similar to CVCs, i.e., emphasizing knowledge brokerage over social brokerage. However, we also find that IVCs with high semiconductor focus differ from CVCs in terms of the impact of knowledge generated following co-patenting; their involvement results in relatively low knowledge impact compared to that facilitated by brokerage via CVCs (Table 10). Thus, although there is some heterogeneity in IVCs, they meaningfully differ from CVCs in terms of brokerage.

Discussion and conclusion

This study focuses on the different roles played by IVCs and CVCs as brokers between the startups they invest in. It extends prior research on the role of VCs as brokers to suggest that IVCs act as social brokers, whereas CVCs act as knowledge brokers between their startup investees. Moreover, we address the gap in CVC research, which has largely focused on the dyadic relationship between corporate investors and startups, by exploring the influence of CVCs on the co-patenting activities between their investees. We provide evidence that startup dyads with common IVCs are more likely to result in co-patenting activities compared with startups not connected by a common investor, whereas those with common CVCs are less likely to result in co-patenting outcomes compared with startups not connected by a common investor. These findings support our arguments that IVCs may be oriented toward connecting their investees socially and in a broad manner, whereas CVCs may be oriented toward connecting their investees strategically and in a targeted manner.

More importantly, such strategic and focused brokerage between startups with common CVCs is likely to manifest as relatively more impactful but less novel downstream inventive outcomes following co-inventing collaborations compared with those resulting from social brokerage by IVCs. We find empirical support for this differential impact by using forward citations for the patents created following co-patenting activities by investees with common investors; knowledge brokerage by CVCs results in relatively lower co-patenting *activity* but in relatively higher subsequent inventive *impact*, compared with social brokerage by IVCs. Conversely, we find support for lower inventive novelty, demonstrated through the significantly fewer unique, novel knowledge recombinations arising through co-patenting activities by investees with common CVC investors.

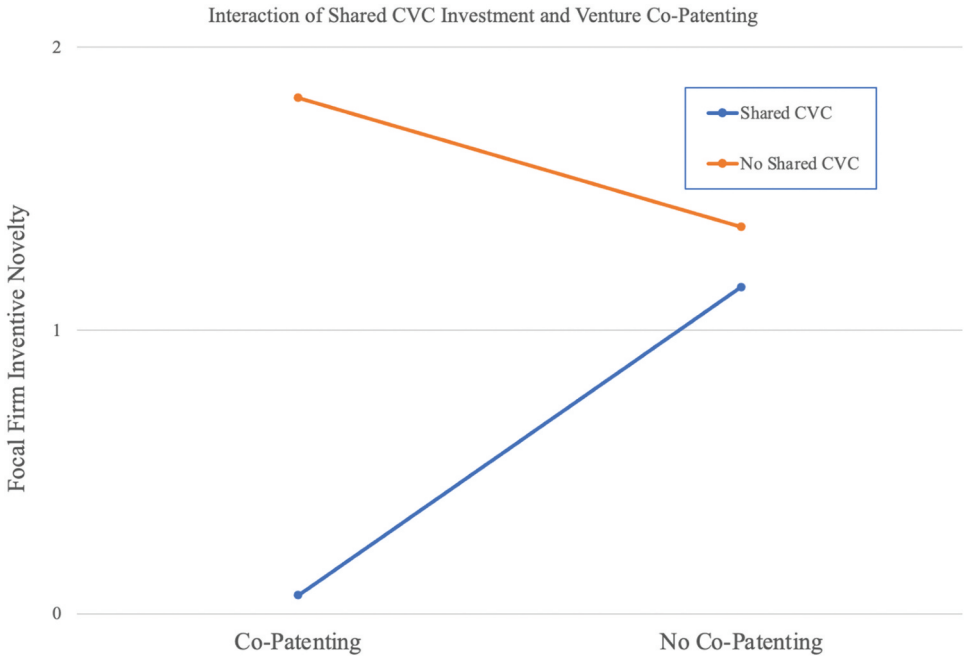

Figure 2. Interaction Effects on Invention Novelty

Contributions

Our study contributes to three streams of literature. First, it contributes to the entrepreneurship literature focused on VCs. Extant research has explored the different types of resources that IVCs and CVCs provide to nurture startups (Drover et al. 2017). However, most studies have considered the relationship between VC firms (or a syndicate of VC firms) and startups. Few have explicitly considered the network resources that IVCs and CVCs bring to their portfolio firms, and those studies have limited their investigation to consequences such as alliance or exit events (Hsu 2006; Lindsey 2008). Our study complements this stream by providing insights into how IVC and CVC investors promote or inhibit co-inventing relationships among their portfolio startups and how those relationships may impact inventing outcomes. Such insights could inform how entrepreneurs use resources from external investors to improve their odds of success (Wang 2020). Moreover, we provide nuanced insights on the effect of common ownership on corporate innovation (Antón et al. 20255). Our study finds that, in the context of startups, common ownership may have a differential impact on the characteristics of inventive outcomes, such as their impact and novelty. Most intriguingly in contrast to the evidence that CVCs tend to foster inventive outputs by their portfolio startups (Alvarez-Garrido and Dushnitsky 2016; Park and Steensma 2013), our study finds that CVC-funded startups are less likely to produce patents collaborating with other startups in their corporate investor's portfolio.

Second, this study contributes to the social network literature focused on the role of brokers. Although extant research has explored the role that structural holes play

Table 5. Robustness tests using instrumental variables.

Model Type	Instrumental Variable Regression								
Outcome Variable	1st stage: Shared IVC Investors			1st stage: Shared CVC Investors			2nd stage: Venture Co-Patenting		
	Model 11			Model 12			Model 13		
	β	SE	*p*-value	β	SE	*p*-value	β	SE	*p*-value
Independent Variable									
Shared Independent VC Investors, 2-year lag	–			–			0.101	(0.062)	.101
Shared Corporate VC Investors, 2-year lag	–			–			−0.047	(0.019)	.014
Instrumental Variable									
Available IVC Investment in Semiconductor Industry, 2-year lag	−6.55E-07	(9.64E-08)	.000	−3.38E-07	1.64E-07	.039	–		
Available CVC Investment in Semiconductor Industry, 2-year lag	1.09E-06	(5.52E-07)	.049	1.83E-06	(9.37E-07)	.051	–		
Control Variables									
Focal Firm Cumulative Number of Investment Rounds	0.001	(1.79E-05)	.000	0.002	(3.04E-05)	.000	−1.95E-04	(1.35E-04)	.150
Alter Firm Cumulative Number of Investment Rounds	0.001	(1.79E-05)	.000	0.002	(3.04E-05)	.000	−1.97E-04	(1.35E-04)	.147
Focal Firm Cumulative Amount of Investment	7.45E-05	(1.67E-06)	.000	2.90E-04	(2.84E-06)	.000	−2.57E-05	(1.72E-05)	.136
Alter Firm Cumulative Amount of Investment	7.45E-05	(1.67E-06)	.000	2.90E-04	(2.84E-06)	.000	−2.64E-05	(1.72E-05)	.125
Focal Firm Cumulative Number of Patents	1.11E-05	(1.20E-06)	.000	4.23E-05	(2.03E-06)	.000	−2.65E-06	(2.52E-06)	.292
Alter Firm Cumulative Number of Patents	1.11E-05	(1.20E-06)	.000	4.23E-05	(2.03E-06)	.000	−5.05E-07	(2.52E-06)	.841
Binary – Venture Pair in Same Industry	0.001	(6.20E-05)	.000	0.004	(1.05E-04)	.000	−3.25E-04	(2.29E-04)	.155
Binary – Venture Pair Located in Same Zip Code	0.001	(3.04E-04)	.006	0.035	(5.15E-04)	.000	−0.003	(0.002)	.137
Constant	−8.14E-04	(1.09E-04)	.000	−0.009	(1.85E-04)	.000	7.86E-04	(5.29E-04)	.138
Model F-Statistic	66.05***			3.21*			29.62***		
Sample Size - # of Venture Dyad-Years	6,864,780			6,864,780			6,864,780		

(Robust standard errors reported in parentheses; two-tailed tests of significance)

in a network and the conditions under which a node in a network retains or releases a structural hole position (Burt 2021), limited research has examined the different types of investors occupying structural holes and influencing the behavior of their portfolio firms. This study develops the different roles actors spanning structural holes play depending on their expertise in transmitting the information embedded in connecting two portfolio firms. Specifically, we consider IVCs as social brokers and CVCs as knowledge brokers, given their differences in expertise and roles in promoting or inhibiting their portfolio startups with respect to collaborative co-inventing activities. Our conceptualization shares some aspects of *tertius jungens* and *tertius gaudens* orientation of brokers. However, much of the literature adopting that approach has examined inventive outcomes at an individual level (Obstfeld 2005;

Table 6. Robustness test for hypothesis 1 with 3-year lag.

Model Type	Rare Events Logistic Regression		
Outcome Variable	Venture Co-Patenting		
	3-year lag		
	β	SE	*p*-value
Independent Variables			
Shared Independent VC Investors, 3-year lag	1.226	(0.158)	.000
Shared Corporate VC Investors, 3-year lag	−2.778	(1.206)	.021
Control Variables			
Focal Firm Cumulative Number of Investment Rounds	−0.002	(0.035)	.951
Alter Firm Cumulative Number of Investment Rounds	−0.099	(0.054)	.066
Focal Firm Cumulative Amount of Investment	0.005	(0.002)	.002
Alter Firm Cumulative Amount of Investment	0.006	(0.002)	.010
Focal Firm Cumulative Number of Patents	0.009	(0.001)	.000
Alter Firm Cumulative Number of Patents	0.012	(0.001)	.000
Binary – Venture Pair in Same Industry	2.056	(0.285)	.000
Binary – Venture Pair Located in Same Zip Code	2.148	(0.292)	.000
Constant	−12.870	(0.317)	.000
Model Wald Chi^2	116.20***		
Sample Size - # of Venture Dyad-Years	5,491,824		

(Robust standard errors reported in parentheses; two-tailed tests of significance)

Quintane and Carnabuci 2016), whereas our study has examined firms as its unit of analysis.

Third, our study provides novel insights into the literature focusing on how collaborative inventive network links may be formed during the initial phases of a firm (Noelia and Rosalia 2020; Wang 2020). In this process, external investors are likely to exert substantial influence on the formation and evolution of co-inventing networks for startups. Our results highlight the frequency and impact of ties formed between startups connected through common IVC or CVC investors. Although not explicitly considered in this study, such a process will likely lead to the formation of constellations within an ecosystem that influences the competitive landscape and the evolution of this ecosystem through different industry evolution cycles. Relatedly, we highlight the tension between the generic and specific nature of inventive processes by collaborating with external partners. On the one hand, the resource-based view (RBV) prescribes that firms develop unique and valuable resources to achieve superior performance (Barney 1991; Peteraf 1993). On the other hand, working with an overly specialized bundle of resources may raise the transaction costs of doing business with external partners (Williamson 1991). We offer insights on how different types of VCs influence a startup's evolutionary path in developing generic vis-à-vis specific resources by examining their co-inventive outcomes brokered by VCs.

Our findings have implications for practice. Startups should understand the tradeoff of the influence of IVCs vis-à-vis CVCs in promoting or inhibiting collaborative inventive efforts with other investees connected through a common investor. Although there is no clear advantage of one type of brokerage over another, such an understanding of this tradeoff should be considered in accordance with the overall inventive strategy of the startup. Our findings indicate that brokerage provided by IVCs tends to increase the quantity of co-inventing outputs with other startups, whereas that provided by CVCs will tend to enhance the impact of those outputs. Likewise, both IVCs and CVCs should

Table 7. Robustness test for hypothesis 2 controlling for co-patent impact.

Model Type	Poisson Quasi-Maximum Likelihood Estimation											
Outcome Variable	Focal Firm Knowledge Impact											
	Model 3			Model 4			Model 5			Model 6		
	β	SE	*p*-value	β	SE	*p*-value	β	SE	*p*-value	β	SE	*p*-value
Independent Variables												
Shared Independent VC Investors, 2-year lag	–			−0.281	(0.035)	.000	−0.281	(0.035)	.000	−0.281	(0.035)	.000
Shared Corporate VC Investors, 2-year lag	–			−0.425	(0.031)	.000	−0.425	(0.031)	.000	−0.425	(0.031)	.000
Venture Pair Co-patenting	–			0.187	(0.212)	.377	0.246	(0.228)	.280	0.172	(0.213)	.419
Shared IVC Investors X Co-patenting	–			-			−0.079	(0.236)	.739	–		
Shared CVC Investors X Co-patenting	–			-			-			1.018	(0.182)	.000
Control Variables												
Focal Firm Cumulative Number of Investment Rounds	0.038	(0.002)	.000	0.051	(0.002)	.000	0.051	(0.002)	.000	0.051	(0.002)	.000
Alter Firm Cumulative Number of Investment Rounds	−0.143	(0.004)	.000	−0.140	(0.004)	.000	−0.140	(0.004)	.000	−0.140	(0.004)	.000
Focal Firm Cumulative Amount of Investment	−0.005	(1.73E-04)	.000	−0.006	(1.95E-04)	.000	−0.006	(1.95E-04)	.000	−0.006	(1.95E-04)	.000
Alter Firm Cumulative Amount of Investment	0.001	(3.97E-04)	.039	0.001	(4.65E-04)	.115	0.001	(4.65E-04)	.115	0.001	(4.65E-04)	.115
Focal Firm Cumulative Number of Patents	0.005	(8.04E-05)	.000	0.005	(9.31E-05)	.000	0.005	(9.31E-05)	.000	0.005	(9.31E-05)	.000
Alter Firm Cumulative Number of Patents	2.26E-04	(2.57E-04)	.379	4.86E-04	(2.68E-04)	.069	4.87E-04	(2.68E-04)	.069	4.86E-04	(2.68E-04)	.070
Dyad Copatents Average Knowledge Impact	3.578	(0.428)	.000	3.511	(0.496)	.000	3.490	(0.490)	.000	3.503	(0.492)	.000
Model Wald Chi^2	47,859***			45,385***			45,386***			45,385***		
Sample Size - # of Venture Dyad-Years	1,840,748			1,840,748			1,840,748			1,840,748		
(Robust standard errors reported in parentheses; two-tailed tests of significance)												

Table 8. Robustness test for hypothesis 3 controlling for co-patent novelty.

Model Type	Poisson Quasi-Maximum Likelihood Estimation											
Outcome Variable	Focal Firm Knowledge Novelty											
	Model 7			Model 8			Model 9			Model 10		
	β	SE	*p*-value	β	SE	*p*-value	β	SE	*p*-value	β	SE	*p*-value
Independent Variables												
Shared Independent VC Investors, 2-year lag	–			−0.100	(0.028)	.000	−0.099	(0.028)	.000	−0.100	(0.028)	.000
Shared Corporate VC Investors, 2-year lag	–			−0.168	(0.031)	.000	−0.169	(0.031)	.000	−0.168	(0.031)	.000
Venture Pair Co-patenting	–			0.250	(0.229)	.275	0.450	(0.315)	.153	0.258	(0.229)	.260
Shared IVC Investors X Co-patenting	–			-			−0.242	(0.164)	.140	–		
Shared CVC Investors X Co-patenting	–			-			-			−3.090	(0.157)	.000
Control Variables												
Focal Firm Cumulative Number of Investment Rounds	0.098	(0.002)	.000	0.105	(0.003)	.000	0.105	(0.003)	.000	0.105	(0.003)	.000
Alter Firm Cumulative Number of Investment Rounds	0.001	(0.003)	.764	0.008	(0.004)	.037	0.008	(0.004)	.037	0.008	(0.004)	.037
Focal Firm Cumulative Amount of Investment	−0.003	(2.18E-04)	.000	−0.004	(2.69E-04)	.000	−0.004	(2.69E-04)	.000	−0.004	(2.69E-04)	.000
Alter Firm Cumulative Amount of Investment	0.000	(3.96E-04)	.982	0.000	(4.37E-04)	.851	0.000	(4.37E-04)	.853	0.000	(4.37E-04)	.851
Focal Firm Cumulative Number of Patents	0.004	(5.29E-05)	.000	0.004	(5.40E-05)	.000	0.004	(5.40E-05)	.000	0.004	(5.40E-05)	.000
Alter Firm Cumulative Number of Patents	−7.11E-04	(2.71E-04)	.009	−6.03E-04	(2.75E-04)	.029	−6.02E-04	(2.75E-04)	.029	−6.02E-04	(2.75E-04)	.029
Dyad Copatents Knowledge Novelty	0.033	(0.013)	.012	0.031	(0.012)	.011	0.032	(0.012)	.010	0.031	(0.012)	.011
Model Wald Chi^2	8.50E + 06***			7.75E + 06***			7.75E + 06***			7.75E + 06***		
Sample Size - # of Venture Dyad-Years	1,840,748			1,840,748			1,840,748			1,840,748		
(Robust standard errors reported in parentheses; two-tailed tests of significance)												

Table 9. Supplementary analysis for hypothesis 1: IVCs' semiconductor focus.

Model Type	Rare Events Logistic Regression		
Outcome Variable	Venture Co-Patenting		
	β	SE	*p*-value
Independent Variables			
Shared Independent VC Investors – High Semiconductor Focus, 2-year lag	0.928	(0.528)	.079
Shared Independent VC Investors – Low Semiconductor Focus, 2-year lag	1.304	(0.158)	.000
Shared Corporate VC Investors, 2-year lag	−2.714	(1.012)	.007
Control Variables			
Focal Firm Cumulative Number of Investment Rounds	−0.014	(0.034)	.680
Alter Firm Cumulative Number of Investment Rounds	−0.142	(0.055)	.010
Focal Firm Cumulative Amount of Investment	0.005	(0.002)	.003
Alter Firm Cumulative Amount of Investment	0.007	(0.003)	.007
Focal Firm Cumulative Number of Patents	0.009	(0.001)	.000
Alter Firm Cumulative Number of Patents	0.012	(0.001)	.000
Binary – Venture Pair in Same Industry	1.985	(0.257)	.000
Binary – Venture Pair Located in Same Zip Code	2.146	(0.275)	.000
Constant	−12.589	(0.281)	.000
Model Wald Chi^2	4,852***		
Sample Size - # of Venture Dyad-Years	6,864,780		
(Robust standard errors reported in parentheses; two-tailed tests of significance)			

Table 10. Supplementary analysis for hypothesis 2: IVCs' semiconductor focus.

Model Type	Poisson Quasi-Maximum Likelihood Estimation		
Outcome Variable	Focal Firm Knowledge Impact		
	β	SE	*p*-value
Independent Variables			
Shared Independent VC Investors – High Semiconductor Focus, 2-year lag	−0.007	(0.046)	.882
Shared Independent VC Investors – Low Semiconductor Focus, 2-year lag	−0.286	(0.035)	.000
Shared Corporate VC Investors, 2-year lag	−0.425	(0.031)	.000
Venture Pair Co-patenting	0.284	(0.248)	.251
Shared IVC Investors – High Semiconductor Focus X Co-patenting	−2.641	(0.714)	.000
Control Variables			
Focal Firm Cumulative Number of Investment Rounds	0.051	(0.002)	.000
Alter Firm Cumulative Number of Investment Rounds	−0.140	(0.004)	.000
Focal Firm Cumulative Amount of Investment	−0.006	(1.95E-04)	.000
Alter Firm Cumulative Amount of Investment	0.001	(4.65E-04)	.115
Focal Firm Cumulative Number of Patents	0.005	(9.31E-05)	.000
Alter Firm Cumulative Number of Patents	4.85E-04	(2.68E-04)	.071
Model Wald Chi^2	45,374***		
Sample Size - # of Venture Dyad-Years	1,840,748		
(Robust standard errors reported in parentheses; two-tailed tests of significance)			

understand the role they tend to play in connecting their portfolio startups and examine whether this role is consistent with their overall investment strategy. Such an understanding would inform these investors about the benefits and costs of syndicating with a particular type of potential syndicate partners.

Limitations and avenues for future research

This study has a number of limitations. First, it focuses on the semiconductor industry. This sector exhibits relatively high levels of CVC and patenting activity; therefore, our study requires future research to generalize its findings to similar

knowledge-driven industries such as biotechnology, chemicals, or telecommunications. Moreover, we note that there are certain attributes that are unique to semiconductor industry, such as its reliance on patents or modularity of technological inventions. For industries with relatively lower levels of CVC investment, scholars could investigate whether IVCs need to play a greater role in knowledge brokerage between investees. Our supplementary analysis showed that IVCs that act similarly to a CVC (i.e., those that are more focused on a particular sector) indeed tend to engage in more knowledge brokerage compared to IVCs that offer pure social brokerage, yet future studies could examine outcomes exploiting different types of IVCs. Likewise, for industries with relatively lower levels of patenting activity, scholars can explore whether CVCs are likely to engage in social brokerage centered on market insights and customer relationships rather than knowledge brokerage centered on technological know-how and expertise.

Second, this study assumes that the brokerage effort by IVCs and CVCs remains constant throughout the lifecycle of their investment in ventures. However, to the extent that the participation of IVCs and CVCs in a syndicate may change over time – proactively or due to shifting priorities (Cabral, Kumar, and Park 2024). As a result, the intensity of such social and knowledge brokerage between investees could vary over time. The resulting influence on co-inventing activity, impact, and novelty of the inventing outcomes merits further investigation. For example, CVCs may reduce their brokering efforts following future rounds of investment, which tend to be led by IVCs. Likewise, IVCs may increase their social brokering efforts for investees who show relatively greater promise in terms of survival, growth, or fundraising.

Third, we conceptualize social and knowledge brokerage using a dichotomous approach, due to our operationalization of these concepts that maps the roles of IVCs and CVCs to social and knowledge brokerages, respectively. However, we acknowledge that these concepts are not dichotomous in real life but are more continuous. Moreover, these concepts may or may not be orthogonal to each other. That is, it is possible that some CVCs offer high levels of both social and knowledge brokerages to their portfolio startups.

Finally, we were not able to exclude all possible alternative explanations of co-inventing activities, along with their impact and novelty in the context of knowledge-intensive startups with common IVC or CVC investors. Although we have endeavored to address plausible alternative mechanisms through our study design, use of control variables, and robustness tests, future research may consider how factors such as common directors, top management team members, or external advisors (e.g., finance, legal, and technical) may influence social or knowledge brokerage between investees. Likewise, we cannot perfectly draw causal inference for our theoretical relationships in our empirical model. For instance, it is possible that certain characteristics of startups and their innovation-related traits might be related to both their ability to attract CVC funding and tendency to collaborate with other startups for inventive activities. Although we attempted to account for such a possibility through various statistical methods, we are not able to perfectly do so.

Conclusion

We examined how the social and knowledge brokerage provided by IVCs and CVCs influence the frequency, impact, and novelty of co-inventing activities by portfolio start-ups sharing a common investor. We found that IVCs tend to lead to more frequent, less impactful, and more novel co-inventing outcomes by their portfolio startups, whereas CVCs tend to lead to less frequent, more impactful, and less novel inventive outcomes.

Notes

1. We acknowledge that both IVCs and CVCs may offer brokerage roles of both kinds. Nevertheless, our dichotomized conceptualization of social and knowledge brokerage closely resemble their strengths and objectives in their investment practices.
2. These results are conservative in that, given the presumed lower likelihood of co-inventive attempts converted by social brokerage via IVCs, our models are likely to under-estimate the effect of social brokerage. Conversely, despite the presumed higher likelihood of inventive attempts converted by knowledge brokerage via CVCs, our results suggest that such brokerage results in a lower likelihood of co-patenting.

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References

Allison, P. D., and R. P. Waterman. 2002. "Fixed-Effects Negative Binomial Regression Models." *Sociological Methodology* 32 (1): 247–265. https://doi.org/10.1111/1467-9531.00117.

Alvarez-Garrido, E., and G. Dushnitsky. 2016. "Are Entrepreneurial Venture's Innovation Rates Sensitive to Investor Complementary Assets? Comparing Biotech Ventures Backed by Corporate and Independent VCs." *Strategic Management Journal* 37 (5): 819–834. https://doi.org/10.1002/smj.2359.

Amit, R., J. Brander, and C. Zott. 1998. "Why Do Venture Capital Firms Exist? Theory and Canadian Evidence." *Journal of Business Venturing* 13 (6): 441–466. https://doi.org/10.1016/S0883-9026(97)00061-X.

Antón, M., F. Ederer, M. Giné, and M. Schmalz 2025. "Innovation: The Bright Side of Common Ownership?." *Management Science* 71 (5): 3713–3733.

Bae, J., and M. Gargiulo. 2004. "Partner Substitutability, Alliance Network Structure, and Firm Profitability in the Telecommunications Industry." *Academy of Management Journal* 47 (6): 843–859.

Balachandran, S., and E. Hernandez. 2018. "Networks and Innovation: Accounting for Structural and Institutional Sources of Recombination in Brokerage Triads." *Organization Science* 29 (1): 80–99. https://doi.org/10.1287/orsc.2017.1165.

Barney, J. 1991. "Firm Resources and Sustained Competitive Advantage." *Journal of Management* 17 (1): 99–120. https://doi.org/10.1177/014920639101700108.

Barra, C., and R. Zotti. 2018. "The Contribution of University, Private and Public Sector Resources to Italian Regional Innovation System (In)Efficiency." *The Journal of Technology Transfer* 43 (2): 432–457. https://doi.org/10.1007/s10961-016-9539-7.

Basu, S., A. Sahaym, M. D. Howard, and W. Boeker. 2015. "Parent Inheritance, Founder Expertise, and Venture Strategy: Determinants of New Venture Knowledge Impact." *Journal of Business Venturing* 30 (2): 322–337. https://doi.org/10.1016/j.jbusvent.2014.06.002.

Batjargal, B., M. A. Hitt, A. S. Tsui, J.-L. Arregle, J. W. Webb, and T. L. Miller. 2013. "Institutional Polycentrism, Entrepreneurs' Social Networks, and New Venture Growth." *Academy of Management Journal* 56 (4): 1024–1049. https://doi.org/10.5465/amj.2010.0095.

Baum, J. A., T. Calabrese, and B. S. Silverman. 2000. "Don't Go it Alone: Alliance Network Composition and Startups' Performance in Canadian Biotechnology." *Strategic Management Journal* 21 (3): 267–294.

Belderbos, R., B. Cassiman, D. Faems, B. Leten, and B. Van Looy. 2014. "Co-Ownership of Intellectual Property: Exploring the Value-Appropriation and Value-Creation Implications of Co-Patenting with Different Partners." *Research Policy* 43 (5): 841–852. https://doi.org/10.1016/j.respol.2013.08.013.

Bidwell, M., and I. Fernandez-Mateo. 2010. "Relationship Duration and Returns to Brokerage in the Staffing Sector." *Organization Science* 21 (6): 1141–1158. https://doi.org/10.1287/orsc.1090.0509.

Burt, R. S. 2004. "Structural Holes and Good Ideas." *The American Journal of Sociology* 110 (2): 349–399. https://doi.org/10.1086/421787.

Burt, R. S. 2007. *Brokerage and Closure: An Introduction to Social Capital*. New York, NY: Oxford University Press.

Burt, R. S. 2021. "*Structural Holes* Capstone, Cautions, and Enthusiasms." In *Personal Networks*, edited by M. L. Small and B. L. Perry, 384–416. 1st ed. New York, NY: Cambridge University Press.

Busenbark, J. R., H. Yoon (Elle), D. L. Gamache, and M. C. Withers. 2022. "Omitted Variable Bias: Examining Management Research with the Impact Threshold of a Confounding Variable (ITCV)." *Journal of Management* 48 (1): 17–48. https://doi.org/10.1177/01492063211006458.

Cabral, J. J., M. S. Kumar, and H. D. Park. 2024. "The Value of a Reputation for Sustaining Commitment in Interfirm Relationships: The Inclusion of Corporate Venture Capitalists in Investment Syndicates." *Journal of Business Venturing* 39 (3): 106391. https://doi.org/10.1016/j.jbusvent.2024.106391.

Carnahan, S., and D. Somaya. 2013. "Alumni Effects and Relational Advantage: The Impact on Outsourcing When a Buyer Hires Employees from a Supplier's Competitors." *Academy of Management Journal* 56 (6): 1578–1600. https://doi.org/10.5465/amj.2011.0089.

Chemmanur, T. J., E. Loutskina, and X. Tian. 2014. "Corporate Venture Capital, Value Creation, and Innovation." *Review of Financial Studies* 27 (8): 2434–2473. https://doi.org/10.1093/rfs/hhu033.

Cook, K. S., and R. M. Emerson. 1978. "Power, Equity and Commitment in Exchange Networks." *American Sociological Review* 43 (5): 721. https://doi.org/10.2307/2094546.

Crescenzi, R., M. Nathan, and A. Rodríguez-Pose. 2016. "Do Inventors Talk to Strangers? on Proximity and Collaborative Knowledge Creation." *Research Policy* 45 (1): 177–194. https://doi.org/10.1016/j.respol.2015.07.003.

Csaszar, F. A. 2013. "An Efficient Frontier in Organization Design: Organizational Structure as a Determinant of Exploration and Exploitation." *Organization Science* 24 (4): 1083–1101. https://doi.org/10.1287/orsc.1120.0784.

Dhanaraj, C., and A. Parkhe. 2006. "Orchestrating Innovation Networks." *Academy of Management Review* 31 (3): 659–669. https://doi.org/10.5465/amr.2006.21318923.

Di Lorenzo, F., and V. van de Vrande. 2019. "Tapping Into the Knowledge of Incumbents: The Role of Corporate Venture Capital Investments and Inventor Mobility." *Strategic Entrepreneurship Journal* 13 (1): 24–46. https://doi.org/10.1002/sej.1304.

Drover, W., L. Busenitz, S. Matusik, D. Townsend, A. Anglin, and G. Dushnitsky. 2017. "A Review and Road Map of Entrepreneurial Equity Financing Research: Venture Capital, Corporate Venture Capital, Angel Investment, Crowdfunding, and Accelerators." *Journal of Management* 43 (6): 1820–1853. https://doi.org/10.1177/0149206317690584.

Dushnitsky, G., and S. Kang. 2018. "Seeding a Star or Constructing a Constellation? Corporate Venturing as an Ecosystem Strategy." *Academy of Management Proceedings* 2018 (1): 11361. https://doi.org/10.5465/AMBPP.2018.11361abstract.

Dushnitsky, G., and D. Lavie. 2010. "How Alliance Formation Shapes Corporate Venture Capital Investment in the Software Industry: A Resource-Based Perspective." *Strategic Entrepreneurship Journal* 4 (1): 22–48. https://doi.org/10.1002/sej.81.

Dushnitsky, G., and M. J. Lenox. 2005. "When Do Incumbents Learn from Entrepreneurial Ventures?" *Research Policy* 34 (5): 615–639. https://doi.org/10.1016/j.respol.2005.01.017.

Dushnitsky, G., and Z. Shapira. 2010. "Entrepreneurial Finance Meets Organizational Reality: Comparing Investment Practices and Performance of Corporate and Independent Venture Capitalists." *Strategic Management Journal* 31 (9): 990–1017. https://doi.org/10.1002/smj.851.

Dushnitsky, G., and J. M. Shaver. 2009. "Limitations to Interorganizational Knowledge Acquisition: The Paradox of Corporate Venture Capital." *Strategic Management Journal* 30 (10): 1045–1064. https://doi.org/10.1002/smj.781.

Ewens, M., R. Nanda, and M. Rhodes-Kropf. 2018. "Cost of Experimentation and the Evolution of Venture Capital." *Journal of Financial Economics* 128 (3): 422–442. https://doi.org/10.1016/j.jfineco.2018.03.001.

Fleming, L. 2001. "Recombinant Uncertainty in Technological Search." *Management Science* 47 (1): 117–132. https://doi.org/10.1287/mnsc.47.1.117.10671.

Gompers, P. A., and J. Lerner. 1999. *The Venture Capital Cycle*. Cambridge, MA: MIT Press.

Grigoriou, K., and F. T. Rothaermel. 2017. "Organizing for Knowledge Generation: Internal Knowledge Networks and the Contingent Effect of External Knowledge Sourcing." *Strategic Management Journal* 38 (2): 395–414. https://doi.org/10.1002/smj.2489.

Hagedoorn, J. 2003. "Sharing Intellectual Property Rights—An Exploratory Study of Joint Patenting Amongst Companies." *Industrial and Corporate Change* 12 (5): 1035–1050. https://doi.org/10.1093/icc/12.5.1035.

Hall, B. H., and R. H. Ziedonis. 2001. "The Patent Paradox Revisited: An Empirical Study of Patenting in the U.S. Semiconductor Industry, 1979-1995." *The RAND Journal of Economics* 32 (1): 101. https://doi.org/10.2307/2696400.

Hargadon, A. B. 2002. "Brokering Knowledge: Linking Learning and Innovation." *Research in Organizational Behavior* 24:41–85. https://doi.org/10.1016/S0191-3085(02)24003-4.

Hellmann, T., and M. Puri. 2002. "Venture Capital and the Professionalization of Start-Up Firms: Empirical Evidence." *Journal of Finance* 57 (1): 169–197. https://doi.org/10.1111/1540-6261.00419.

Howard, M. D., M. C. Withers, and L. Tihanyi. 2017. "Knowledge Dependence and the Formation of Director Interlocks." *Academy of Management Journal* 60 (5): 1986–2013. https://doi.org/10.5465/amj.2015.0499.

Hsu, D. H. 2004. "What Do Entrepreneurs Pay for Venture Capital Affiliation?" *Journal of Finance* 59 (4): 1805–1844. https://doi.org/10.1111/j.1540-6261.2004.00680.x.

Hsu, D. H. 2006. "Venture Capitalists and Cooperative Start-Up Commercialization Strategy." *Management Science* 52 (2): 204–219. https://doi.org/10.1287/mnsc.1050.0480.

Huang, P., and R. Madhavan. 2021. "Dumb Money or Smart Money? Meta-Analytically Unpacking Corporate Venture Capital." *Strategic Entrepreneurship Journal* 15 (3): 403–429. https://doi.org/10.1002/sej.1369.

Jeon, E., and M. Maula. 2022. "Progress Toward Understanding Tensions in Corporate Venture Capital: A Systematic Review." *Journal of Business Venturing* 37 (4): 106226. https://doi.org/10.1016/j.jbusvent.2022.106226.

Katila, R., J. D. Rosenberger, and K. M. Eisenhardt. 2008. "Swimming With Sharks: Technology Ventures, Defense Mechanisms and Corporate Relationships." *Administrative Science Quarterly* 53 (2): 295–332. https://doi.org/10.2189/asqu.53.2.295.

Keil, T., M. V. Maula, and C. Wilson. 2010. "Unique Resources of Corporate Venture Capitalists as a Key to Entry into Rigid Venture Capital Syndication Networks." *Entrepreneurship Theory and Practice* 34 (1): 83–103. https://doi.org/10.1111/j.1540-6520.2009.00366.x.

Kim, J. Y., and H. D. Park. 2017. "Two Faces of Early Corporate Venture Capital Funding: Promoting Innovation and Inhibiting IPOs." *Strategy Science* 2 (3): 161–175. https://doi.org/10.1287/stsc.2017.0032.

Kim, J. Y., H. K. Steensma, and H. D. Park. 2019. "The Influence of Technological Links, Social Ties, and Incumbent Firm Opportunistic Propensity on the Formation of Corporate Venture Capital Deals." *Journal of Management* 45 (4): 1595–1622. https://doi.org/10.1177/0149206317720722.

King, G., and L. Zeng. 2001. "Logistic Regression in Rare Events Data." *Political Analysis* 9 (2): 137–163. https://doi.org/10.1093/oxfordjournals.pan.a004868.

Kogan, L., D. Papanikolaou, A. Seru, and N. Stoffman. 2017. "Technological Innovation, Resource Allocation, and Growth." *Quarterly Journal of Economics* 132 (2): 665–712. https://doi.org/10.1093/qje/qjw040.

Kortum, S., and J. Lerner. 2000. "Assessing the Contribution of Venture Capital to Innovation." *The RAND Journal of Economics* 31 (4): 674. https://doi.org/10.2307/2696354.

Kotabe, M., D. Dunlap-Hinkler, R. Parente, and H. A. Mishra. 2007. "Determinants of Cross-National Knowledge Transfer and Its Effect on Firm Innovation." *Journal of International Business Studies* 38 (2): 259–282. https://doi.org/10.1057/palgrave.jibs.8400261.

Kwon, S.-W., E. Rondi, D. Z. Levin, A. De Massis, and D. J. Brass. 2020. "Network Brokerage: An Integrative Review and Future Research Agenda." *Journal of Management* 46 (6): 1092–1120. https://doi.org/10.1177/0149206320914694.

Lindsey, L. 2008. "Blurring Firm Boundaries: The Role of Venture Capital in Strategic Alliances." *Journal of Finance* 63 (3): 1137–1168. https://doi.org/10.1111/j.1540-6261.2008.01354.x.

Llopis, O., P. d'Este, and A. A. Díaz-Faes. 2021. "Connecting Others: Does a Tertius Iungens Orientation Shape the Relationship Between Research Networks and Innovation?" *Research Policy* 50 (4): 104175. https://doi.org/10.1016/j.respol.2020.104175.

Ma, S. 2020. "The Life Cycle of Corporate Venture Capital." *Review of Financial Studies* 33 (1): 358–394. https://doi.org/10.1093/rfs/hhz042.

Maula, M. V., T. Keil, and S. A. Zahra. 2013. "Top Management's Attention to Discontinuous Technological Change: Corporate Venture Capital as an Alert Mechanism." *Organization Science* 24 (3): 926–947. https://doi.org/10.1287/orsc.1120.0775.

McEvily, B., J. Jaffee, and M. Tortoriello. 2012. "Not All Bridging Ties Are Equal: Network Imprinting and Firm Growth in the Nashville Legal Industry, 1933–1978." *Organization Science* 23 (2): 547–563. https://doi.org/10.1287/orsc.1100.0633.

Mizruchi, M. S., and L. B. Stearns. 2001. "Getting Deals Done: The Use of Social Networks in Bank Decision-Making." *American Sociological Review* 66 (5): 647. https://doi.org/10.1177/000312240106600502.

Noelia, F. L., and D. C. Rosalia. 2020. "A Dynamic Analysis of the Role of Entrepreneurial Ecosystems in Reducing Innovation Obstacles for Startups." *Journal of Business Venturing Insights* 14:e00192. https://doi.org/10.1016/j.jbvi.2020.e00192.

Obstfeld, D. 2005. "Social Networks, the Tertius Iungens Orientation, and Involvement in Innovation." *Administrative Science Quarterly* 50 (1): 100–130. https://doi.org/10.2189/asqu.2005.50.1.100.

Park, H. D., M. D. Howard, and D. M. Gomulya. 2018. "The Impact of Knowledge Worker Mobility Through an Acquisition on Breakthrough Knowledge." *Journal of Management Studies* 55 (1): 86–107. https://doi.org/10.1111/joms.12320.

Park, H. D., and H. K. Steensma. 2012. "When Does Corporate Venture Capital Add Value for New Ventures?" *Strategic Management Journal* 33 (1): 1–22. https://doi.org/10.1002/smj.937.

Park, H. D., and H. K. Steensma. 2013. "The Selection and Nurturing Effects of Corporate Investors on New Venture Innovativeness: Role of Corporate Investors on New Venture Innovativeness." *Strategic Entrepreneurship Journal* 7 (4): 311–330. https://doi.org/10.1002/sej.1165.

Park, H. D., and D. Tzabbar. 2016. "Venture Capital, CEOs' Sources of Power, and Innovation Novelty at Different Life Stages of a New Venture." *Organization Science* 27 (2): 336–353. https://doi.org/10.1287/orsc.2016.1054.

Peteraf, M. A. 1993. "The Cornerstones of Competitive Advantage: A Resource-Based View." *Strategic Management Journal* 14 (3): 179–191. https://doi.org/10.1002/smj.4250140303.

Pitchbook. 2022. "VCs Take Aim at Semiconductor Innovation." https://pitchbook.com/news/articles/vc-startups-semiconductor-ai-ml-innovation.

Polidoro, F., and W. Yang. 2021. "Corporate Investment Relationships and the Search for Innovations: An Examination of Startups' Search Shift Toward Incumbents." *Organization Science* 32 (4): 909–939. https://doi.org/10.1287/orsc.2020.1421.

Quintane, E., and G. Carnabuci. 2016. "How Do Brokers Broker? Tertius Gaudens, Tertius Iungens, and the Temporality of Structural Holes." *Organization Science* 27 (6): 1343–1360. https://doi.org/10.1287/orsc.2016.1091.

Rhee, L., and P. M. Leonardi. 2018. "Which Pathway to Good Ideas? An Attention-Based View of Innovation in Social Networks." *Strategic Management Journal* 39 (4): 1188–1215. https://doi.org/10.1002/smj.2755.

Rossi, M., J. Chouaibi, D. Graziano, and G. Festa. 2022. "Corporate Venture Capitalists as Entrepreneurial Knowledge Accelerators in Global Innovation Ecosystems." *Journal of Business Research* 142:512–523. https://doi.org/10.1016/j.jbusres.2022.01.003.

Rossi, M., G. Festa, A. Papa, A. Kolte, and R. Piccolo. 2020. "Knowledge Management Behaviors in Venture Capital Crossroads: A Comparison Between IVC and CVC Ambidexterity." *Journal of Knowledge Management* 24 (10): 2431–2454. https://doi.org/10.1108/JKM-05-2020-0328.

Semadeni, M., M. C. Withers, and S. Trevis Certo. 2014. "The Perils of Endogeneity and Instrumental Variables in Strategy Research: Understanding through Simulations." *Strategic Management Journal* 35 (7): 1070–1079. https://doi.org/10.1002/smj.2136.

Shapiro, C. 2001. "Navigating the Patent Thicket: Cross Licenses, Patent Pools, and Standard Setting." In *Innovation Policy and the Economy*, 119–150. Vol. 1. Chicago, IL: University of Chicago Press.

Soda, G., A. Zaheer, X. Sun, and W. Cui. 2021. "Brokerage Evolution in Innovation Contexts: Formal Structure, Network Neighborhoods and Knowledge." *Research Policy* 50 (10): 104343. https://doi.org/10.1016/j.respol.2021.104343.

Sorenson, O., J. W. Rivkin, and L. Fleming. 2006. "Complexity, Networks and Knowledge Flow." *Research Policy* 35 (7): 994–1017. https://doi.org/10.1016/j.respol.2006.05.002.

Stinchcombe, A. L. 1965. "Social Structure and Organizations." In *Handbook of Organizations*, edited by JG March,142–193. Chicago, IL: Rand McNally.

Stuart, T. E., H. Hoang, and R. C. Hybels. 1999. "Interorganizational Endorsements and the Performance of Entrepreneurial Ventures." *Administrative Science Quarterly* 44 (2): 315–349. https://doi.org/10.2307/2666998.

Trajtenberg, M. 1990. "A Penny for Your Quotes: Patent Citations and the Value of Innovations." *The RAND Journal of Economics* 21 (1): 172–187. https://doi.org/10.2307/2555502.

Wadhwa, A., C. Phelps, and S. Kotha. 2016. "Corporate Venture Capital Portfolios and Firm Innovation." *Journal of Business Venturing* 31 (1): 95–112. https://doi.org/10.1016/j.jbusvent.2015.04.006.

Wang, P. 2020. "Broadening Versus Reinforcing Investor Portfolios: Social Structure and the Search for Venture Capital Investors." *Journal of Business Venturing* 35 (1): 105915. https://doi.org/10.1016/j.jbusvent.2018.12.001.

Williamson, O. E. 1991. "Comparative Economic Organization: The Analysis of Discrete Structural Alternatives." *Administrative Science Quarterly* 36 (2): 269–296. https://doi.org/10.2307/2393356.

Wooldridge, J. M. 2010. *Econometric Analysis of Cross Section and Panel Data*. 2nd ed. Cambridge, MA: MIT Press.

Yayavaram, S., and G. Ahuja. 2008. "Decomposability in Knowledge Structures and Its Impact on the Usefulness of Inventions and Knowledge-Base Malleability." *Administrative Science Quarterly* 53 (2): 333–362. https://doi.org/10.2189/asqu.53.2.333.