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Research Article

The Influence Mechanism of Knowledge Heterogeneity of Venture Capital Syndication on Innovation Performance of Entrepreneurial Firms: Evidence from China

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Venture capital syndication (VCS), an investment model, is gaining increasing attention. This paper uses a new perspective on knowledge transfer to explore the influence mechanism of knowledge heterogeneity in VCS on the innovation performance (IP) of entrepreneurial firms. We use firm-year panel data from the Shenzhen Stock Exchange for 2000–2017 and find that the knowledge heterogeneity of VCS includes, at least, management knowledge heterogeneity, investment knowledge heterogeneity, and technical knowledge heterogeneity. In particular, management knowledge heterogeneity and technical knowledge heterogeneity positively affect the IP of entrepreneurial firms. We further find that the intellectual capital (IC) of entrepreneurial firms mediates these positive relationships. Moreover, the equity concentration of VCS positively moderates the relationship between knowledge heterogeneity and IP and negatively moderates the relationship between knowledge heterogeneity and IC. This paper provides a new theoretical explanation of the relationship between VCS and IP of entrepreneurial firms from a knowledge transfer perspective and explores the impact paths of this relationship.

1. Introduction

Policymakers seeking to stimulate economic growth frequently attempt to establish or expand their local venture capital (VC) industries [1]. There are two common reasons for this approach. The first is that venture capitalists (VCs) can help small and new firms mitigate the problem of underinvestment in innovative activities [2]. The second is that venture capitalists can help new firms grow quickly and profitably [3]. Venture capital syndication (VCS), a new investment model, has attracted academic attention. By bringing together complementary resources, VCS may result in a better selection of investments and higher value-added for investees, namely, entrepreneurial firms [4]. According to the China Venture Source Database, 1,615 firms issued initial public offerings (IPOs) on the Shenzhen Stock Exchange's small- and medium-sized boards and growth enterprise boards from 2000 to 2017, and approximately 25% of these firms received financing from VCS.

In general, there are three main types of impacts of VC on firms' innovation performance: incentive [5], neutral [1], and disincentive effects [6]. The more VCS investors there are, the more complex the impact of VCS on innovation will be. Previous studies have explored the impact of syndication background heterogeneity [7], the degree of similarity among VCs [8], and the characteristics of the lead VCs in syndication [9] on the IP of entrepreneurial firms and have mainly used resource-based or marginal cost theory to explain these relationships. However, these theories do not fully represent the nature of innovation and ignore the key role of the entrepreneurial firm as the main innovation agent. Furthermore, there are various knowledge related interactions between VCS and entrepreneurial firms. Inter-firm knowledge transfer meets enterprises' need for knowledge diversification [10]. The transfer of knowledge between network members can also help firms obtain knowledge beyond their existing market customers and

facilitate the rapid development of new products or services [11]. Stam found that VCs have a certification role and typically provide access to an extensive social network, which helps companies to obtain various resources (e.g., knowledge, technology, human resources, and so on) from external sources for technological innovation [12]. Certainly, resource-based theory and marginal cost theory alone are inadequate for explaining the interactions between VCS and entrepreneurial firms. However, the current literature lacks not only theoretical explanations but also discussions of pathway mechanisms.

To address these gaps in the literature, this paper uses the knowledge transfer perspective to explore how VCS affects entrepreneurial firms' IP. When VC investors form a syndicate to co-invest in a project, the syndicate members typically have heterogeneous skills, information, and industry expertise [12]. A natural implication from prior studies is that syndicate members can provide a broad range of heterogeneous knowledge of entrepreneurial firms. We consider VC syndicates to be knowledge sources and entrepreneurial firms to be knowledge receivers. VC syndicates transfer knowledge to entrepreneurial firms in post-investment management, and the knowledge characteristics called knowledge heterogeneity of VCS (KHS) influence the effectiveness of knowledge transfer. As a result, KHS may directly impact entrepreneurial firms' IP. Additionally, this paper considers the role of intellectual capital (IC) as a mediator in the relationship between KHS and entrepreneurial firms' IP. When the knowledge of VCs syndicate is embedded in the organization through knowledge transfer, it forms the firm's IC, and the enhancement of IC promotes innovation. VCS is a special alliance formed by equity investment, and the equity structure of VCS is an important characteristic. The equity structure of VCS can reflect the investment relationship between VCS members and their willingness to transfer knowledge. To accurately reflect the influence of the equity structure of VCS (beyond simply identifying leaders and followers), we use the measure of KHS and empirically test the moderating effect of the equity structure of VCS on the aforementioned knowledge transfer path. Our research sample includes 398 firms that received VCS between 2000 and 2017 and is successfully listed on the Shenzhen Stock Exchange. We find that KHS impacts entrepreneurial firms' IP through the mediating role of the entrepreneurial firm's IC. The equity structure of VCS moderates the relationship between the above.

There is a problem of potential endogeneity in the underlying regression results. Tian believes that endogeneity in VC syndication may occur due to reverse causality because promising deals may be more likely to attract VC firms that want to form a syndicate [12]. Similarly, VCS with more heterogeneous knowledge may have better screening capabilities and be better able to identify firms with high-innovation potential. This means that our sample is subject to selection bias, which may result in estimation errors in the main results. To address this selection bias, we use an alternative measure of IP and Heckman's two-stage approach [13]. This method produces results remarkably comparable to our baseline estimates.

This paper makes some meaningful contributions to the literature. First, differing from resource-based theory, we explain the relationship between VCS and entrepreneurial firms' IP from a new perspective on knowledge transfer. We introduce knowledge transfer theory to the literature on VC, broadening the application of knowledge transfer theory and breaking the research tradition of focusing solely on the flow of capital while ignoring the flow of knowledge in venture capital. We summarize three types of knowledge that VC provides to entrepreneurial firms: management knowledge, investment knowledge, and technical knowledge. The knowledge heterogeneity of VCS was further developed to capture the degree of differences in knowledge. We find that absorbing, integrating, and utilizing heterogeneous knowledge from VC syndicates for innovation is an important way for entrepreneurial firms to obtain external knowledge. Second, after further verifying the impact path, we find that entrepreneurial firms' IC mediates the positive impact of heterogeneous knowledge of VCS on entrepreneurial firms' IP. Additionally, our paper constructs new variables describing the equity structure of VCS, which can help to open the "black box" of the relationship between VCS and entrepreneurial firms.

The rest of this article is organized as follows. Section 2 presents the theoretical background and our hypotheses. Section 3 describes the data and sample selection procedures, the construction of variables used in this study, and our empirical methodology. Section 4 reports our empirical results, analysis, and robustness checks. Section 5 provides theoretical implications and suggestions for management. Section 6 concludes and discusses the potential limitations of this study.

2. Theoretical Background and Hypotheses

2.1. Theoretical Background

2.1.1. VCS and IP. VCS can be defined in two ways. The first narrowly defines VCS as a group of two or more VC firms that share a financing round. In contrast, the entrepreneurial firm is classified as an individual backed firm if it receives funding from only one VC firm across all rounds or if the different rounds each involve a different VC firm, but only one firm in each round. A broader and more relaxed definition of VCS categorizes an entrepreneurial firm as syndicate funded if two or more VCs fund it (regardless of the rounds in which each provided funding) [12, 14]. We adopt the first and more rigorous definition. Tian identified some critical contrasts between VCS and individual VC, including the variety of talent, knowledge, industry expertise, and network of VCS members. Therefore, VCS enables a better understanding and evaluation of entrepreneurial firms' technology and so nurtures innovation [12]. However, a substantial body of literature has reached different conclusions on the relationship between VCS characteristics and investment performance. Du found that co-investing with similar partners may lower transaction costs but may also limit learning opportunities. However, eventually, venture capital firms may benefit more from co-investing with partners who are not in their industry [8].

In contrast, Zhang demonstrated that startups backed by mixed syndication in their initial financing round are less likely to survive to the next financing round to obtain refinancing (because of the higher coordination cost in mixed syndication) than those backed by syndication among VCs only [9]. In contrast to these studies, Pierrakis found that the likelihood of a company applying for or obtaining a patent does not differ significantly between companies that receive only private VC funds and those that receive both public and private sector investments [15]. Bayar demonstrated that firms financed mainly by the same set of VCs across multiple financing rounds are more likely to succeed [16]. Furthermore, Lu et al. reported that the greater the heterogeneity in the syndication experience, the greater the impact on entrepreneurial firm innovation [17].

2.1.2. Knowledge Transfer Theory. Knowledge transfer is a dynamic learning process [18] in which information is continuously exchanged between the sender and receiver. Knowledge transfer ensures that new knowledge is absorbed and used effectively [19]. The SECI model of knowledge transformation proposed by Nonaka reflects the entire process of knowledge creation. This model posits that an organization cannot create knowledge on its own and that the tacit knowledge of individuals is the basis of organizational knowledge creation. Individuals, groups, and organizations are the three levels of knowledge creators. Organizational knowledge can be transferred, expanded, and value-added through four stages: socialization, externalization, combination, and internalization. According to the SECI model, VCS can complete the knowledge transfer process through the post-investment management of entrepreneurial firms and the provision of value-added services. The organization will accelerate the application of the knowledge gained through knowledge transfer, continuously creating new knowledge and developing new technologies and products [20]. Knowledge transfer is a strenuous activity that is influenced by many factors, such as knowledge transfer motivation [21], absorptive capacity [22], individual relationships [23], and so on. Effective knowledge transfer can help a firm accumulate and expand its knowledge base and improve its innovation ability. Knowledge related characteristics are among the most important factors impacting knowledge transfer effectiveness [24]. Chen emphasizes the importance of heterogeneous external knowledge for enterprise innovation and the use of knowledge transfer to actively acquire external knowledge in the context of open innovation [25].

2.1.3. Intellectual Capital. With the rise of the knowledge economy, intellectual assets, or unique knowledge, abilities, values, and methods have surpassed physical assets like land, equipment, and capital as the primary "economic wealth production factor" [26]. These intellectual assets, which can be converted into profit but are not reported in the firm's financial statements, are called intellectual capital (IC) [27]. According to the classification in the literature, IC is generally considered to consist of human capital (HC), structural capital (SC), and relational capital (RC) [28, 29]. Human capital is defined as the sum of all the knowledge, skills, abilities, expertise, and experience of individuals in an institution that can be used to accomplish firm objectives [30, 31]. Structural capital (SC) refers to the knowledge that would remain at the firm after employees have left, and it mainly involves the "nonhuman stocks of codified knowledge in an organization" [32, 33]. Relational capital is the aggregation of existing and potential resources acquired through an individual's or organization's network of relationships [34]. Grant argues that the essence of IC formation is the process of organizational knowledge integration, which is primarily accomplished through knowledge creation [35]. In terms of the relationship between IC and corporate innovation, Harrison and Sullivan argue that IC can benefit companies in various ways and improve their ability to innovate [36].

2.2. Research Hypotheses. Some scholars suggest that enterprises absorb and integrate rich and novel heterogeneous knowledge from outside sources to effectively compensate for internal knowledge resource gaps and promote collaborative knowledge innovation [37]. External heterogeneous knowledge can also alleviate core rigidity and path dependence effects in the development of enterprise innovation. This motivates firms to continuously reconfigure their knowledge resources to continuously generate novel innovations and improve the performance of breakthrough innovations [38]. After a syndication formation, VC investors actively monitor portfolio companies and commonly provide valuable coaching to transfer knowledge [39]. The following are some possible approaches. Primarily, VC investors provide management knowledge. VC investors are involved in the operation and management of enterprises, offering advice and consulting services to entrepreneurs, evaluating strategic plans, hiring financial and human resource management experts, and establishing rules and regulations [40]. Second, VC provides expertise in investment. Startup companies are too small to rely on public debt and equity markets for finance because they lack collateral assets to secure their debt [41]. When entrepreneurial firms begin operating, a large amount of money is needed for product upgrades, market expansion, and marketing channel development. Venture capitalists usually do not provide all the funds required for a project at once in order to reduce their investment risk. As a result, they must prepare for additional funding by drawing on their extensive investment experience and knowledge. Finally, VC investors provide technical expertise. They are commonly proficient in a specific industry's products, technologies, and markets and can use their knowledge to assist entrepreneurial firms in overcoming technical challenges and reducing technical risks [42]. Based on the abovementioned research on VC practice, we summarize the knowledge provided by VC to entrepreneurial firms into three types: management knowledge, investment knowledge, and technical knowledge.

The multiple parties involved in syndication further lead to the heterogeneous composition of various types of

knowledge. We use KHS to capture the degree of knowledge differences as a characteristic of knowledge. According to resource dependency theory, a heterogeneous knowledge base, which can stimulate the exchange and interaction of knowledge between VC investors and entrepreneurial firms, provides different perspectives and areas for combining multiple potential innovative ideas [43]. We argue that the higher the KHS, the better the enhancement of entrepreneurial firms' IP.

2.2.1. H1: KHS Promotes the IP of Entrepreneurial Firms. Much of the theoretical literature has explored VCS's role in monitoring, advising, and providing support. VC investors can communicate valuable knowledge to an entrepreneur to facilitate innovation. Dessi argues that venture capitalists can communicate the entrepreneur's innovative knowledge to other portfolio companies by performing a new role as knowledge intermediaries [44]. Chemmanur et al. also found that venture capitalists can improve the efficiency of entrepreneurial firms (e.g., product market support using VCS' contact networks and expert advice) and perform explicit monitoring activities (e.g., reviewing management behavior and developing incentive compensation plans) by providing value-added activities [45]. Kaplan and Stromberg examined actual contracts between venture capitalists and entrepreneurs and found that the distinguishing characteristic of VC financing is that it allows VCs to separately allocate cash flow rights, board rights, voting rights, liquidation rights, and other control rights [39]. This means that VC investors can be fully engaged in the governance of entrepreneurial firms.

Knowledge management and IC are vital sources of competitive advantage and organizational performance [46]. It is imperative for organizations to use knowledge management to accumulate IC to cope with their increasingly challenging environments [47]. Conceptually, knowledge management and IC are related because they include a whole range of intellectual activities, from knowledge creation to knowledge leverage [48]. Knowledge management encompasses the two related elements of organizational learning flows and intellectual capital stocks [49]. In knowledge management theory, knowledge acquisition and knowledge transfer are considered to be fundamental processes of knowledge management [50]. External knowledge characteristics (e.g., knowledge heterogeneity) are important factors that influence the effectiveness of knowledge acquisition and transfer. According to the SECI model, knowledge is transferred between a VC syndicate and an entrepreneurial firm in the post-investment management process. The knowledge owned by the VC syndicate is shared, conceptualized, systematized, and disseminated among the entrepreneurial firms to be absorbed and sublimated by the entrepreneurs and employees. New intellectual capital is created by the value-added and structural transformation of an entrepreneurial firm's knowledge.

Specifically, VC syndicates provide management knowledge to entrepreneurial firms. VC syndicates improve the firm's human capital by improving the work skills of employees and developing their sense of innovation and improve the firm's structural capital by developing intricate document management systems and efficient decision-making mechanisms [51]. Brander examines possible reasons for syndication, such as accessing the complementary management skills of other venture capitalists [51]. To meet the capital market's requirements for entrepreneurial firms' innovation, investment knowledge can be provided by VC syndicates to improve relationship capital by adjusting the speed of technology development [52]. VC syndicates provide technical knowledge to deepen knowledge of the enterprise's technology and product development through structured and repetitive activities, which can help entrepreneurial firms overcome specific technical challenges and reduce technical risks. Du found that VC firms may benefit more eventually from co-investing with partners different from themselves [8]. Entrepreneurial firms require different intellectual capital at different stages of development. For example, entrepreneurial firms need good innovative ideas and entrepreneurship-based human capital at the seed stage. However, entrepreneurial firms need more management experience to scale their business and have a greater reliance on structured capital at the growth stage [53]. We have argued above that entrepreneurial firms require different IC at different growth stages and that KHS can meet the demand for external knowledge at various stages of growth.

2.2.2. H2: KHS Promotes IC of Entrepreneurial Firms. Human capital is a critical element of innovation, and employees contribute to innovation through their experience, knowledge, and skills. Highly qualified and experienced managers are more receptive to new ideas, and as a result, they enable higher corporate innovation [52]. Highly qualified employees can turn new ideas into new products or services by applying their unique knowledge, skills, and experience [52]. Knowledgeable and skilled employees can spot market opportunities, generate new ideas, and use organizational resources to develop new products [54].

Another critical element is structural capital. Numerous studies have confirmed the importance of structural capital in promoting innovation. The speed of developing new products is determined by business management systems, business processes, and knowledge management systems [55]. A high level of structural capital can boost technological innovation performance by increasing the efficiency of corporate knowledge management and fostering a culture of sharing and communication [56].

In addition, relational capital is important. The company's communication and interactions with customers, suppliers, and research institutions, such as universities, can enrich the company's internal resources, reduce costs, and accelerate the innovation process [57]. Relational capital encourages the acquisition and application of external knowledge, thereby improving the firm's innovation performance.

Accordingly, the three types of IC are expected to support firm IP. We, therefore, form the following hypothesis.

2.2.3. H3: The Entrepreneurial Firm's IC Is Positively Related to Its IP. Together, hypotheses H1 to H3 argue that KHS enhances entrepreneurial firms' IP and does so by directly enhancing their IC, which in turn is the foundation of IP. According to Baron and Kenny's [58] classic mediation analysis framework, IC is a mediating variable between KHS and the IP of entrepreneurial firms.

2.2.4. H4: The Relationship between KHS and IP of Entrepreneurial Firms Is Mediated by IC. Previous studies have analyzed relationships between VCS members from the perspectives of leaders and followers, focusing on the impact of the lead VC [9] and overlooking the role of followers. The size of a venture capitalist's equity generally indicates their degree of involvement in managing the investee company and the percentage of profits they receive. The amount of equity will further influence the venture capitalist's level of effort and decision-making behavior and the relationship between VCS members. Therefore, this paper analyzes the internal equity structure of VCS and explores its moderating effect on the relationship between KHS and IP.

When there is a high concentration of equity in syndication, a small number of venture capitalists own a large proportion of the equity, and VCS has an absolute lead and follows its investment strategy. Eventually, VC investors with greater equity tend to support entrepreneurial firms by performing duties, such as assisting them in establishing organizational structures, participating in decision-making, and establishing a coherent and effective decision-making system. This limits the participation and knowledge input of VC investors with smaller equity, to a certain extent, giving them a reduced sense of responsibility and leading to "free riding" behavior [59]. VC investors with greater equity will indirectly hold the company's decision-making control and operational execution power and form a situation of "one voice," which will affect the entrepreneurial firm's knowledge absorption and utilization. In contrast, VC investors with smaller equity are more likely to invest for strategic reasons and focus on the technology owned by the entrepreneurial firm [60].

When the equity is relatively dispersed, VC investors hold a similar amount of equity. Each VC investor expects to actively participate in the entrepreneurial firm to the same extent due to its equal shareholder status, which encourages VCS members to transfer knowledge to the entrepreneurial firm, enhancing the quantity and quality of knowledge transfer [61]. Furthermore, the more dispersed the equity is the greater the mutual checks and balances among VCS members. A reasonable degree of equity checks and balances ensures that corporate governance and control mechanisms operate effectively. To summarize, the more concentrated the equity is, the more likely there is a situation of "one voice" and "free riding," thus enabling the manipulation of the enterprise and reducing the participation of other VC investors, which is not conducive to knowledge transfer from VC syndicates. As a result of the above analysis, we propose the following hypotheses:

H5: the relationship between KHS and IP of entrepreneurial firms is negatively moderated by the degree of the equity concentration of VCS

H6: the relationship between KHS and IC of entrepreneurial firms is negatively moderated by the degree of the equity concentration of VCS

Figure 1 shows the theoretical model and variables.

3. Materials and Methods

3.1. Sample Collection. The empirical study used data from firms that accepted syndicating funding and successfully listed on the Shenzhen Stock Exchange's small- or medium-sized boards (SME) or growth enterprise boards (GEM) between 2000 and 2017. The SME and GEM boards focus heavily on providing financing channels and development platforms for emerging enterprises with outstanding main business, growth, and high technology content compared with those listed on the mainboard market. The sample data are comprised of three parts. (1) VC data with sample companies were obtained from the China Venture Source Database. This dataset included the names of VC firms, their participation in syndication, firm background information, investment amount, and the number of shares. (2) Financial data for the entrepreneurial firms were obtained from the China Stock Market & Accounting Research (CSMAR) database, a widely used source of Chinese firms' financial data. (3) Patent data for sample companies were obtained from the Dawei Innojoy patent search engine, a comprehensive patent information application platform. After excluding companies with missing data, the sample comprised 398 entrepreneurial firms with syndicating venture capital support. The distribution of the characteristics of the number of syndications is shown in Table 1.

3.2. Variables and Measurement

3.2.1. Innovation Performance. IP is our model's dependent variable. Prior studies have used two main methods to measure IP. First, IP can be measured by the input of innovation resources, such as indicators of R&D input. Second, it can be measured by innovation output, mainly using patents (such as the number of patent applications or patents granted to enterprises) or innovative products. Our model's dependent variable (patapply) is the total number of patent applications in the three years following the IPO (the year of the IPO and the next two years). R&D input (RDI) is used as a proxy variable for robustness testing.

3.2.2. Knowledge Heterogeneity of VCS. KHS was our independent variable. The paper's primary goal is to investigate the knowledge heterogeneity of VCS. Prior studies identify three main types of knowledge transferred from syndicating venture capitalists to entrepreneurial firms: management knowledge, investment knowledge, and technical knowledge. This paper designates management knowledge heterogeneity (MKH), investment knowledge

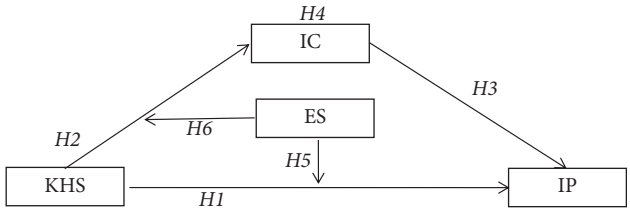

Figure 1: The theoretical model. KHS: knowledge heterogeneity of VCS; IC: intellectual capital of entrepreneurial firms; IP: innovation performance of entrepreneurial firms; ES: equity structure of VCS.

Table 1: Distribution of characteristics of the number of syndications.

Number of VC investors	Number of entrepreneurial firms	Percentage (%)
2	254	63.82
3	107	26.88
4	26	6.53
5	10	2.51
6	1	0.26
Total	398	100

heterogeneity (IKH), and technical knowledge heterogeneity (TKH) as aspects of the knowledge heterogeneity of VCS (KHS).

First, management knowledge is calculated as the total number of venture capital investments [62], that is, investments of venture capital between January 1, 2000, and the formation of the syndicate. The amount invested typically reflects the size of the venture capital. Different sizes of venture capital will accumulate different management knowledge. Investment knowledge is measured as the cumulative number of investment rounds [63], the total number of investments made by VC investors between January 1, 2000, and the formation of the syndicate. A larger cumulative number of investment rounds indicates that VC investors can better understand the needs of both the supply and demand sides of the capital market. Technical knowledge, indicated by the industry specialization of venture capital [62], is measured as a percentage of all investment events that occurred in the same industry as the entrepreneurial firm between January 1, 2000, and the formation of the syndicate.

Second, we measure the three types of knowledge heterogeneity in syndication. Management knowledge and technical knowledge are continuous variables, and investment knowledge is a discrete variable. We follow Beckman and Haunschild (2002) and measure heterogeneity for continuous variables by constructing the coefficient of variation, which is the ratio of the variable's standard deviation to its mean [64]. For the discrete variable, we follow Jacquemin and Berry [65] and use the entropy measure to assess the degree of heterogeneity of investment knowledge in syndication [65]. The greater the indicator's value, the greater the knowledge heterogeneity. The specific calculation of each heterogeneity index is shown in the following equations:

$$\mathrm{MKH} = \frac{\sqrt{E\left(\mathrm{me}_i - E(\mathrm{me})\right)^2}}{E(\mathrm{me})} = \frac{\sigma_{\mathrm{me}}}{E(\mathrm{me})}, \tag{1}$$

$$\mathrm{TKH} = \frac{\sqrt{E\left(tk_i - E(tk)\right)^2}}{E(tk)} = \frac{\sigma_{tk}}{E(tk)}, \tag{2}$$

$$\mathrm{IKH} = -\sum P_i * \ln(p_i), \tag{3}$$

where p_i is the ratio of the cumulative number of investments by the i-th VC investor to the total number of investments made by all syndicating VC investors.

Finally, we used principal component analysis to determine KHS. Under the condition that the cumulative variance contribution rate is greater than 80%, there are two principal components, $F1$ and $F2$. The final value of KHS is $40.62\%F1 + 39.54\%F2$.

3.2.3. Equity Structure (ES). This paper examines the moderating effect of an equity structure. We use the ratio of the standard deviation to the mean for the shareholding of VCS members to measure the equity structure of VCS, following the KHS variable construction method. A higher value denotes more concentrated equity.

3.2.4. Intellectual Capital. IC is our mediating variable. We use the value-added intellectual coefficient (VAIC) model developed by Pulic [66] to measure the value creation efficiency of IC. Pulic suggested that the difference between outputs and inputs is the value-added (VA) by the firm. In addition, the VAIC model measures the value creation efficiency of each factor by the ratio of VA to the input of the factor [66]. The extended VAIC model consists of human capital efficiency (HCE), structural capital efficiency (SCE), and relationship capital efficiency (RCE), which are calculated as follows: VAIC = HCE + SCE + CEE, HCE = VA/HC, SCE = SC/VA, and RCE = VA/RC. HC, SC, and RC are the factor inputs of human capital, structural capital, and relationship capital, respectively, and SC = VA − HC.

Following the current practice in the disclosure of financial information by listed companies in China and existing research, this paper calculates VA as net profit + income tax + sales tax and surcharge + sales expenses + salaries payable. Investment in HC is represented by salaries payable, and the investment in RC is represented by sales expenses.

3.2.5. Control Variables. We construct control variables based on existing literatures [7, 17], including company financial indicators, corporate governance structure indicators, and other company characteristics. Table 2 lists the definition and measurement for each variable.

3.3. Empirical Models. Because our measure of patent applications is a discrete variable, following prior studies, we constructed Poisson regression models to test our hypotheses [67].

Table 2: Descriptive analysis of controlling variables.

Variable	Variable definition	Variable measurement
Lnasset	Company size	Logarithm of total assets in IPO year
Roa	Profitability	IPO year net profit/total assets
Tobinsq	Company value	Tobin's Q in IPO year
Indepnum	Percentage of independent directors	Percentage of independent directors on the board of directors in the IPO year
Synnum	Number of syndicate members	Number of VCS members
Grants	Cumulative number of patents at the time of investment	Cumulative number of patents at the time of investment
Stage	Investment stage	Investment stage
Ownnum	Number of shares held by senior management	Number of shares held by senior management in the IPO year
Mancost	Management fees	Management fees in IPO year

3.3.1. Model for H1. The following model is constructed to test H1:

$$E(\text{innovation}|X) = \exp\left[\beta_1 x_{i,t} + \sum \beta_i \text{Control}_{i,t} + \lambda_{\text{ind}} + \varepsilon_{\text{province}} + \eta_{\text{year}}\right]. \quad (4)$$

In model (4), innovation is IP. x_i refers to KHS. Control denotes the control variables. We also control for a series of fixed effects, including industry (λ_{ind}), province ($\varepsilon_{\text{province}}$), and year ($\eta_{\text{year}}$) fixed effects.

3.3.2. Model for H2. The following model is constructed to test H2:

$$E(IC|X) = \exp\left[\beta_1 x_{i,t} + \sum \beta_i \text{Control}_{i,t} + \lambda_{\text{ind}} + \varepsilon_{\text{province}} + \eta_{\text{year}}\right]. \quad (5)$$

In model (5), IC indicates the intellectual capital variable. The other variables are as described for model 1.

3.3.3. Model for H3. The following model is constructed to test H3:

$$E(\text{innovation}|X) = \exp\left[\beta_1 IC_{i,t} + \sum \beta_i \text{Control}_{i,t} + \lambda_{\text{ind}} + \varepsilon_{\text{province}} + \eta_{\text{year}}\right]. \quad (6)$$

In model (6), innovation is IP. IC_i indicates the intellectual capital variable. The other variables are as described for model 1.

3.3.4. Model for H4. Baron and Kenny argue that a variable functions as a mediator when it meets the following conditions: (a) variations in levels of the independent variable significantly account for variations in the presumed mediator (path a); (b) variations in the mediator significantly account for variations in the dependent variable (path b); and (c) when paths a and b are controlled, a previously significant relation between the independent and dependent variables is no longer significant, with the strongest demonstration of mediation occurring when path c is zero [58]. Based on models 1 and 2, we construct model 4:

$$E(\text{innovation}|X) = \exp\left[\beta_1 x_{i,t} + \beta_2 IC_{i,t} + \sum \beta_i \text{Control}_{i,t} + \lambda_{\text{ind}} + \varepsilon_{\text{province}} + \eta_{\text{year}}\right]. \quad (7)$$

In model (7), innovation is IP. x_i refers to KHS. IC_i indicates the intellectual capital variable. The other variables are as described for model 1.

3.3.5. Model for H5 and H6. The following model is constructed:

$$E(\text{innovation}(IC)|X) = \exp\left[\begin{array}{c}\beta_1 x_{i,t} + \beta_2 ES_{i,t} + \beta_3 x_{i,t} * ES_{i,t} \\ + \sum \beta \text{Control}_{i,t} + \lambda_{\text{ind}} + \varepsilon_{\text{province}} + \eta_{\text{year}}\end{array}\right]. \quad (8)$$

In model (8), $\text{ES}_{i,\,t}$ denotes the equity structure variable. The other variables are as described for model 4.

4. Results

4.1. Descriptive Statistics. Descriptive statistics are provided in Table 3. We note that (1) the mean value of the dependent variable patapply is smaller than its standard deviation, indicating that the innovation performance levels of entrepreneurial firms vary widely; (2) the mean value of the independent variable TKH is greater than its standard deviation, indicating that VCS has a similar degree of KHS; and (3) the mean values of the control variables synnum and stage show that the formation of VC syndicates mostly occurs during entrepreneurial firms' expansion or maturity stages and typically contains two or three VC investors.

4.2. Correlation Analysis. Table 4 shows the correlation matrix for the main variables. We note the following: (1) there is a significant positive correlation between KHS and patapply; (2) there is a significant positive correlation between VAIC and KHS. The results of the correlation coefficient test between the variables show that regression analysis could be performed.

Table 3: Descriptive analysis of variables.

Type	Variable	Mean	Std. dev.	Min	Max
Dependent	Patapply	50.053	85.065	0	640
	RDI	4508.6	7979.2	0	10470.9
Independent	KHS	0.757	0.454	0	1.935
	MKH	1.113	0.523	0	2.236
	IKH	0.352	0.322	0	1.196
	TKH	0.612	0.764	0	2.236
Mediator	VAIC	105.942	568.306	6.144	6715.26
Moderator	Equity structure	0.525	0.324	0	1.371
Control	Lnasset	9.023	0.266	8.465	10.461
	Roa	0.061	0.031	-0.006	.187
	Tobinsq	1.886	0.791	1.054	8.069
	Indepnum	0.365	0.046	0.2	0.6
	Synnum	2.485	0.75	2	6
	Grants	12.894	30.235	0	373
	Stage	3.281	0.696	1	4
	Ownnum	30.929	53.602	0	583.697
	Mancost	48.312	43.297	4.634	374.216

Table 4: Correlation matrix for main study variables.

	Patapply	MKH	IKH	TKH	KHS	ES	VAIC
Patapply	1.000						
MKH	−0.028	1.000					
IKH	−0.065*	−0.219***	1.000				
TKH	0.012	0.188***	0.174***	1.000			
KHS	0.003*	0.382***	0.315***	0.950***	1.000		
ES	−0.000	0.148***	−0.079*	0.095*	0.114***	1.000	
VAIC	0.013*	−0.017	0.033	0.056*	0.056*	−0.008	1.000

* $p < 0.01$,** $p < 0.05$,*** $p < 0.01$.

Table 5: Relationship between KHS, IC, and IP of entrepreneurial firms.

Main	(1) Patapply	(2) Patapply	(3) Patapply	(4) Patapply	(5) VAIC	(6) Patapply	(7) Patapply
KHS	0.052*** (0.0171)				0.021* (0.012)		0.052*** (0.017)
MKH		0.027* (0.014)					
IKH			−0.029 (0.024)				
TKH				0.034*** (0.010)			
VAIC						0.000*** (0.000)	0.000*** (0.000)
_Cons	−0.936** (0.403)	−0.982** (0.403)	−0.929** (0.405)	−0.889** (0.404)	−8.537*** (0.224)	−0.919** (0.403)	−0.874** (0.404)
Controls	Y	Y	Y	Y	Y	Y	Y
Industry	Y	Y	Y	Y	Y	Y	Y
Province	Y	Y	Y	Y	Y	Y	Y
Year	Y	Y	Y	Y	Y	Y	Y
N	397	397	397	397	397	397	397
R^2	0.225	0.225	0.225	0.225	0.412	0.225	0.226

Standard errors are reported in parentheses * $p < 0.01$,** $p < 0.05$,*** $p < 0.01$.

4.3. Empirical Analysis of Results

4.3.1. Relationship between KHS, IC, and IP of Entrepreneurial Firms. The regression reported in column 1 of Table 5 yields a coefficient on KHS of 0.052, significant at the 1% level (see the supplementary materials (available here) for a comprehensive analysis of results), suggesting that KHS has a positive effect on the IP of entrepreneurial firms, supporting H1. Columns 2 to 4 examine the impact of MKH, IKH, and TKH, respectively, on the IP of entrepreneurial firms. The results indicate that MKH and TKH directly promote the IP of entrepreneurial firms, whereas the coefficient estimate for IKH is not statistically significant. The regression coefficient on KHS in column 5 of Table 5 is 0.021, significant at the 10% level, suggesting that KHS promotes IC of entrepreneurial firms, supporting H2. The regression

coefficient of VAIC in column 6 of Table 5 is 0.000, significant at the 1% level, suggesting that VAIC can promote the IP of entrepreneurial firms, supporting H3. The relationship between the IP of entrepreneurial firms and KHS and VAIC is tested in column 7 of Table 5, and the coefficient estimates on KHS and VAIC are positive and significant. According to the findings in columns 1, 5, and 7 of Table 5 and the classic mediation analysis of Baron and Kenny, IC partially mediates the relationship between KHS and IP of entrepreneurial firms, supporting H4.

4.3.2. Moderating Effect of Equity Structure. The moderating effect of the equity structure is confirmed by the results in Table 6. As reported in column 1 of Table 6, the regression coefficient of the interaction between KHS and ES is 0.431, significant at the 1% level, indicating that equity concentration positively moderates the relationship between KHS and IP of entrepreneurial firms. This finding contradicts hypothesis H5. Based on Bayar's research, we believe that VC investors with more equity are more likely to be generalists with some degree of expertise in multiple areas of value addition [15]. A higher equity concentration facilitates full participation and knowledge transfer from the lead investor. Concurrently, we further examined the moderating impact of ES on the relationships between the IP of entrepreneurial firms and MKH, IKH, and TKH (columns 2–4 of Table 6). As reported in column 2 (4) of Table 6, the regression coefficient of the interaction between MHS (TKS) and ES is 0.350 (0.152) (both significant at the 1% level), implying that equity concentration positively moderates the relationship between MHS (TKS) and IP of entrepreneurial firms. In column 5 of Table 6, the regression coefficient on the interaction between KHS and ES is −1.492, significant at the 1% level, indicating that equity concentration negatively moderates the relationship between KHS and IC of entrepreneurial firms, supporting H6. To rule out potential multicollinearity in interaction items, we have performed variance inflation factor (VIF) testing. The average value of VIF for all models is less than 5 (the mean VIF for column 5 is 2.06), which indicates there is no multicollinearity.

4.4. Robustness Check

4.4.1. Replacing the Dependent Variable. To test our main model's robustness, we use entrepreneurial firms' R&D input as an alternative measure of IP (columns 1–3 of Table 7). The regression coefficients are positive and significant, indicating that our main results are robust.

4.4.2. Heckman Two-Stage Method for Correction. Although this paper empirically examines the effect of KHS on IP in entrepreneurial firms, our findings may be affected by endogeneity. In particular, VC syndicates with higher KHS may have better screening capabilities and be better able to identify firms with high innovation potential in which to invest. We use Heckman's two-stage method to correct for possible endogeneity. The sample was first divided into observations with KHS above or below the median. The subsample above the median was identified as having high knowledge heterogeneity (H-KHS = 1), and the subsample below the median was identified as having low knowledge heterogeneity (H-KHS = 0). This dummy variable for knowledge heterogeneity is the dependent variable in column 4 of Table 7. The inverse Mills ratio (IMR) is calculated using a probit model including control variables. It is then brought into the original regression equation for the second stage of estimation. The IMR describes the selection effect whereby VC syndicates with a high KHS may choose firms with good innovation potential for investment. The regression results are shown in column 5 in Table 7. Although the IMR value is statistically significant in the second stage, the regression coefficient on KHS remains positive and significant at the 1% level, indicating that our main results are not attributable to the "screening" effect of VC syndicates. Our main conclusions are therefore supported.

5. Discussion

5.1. Theoretical Discussion. Differing from previous studies that take a resource-based approach, our study provides a new knowledge-based explanatory perspective for understanding the relationship between VCS and IP of entrepreneurial firms. Using the knowledge transfer perspective, we document that KHS can directly enhance the IP of entrepreneurial firms or indirectly promote the IP of entrepreneurial firms by enhancing the IC of entrepreneurial firms. This paper confirms the "value addition hypothesis" of the impact of VCS on entrepreneurial firms rather than the "selection hypothesis" [12]. Further, our study responds to some extent to Du's research by comparing co-investing with similar and different partners and finding that VC firms may benefit more eventually from co-investing with different partners [8].

Second, we find that IC has a mediating effect on the relationship between KHS and IP of entrepreneurial firms, which enriches the literature related to IC. Lu et al. find that the IC of investee firms affects their IP [7], but there is little literature on how venture capital improves the IC of entrepreneurial firms. We extend Lu et al.'s study by identifying KHS as an essential external antecedent variable of IC, and we discover that IC mediates the relationship between KHS and IP of entrepreneurial firms. This finding supports De's research, which found that knowledge management in external knowledge can influence firms' IC [68].

Finally, our discussion of the equity structure variable for VCS may be the first in the literature. Although the background composition and number of VCS members significantly impact the IP of entrepreneurial firms [17], VCS has multiple parties with complex internal relationships. The importance of the size of venture capitalist shareholdings is highlighted by our research, which incorporates this variable into the VCS relationship. We find that equity concentration positively moderates the relationship between KHS and the IP of entrepreneurial firms and negatively moderates the relationship between KHS and IC. Therefore, further study

Table 6: Moderating Effect of equity structure.

Main	(1) Patapply	(2) Patapply	(3) Patapply	(4) Patapply	(5) VAIC
KHS	−0.118*** (0.038)				0.486*** (0.028)
KHS ∗ ES	0.431*** (0.060)				−1.492*** (0.044)
ES	−0.604*** (0.048)	−0.695*** (−11.396)	−0.557*** (−13.738)	−0.409*** (−12.030)	0.965*** (0.032)
MKH		−0.128*** (−4.533)			
MKH ∗ ES		0.350*** (7.189)			
IKH			−0.393*** (−7.600)		
IKH ∗ ES			0.708*** (8.694)		
TKH				−0.009 (−0.406)	
TKH ∗ ES				0.152*** (4.385)	
_Cons	−1.048** (0.435)	−1.124*** (0.433)	−1.124** (0.438)	−1.090** (0.434)	−11.270*** (0.299)
Controls	Y	Y	Y	Y	Y
Industry	Y	Y	Y	Y	Y
Province	Y	Y	Y	Y	Y
Year	Y	Y	Y	Y	Y
N	348	348	348	348	348
R^2	0.223	0.222	0.223	0.222	0.530

Standard errors are reported in parentheses $^{*}p < 0.01, ^{**}p < 0.05, ^{***}p < 0.01$.

Table 7: Robustness check results.

Main	(1) RDI	(2) RDI	(3) RDI	(4) H-KHS	(5) Patapply
KHS	0.108*** (0.000)		0.123*** (0.000)		0.200*** (0.030)
VAIC		0.000*** (1.06e − 08)	0.000*** (1.06e − 08)		
IMR					−0.101*** (0.017)
Debt				−0.362 (0.581)	
Lfirmage				−0.124 (0.382)	
Lnasset	−0.004*** (0.000)	0.020*** (0.000)	−0.014*** (0.000)	0.245 (0.300)	0.467*** (0.034)
Roa	−1.034*** (0.000)	−1.176*** (0.000)	−1.041*** (0.000)	−1.527 (2.502)	−0.749*** (0.268)
Tobinsq	0.091*** (0.000)	0.097*** (0.000)	0.087*** (0.000)		0.043*** (0.015)
Indepnum	−2.247*** (0.000)	−2.222*** (0.000)	−2.304*** (0.000)		−1.866*** (0.178)
Synnum	0.011*** (0.000)	−0.012*** (0.000)	−0.003*** (0.000)		0.049*** (0.010)
Grants	−0.002*** (0.000)	−0.002*** (0.000)	−0.002*** (0.000)	0.000 (0.002)	0.000 (0.000)
Stage	0.301*** (0.000)	0.288*** (0.000)	0.291*** (0.000)		0.0563*** (0.012)
Ownnum	−0.001*** (0.000)	−0.001*** (0.000)	−0.001*** (0.000)		0.004*** (0.000)
Mancost	0.007*** (0.000)	0.007*** (0.000)	0.007*** (0.000)		0.005*** (0.000)
_Cons	17.011*** (0.000)	16.942*** (0.000)	17.206*** (0.000)	−1.624 (2.751)	−0.940** (0.404)
N	396	396	396	392	391
R^2	0.396	0.398	0.400	0.035	0.223

Standard errors are reported in parentheses $^{*}p < 0.01, ^{**}p < 0.05, ^{***}p < 0.01$.

of this variable may open up new possibilities for unlocking the "black box" of the relationships between VCS and entrepreneurial firms.

5.2. Managerial Suggestions. First, managers should consider the KHS of VC syndicates. VC syndicates should consider the differences in knowledge when co-investing in a project and select VC partners with diverse knowledge for syndication. In the post-investment management process, VC syndicates should recognize the differences in their respective knowledge bases and fully participate in the operation and management of the entrepreneurial firms to actively transfer their knowledge to the entrepreneurial firms and so improve their IC. Specifically, VC syndicates should focus on the direct impact of their MKH and TKH on the IP of entrepreneurial firms and improve their IP by optimizing their innovation management processes and giving technological guidance. VC syndicates should also recognize the relationship between IKH and IP and should reduce their interventions in firms' speed of innovation to meet capital market demand. Alongside this, VC syndicates should allocate equity relatively evenly to avoid the lead investor's "dominance" affecting the degree of participation of other VC investors. Lead VCs should also incentivize followers accordingly and seek to avoid free riding behavior that may be caused by an uneven distribution of equity.

Second, as IC contributes increasing amounts to enterprise value, the management process of IC value addition will become a very important element of modern enterprise management. Using VCS to increase IC and effectively managing IC are shortcuts to realizing enterprise value creation. Entrepreneurial firms should interact with VC syndicates based on the characteristics of their development and receive and absorb knowledge to improve their own IC and, as a result, improve their innovation performance. When the equity concentration is high, entrepreneurial firms should interact with the lead investor and increase the frequency of communication with other VC firms, as this is the only way to fully absorb heterogeneous knowledge. In conclusion, entrepreneurial firms often lack experience in innovation management and the experience of technological achievement and transformation. Heterogeneous knowledge from VC syndicates helps to fill the knowledge gap in innovation management and enhances innovation performance.

6. Conclusion

This paper explores the impact mechanism of VCS on the IP of entrepreneurial firms, based on a knowledge transfer perspective. It further investigates the impact of the ES of VCS on the above knowledge transfer path. We find that KHS positively affects the IP of entrepreneurial firms and that the equity concentration of VCS positively moderates this relationship. In particular, MKH and TKH positively affect the IP of entrepreneurial firms. We further find that the IC of entrepreneurial firms mediates the positive relationship between KHS and IP of entrepreneurial firms, and the equity concentration of VCS negatively moderates the relationship between KHS and IC.

However, this paper also has some limitations. First, the definition of VCS used in this paper is relatively narrow, which limits the scope of data collection and the number of entrepreneurial firms in our sample that fulfill the study's criteria. The definition of VCS should be further discussed in future studies to improve the consistency of results. Second, besides IC, other influence paths between KHS and IP of entrepreneurial firms can be discussed, such as trust or geographical distance factors, which can be included in future studies.

Appendix

This paper covers a wider range of literature, including VCS, intellectual capital, and knowledge transfer theory in order to have a comprehensive understanding for the reader. As shown in Table S1, we summarize the literature.

Data Availability

The data sets used for this empirical study are available in https://www.pedata.cn/, https://www.gtarsc.com/, and https://www.innojoy.com/search/index.html.

Conflicts of Interest

The authors declare that they have no conflicts of interest regarding the publication of the paper.

Supplementary Materials

Supplementary material is provided to explain the comprehensive results and demonstrate repeatability. Table S1: the summary of theoretical background. (*Supplementary Materials*)

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