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# The effect of intellectual capital and venture capital on enterprise values: evidence from China

Pang Paul Wang
*Faculty of Business, School of Accounting and Finance, The Hong Kong Polytechnic University, Kowloon, Hong Kong*
Ruolin Zhang
*School of Accountancy, The Chinese University of Hong Kong, Hong Kong, China, and*
Qilin Zhang
*Faculty of Business, School of Accounting and Finance, The Hong Kong Polytechnic University, Kowloon, Hong Kong*

## Abstract

**Purpose** – Intellectual capital (IC) and venture capital (VC) play an important role in enterprise development. While the literature has investigated the relationship between IC and the profitability of companies, the relationship among IC, VC and enterprise value (EV) is still not well understood.

**Design/methodology/approach** – Drawing insights from the literature, we develop a few testable hypotheses about the relationships among IC, VC and EV. Using the panel data of companies listed in the Chinese stock market from 2009 to 2019, we employ fixed-effects regression models to test these hypotheses.

**Findings** – We find that IC has a significant positive effect on long-term EV. VC is found to have a positive direct effect on long-term EV but has a negative direct effect when its moderating effect with IC is considered. To explain this finding, we develop a simple economic model and provide an over-investment perspective.

**Originality/value** – We believe this paper can shed light on pro-venture investment policies in China, as well as provide indications for similar policies around the world.

**Keywords** Venture capital, Intellectual capital, Enterprise value, Moderating effect, Over-investment

**Paper type** Research paper

## 1. Introduction

Theorists, practitioners and policy makers nowadays generally believe that intellectual capital (IC) and venture capital (VC) are important to enterprise development. For instance, in 2014, the Chinese government put forward an important policy called "Mass Entrepreneurship and Innovation", under which the government provides subsidies and a platform to help startup companies gain resources and communicate between companies. Since then, VC and IC have played an increasing role in Chinese enterprises, with estimated enterprise values (EV) of the companies on average increasing by 43.8% from 2009 to 2019 (See Figure 1 and Section 4.1). Literature has mentioned the relationship between IC and the profitability of companies. However, the relationship among the IC, VC and EV of the

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**Figure 1.**
Estimated enterprise value, 2009–2019

companies is still not well understood. Particularly, it remains unclear how VC will interact with the IC of an enterprise and influence the value creation of the enterprise.

To answer these questions, we conducted an empirical analysis using panel data of companies listed in the Chinese stock market from 2009 to 2019. The key variables in the analysis are IC, VC and EV. Drawing insights from the existing literature, we measure EV by the fair value of total assets. We treat IC as a combination of capital in three dimensions: human capital, structural capital and relational capital. VC is captured by a binary indicator showing whether the top ten shareholders during the initial public offering (referred to as "IPO") include VC institutions.

Our analysis shows that both IC and VC have a significant positive effect on long-term EV. VC serves as a moderator that increases the effect of IC on EV. However, when examining VC's moderating effect, we observe that VC's direct effect on EV becomes significantly negative. This observation raises a new question about the conventional point of view that VC enhances rather than weakens the relationship between IV and EV. To provide an explanation, we construct a simple economic model in which innovative enterprises carry out research and development (R&D) activities in the early start-up period and then sell their products in the follow-up commercialization period. The enterprise may receive too much VC, causing a surplus of investment. We name this as "over-investment" (Grompers & Lerner, 2001). Although an affluent amount of VC is likely to improve R&D quality, it may also end up with a longer R&D period, thereby delaying the commercialization period in which revenues and profits are generated. We show that the overall effect can be negative when an R&D enterprise is over-invested.

Our paper makes the following contributions. First, our paper explores the impact on the EV when the IC interacts with VC and other factors in different time periods, thereby offering a new perspective on studying IC. Most of the previous literature has just explored the influence of IC on financial performance and market performance measured by financial ratios (Shaban & Vijayasundaram, 2013; Chen, Cheng, & Hwang, 2005; Ghosh & Mondal, 2009; Garcia Castro, Duque Ramírez, & Moscoso-Escobar, 2021; Olarewaju & Msomi, 2021).

Another contribution of this paper is to propose an alternative view of VC. In most of the previous research, VC has shown a positive impact on EV, value retention and value creation (Song & Kutsuna, 2023; Guo, Wei, Sharma, & Rong, 2017; Michelfelder, Kant, Gonzalez, & Jay, 2022). However, our paper discusses the possible negative influence of VC on EV when interacting with IC under certain circumstances. We provide an alternative view of how to develop IC and manage the resources efficiently from investment. This provides insights to VC institutions that the investments during inappropriate times may lead to a negative impact on EV.

The remaining sections of this paper are organized as follows. Section 2 reviews the related literature. Section 3 discusses the hypothesis development. Section 4 discusses the empirical results. Section 5 presents a tractable theoretical model to explain the role of VC. Section 6 summarizes the paper.

## 2. Literature review

### *2.1 Intellectual capital*

The concept of IC was first put forward by William and Whately (1965). He believes that IC is the sum of knowledge and skills owned by everyone in the enterprise that can create wealth for the enterprise. Thereafter, Stewart (1997) extended the concept of IC to "collecting knowledge, information, spiritual property and everyone's experience in business entities". Zeghal and Maaloul (2010) defined IC as the sum of the entire firm's knowledge that can be used to conduct business and create value. Recently, Nagwan *et al.* (2022) summarized IC as the key role for business sustainability, which is also an important intangible asset for enterprises. Madhavaram, Appan, Manis, and Browne (2022) viewed IC as organizational capital, which can improve the capabilities for a software development firm's competitiveness. However, there has not been a consensus about the components of IC across different papers. IC is composed of one or several resources and covers several types of capital. First, Edvinsson (1997) believed that IC includes human capital and structural capital. Later on, Pulic (2008) put forward a measurement system called the "Value-Added Intellectual Coefficient (VAIC)" system and measures IC in terms of Human Capital Efficiency, Structural Capital Efficiency and Capital Employed Efficiency. After Pulic (2008), many scholars have measured IC in different components. The most popular theory is that most scholars believe that IC consists of three basic components: human capital, structural capital and relational capital (Ruta, 2009; Nagwan *et al.*, 2022; Stewart, 1997). In recent years, more kinds of three-component classification of IC have been put forward to measure different kinds of companies. For example, Cheng, Hsu, Li, and Brading (2022) divide IC into Human Capital, Technology Capital and Political Capital. Based on Madhavaram *et al.* (2022), IC is divided into three parts: customer knowledge acquisition, knowledge exchange and knowledge integration.

In addition, many methods for IC evaluation have been proposed in the literature. These include the above-mentioned VAIC (Shaban & Vijayasundaram, 2013), balanced scorecard (Kaplan & Norton, 2007), MTB ratio (Stewart, 1997) and Skandia Navigator (Edvinsson, 1997). Some scholars (Chen *et al.*, 2005; Shaban & Vijayasundaram, 2013) consider that VAIC is a better method to measure IC, given that VAIC is an easy and simple method to study different dimensions of IC efficiency. Recently, Olarewaju and Msomi (2021) designed an integrated index for estimating the cost of intelligent capital of an organization in order to prove that IC improves the innovation ability and productivity of transport in Russia. Among these methods, VAIC has been the most popular method and adopted in many research studies to measure the IC.

After considering the definitions and measurements of IC, we adopt the most traditional way, which divides IC into three dimensions: human capital, structural capital and relational capital, and calculates the VAIC to measure the IC. In this way, the measurement of IC should be the most representative value for commonly listed companies.

### *2.2 Venture capital*

At present, VC is a very common investment form, which can provide financing, technological expertise and managerial experience to startups. VCs are crucial to startups and are a key driver for economic growth (Banal-Esta~nol *et al.*, 2023). In the past few years, VC has become a main external resource for companies to have equity financing and business innovation (Shuwaikh & Dubocage, 2022). Therefore, many scholars have put forward the idea that VCs have a positive impact on companies. To be more specific, VC can improve the profitability of the companies (Gao, Shen, Gao, & Chan, 2019) and the market performance of the companies (Feng, Chan, & Lo, 2020). Li, Xu, Fung, and Chan (2021) found that VC is positively related to the corporate social responsibility activities and that the corporate social responsibility activities amplify the VC's influence on the firm's financial situation.

Later on, the performance and the influence of VC on the company were explored. Chemmanur, Loutskina, and Tian (2012) classify VC into two kinds, which are corporate venture capital (CVC) and independent venture capital (IVC). CVC seeks to maximize financial returns but IVC stays with the company by taking the minority equity when IPO. The paper of Shuwaikh and Dubocage (2022) has proved that CVC-backed companies have more innovation outputs than their IVC-backed counterparts in terms of the number of patents, which shows that the mechanism is that the investors' complementary resources have a great influence on the innovation of the company. Besides, the performance of VC may be affected by different factors. Wang, Wareewanich, and Chankoson (2023) built a model to test that information acquisition and different VC executives have different impacts on the performance of the VCs with the mediating effect of VC strategies. Specifically, human capital and many other factors have a positive impact on performance. Also, there is a significant U-shaped relationship between knowledge diversification and performance of the VC. Therefore, the performance and the effect of VC are worth considering. In this paper, we check whether there are VC institutions as shareholders during an IPO (Chu, Li, Li, & Ji, 2021). We also explore the impact of VC on EV with the effect of IC, which can provide a new perspective on the relationship between IC, VC and EV.

### *2.3 Enterprise value*

The concept of EV was first put forward by Fisher (1912), which is the summation of the capital and income. Arifatul, Islam, and van Zijl (2016) divided EV into market performance and financial performance, which shows that the EV should be measured in these two aspects. Later on, Yang, Chou, and Yang (2019) concluded that the EV should be evaluated by different factors including fair market value, investment value, intrinsic value, going-concern value, liquidation value and book value. Also, Yang *et al.* (2019) summarized the evaluation models and ratios that are widely used in different research methods, such as the asset value method, book value method, net asset value method, replacement value method, Tobin's Q ratio and dividend discounted model.

Based on Yang *et al.* (2019) and many other literature, we adopt the fair market value method to evaluate the EV. We use the fair value of the equity and liability to represent the EV. This is because the IC and VC may affect both the equities and liabilities part of the companies and improving the IC improves the intrinsic value of the companies. Therefore, our goal is to explore whether improving this intrinsic value will be reflected in the fair value and whether this VC will stimulate this process. Also, Mothlagh, Samadi, and Hajiha (2016) proved that the market value of the total asset is significantly positively correlated with the future abnormal return, which represents the future profitability of the companies. This is consistent with the nature of the IC that improves the future growth of the companies. In this way, the fair value of the equity and liability should be the most suitable indicator for us to evaluate the EV.

### *2.4 Resource-based view*

The resource-based view was first put forward by Wernerfelt (1984), which is based on economic thought. This theory takes enterprises as the observation object. It divides the companies into basic components and looks at the various resources owned by enterprises to find out the power source that can enhance the competitiveness of enterprises. All enterprises are composed of various resources, which transform and interact with other factors to produce a strong integration effect and ultimately form the ability to create value. Therefore, it puts forward that an enterprise that owns or controls unique resources for a long time has stronger competitiveness. Later, the resource-based view almost remains unchanged. For example, Bergen and Peteraf (2002) claimed that different resources among enterprises can create value for enterprises, which is the key to enterprise success. Van Alstyne and Parker (2017) believed that various resources owned by enterprises will form the unique competitiveness and core advantages of enterprises, which can enhance the market competitiveness of enterprises.

## 3. Hypothesis development

In this section, we shall develop our two hypotheses.

### *3.1 IC, VC and EV*

The relationship between IC and EV is still a very popular topic. Most research uses the financial performance ratios and the market performance ratios to explore the relationship among IC, financial performance and market performance. Also, many researchers turn to test whether the IC can improve the long-term growth ability and intrinsic value (Nagwan *et al.*, 2022; Olarewaju & Msomi, 2021).

Based on the resource-based view, we can conclude that resources, especially unique resources, are the internal driving forces for enterprises to obtain competitive advantage and can also help enterprises improve their value and growth. As we have mentioned, IC is an intangible asset and represents companies' internal resources. It also proposes the concept of the IC to coordinate and utilize the human, structural and relational capital of the enterprises. IC for each company is unique and hard to duplicate, so IC can form the differentiation characteristics of enterprises, which helps the companies develop competitive advantages. IC is a unique intangible asset for companies to develop in the future, which can develop competitive advantages and increase the EV in the long term. Therefore, the theories about IC and resource-based view are consistent with each other.

In addition, VC can not only provide more resources for companies to develop IC but also help companies coordinate and fully make use of different kinds of resources to enhance IC. Shuwaikh and Dubocage (2022) pointed out that VC investment can not only provide complementary resources for the companies but also facilitate the transfer of essential resources, knowledge and important personnel in the companies. This is also consistent with the resource-based view. VC is positively related to the financial performance (Yang, Xia, & Wen, 2016) and the market performance of the companies (Feng *et al.*, 2020).

Therefore, we propose:

*H1a.* Value-added IC has significantly positive associations with the EV of listed companies in China.

*H1b.* VC has significantly positive associations with the EV of listed companies in China.

### *3.2 Moderating effects of VC*

VC today is a very common investment strategy. In most of the literature, VC is regarded as an efficient moderator in the market to moderate the relationship between the companies and the market. Chu *et al.* (2021) analyzed that VC can strengthen the relationship between the uncertainty level and the innovation level. Also, this paper says that VC can moderate the incentive effect of management shareholdings on innovation, which can also promote innovation ability by mediating the mechanism of research and development investment. In addition, the participation of VC can avoid the board from IPO underpricing (Wang, Wang, Cebula, & Foley, 2023) and also plays a moderating role in enhancing the relationship between the business model and its value retention (Guo *et al.*, 2017). Song and Kutsuna (2023) put forward that companies with the support of VCs have higher EV than companies without VCs. Also, the involvement of VC could mitigate the negative impact of institutional factors on the companies' EV such as the uncertainty of the policy, financial market condition and technology activities. This influence is especially pronounced for non-state-owned companies, companies with poor corporate governance, and companies with higher research and development investment. These results show that VCs can not only improve the companies' external performance but also can optimize the internal operation process.

Based on the previous literature, it can be inferred that VC can bring more resources for the companies to develop the ICs, stimulate the growth of the business enterprises, accelerate the innovation of enterprises and improve enterprise innovation output. In this way, the innovation ability of enterprises and the competitive strength of enterprises in the market can be enhanced, and the market position of enterprises can be improved to promote the value creation of enterprises (Michelfelder *et al.*, 2022). In general, VC can satisfy the resources required by enterprises in innovation activities and enhance the IC of enterprises by providing a series of value-added services, so as to enhance the entrepreneurial enterprises. Thus, the following hypothesis is proposed:

*H2*. The effect of IC on the EV of listed companies in China is stronger with VC than without VC.

## 4. Empirical analysis

### *4.1 Data sources and description*

We use data from the WIND database to calculate the IC and the EV of the companies. We chose the range of 2009 to 2019, which is after the financial crisis in 2008 and before the COVID-19 pandemic. We also depicted the variations of EV over the time period in Figure 1, which exhibited a maximum around 2015. For each company on the Beijing Stock Exchange (BSE), Shanghai Stock Exchange (SHSE) and Shenzhen Stock Exchange (SZSW), we collected annual financial data including R&D expenditures, total equity, total liabilities, net profit, income tax, wages and salaries, and the names of the top ten shareholders. Then, we filter for companies with data from all years. We further exclude special treatment shares of abnormal enterprises such as ST stocks and *ST stocks. The resulting set is 17393 listed companies. Using this collected information, we now explain how to calculate our key variables, with key descriptions in Table 1. The summary statistics are also provided in Table 1.

*4.1.1 Independent variable.* The main independent variable is VAIC. After considering the relevant literature, we intend to divide VAIC into three dimensions: human capital, structural capital and relational capital. Given the disclosure of financial statements of listed enterprises in China and the available data of the database, this paper uses the method described by Cao, Chen, and Li (2010) to calculate the three dimensions of IC.

$$\begin{aligned} \text{VA} &= \text{Output} - \text{Input} && (1)\\ &= \text{Net profit} + \text{Income tax} + \text{Wages and salaries} && (2) \end{aligned}$$

where *VA* represents the total value added, initially put forward by Pulic (2008). Since Pulic (2008), many calculation methods for the value-added have been put forward. We follow the method proposed based on Cao *et al.* (2010) to calculate the value-added in Equation (2).

Table 1.
Variable calculation method and summary statistics

| Variables | Definitions | Calculation method | Type | Mean | Std. Dev. | Min. | Max. |
|---|---|---|---|---|---|---|---|
| $VAIC_{i,t}$ | Human Capital Efficiency Structural Capital Efficiency Relational Capital Efficiency | Cube root of Equation (3) results | Independent | 2.164 | 1.565 | −35.624 | 46.431 |
| $VC_i$ | The indicator is one if a company has one or more VC institutions as its top ten shareholders during IPO. | Indicator that VC is in top ten shareholders during IPO | Moderate | 0.137 | 0.345 | 0 | 1 |
| $EV_{i,t}$ | The total fair value of the equity and the liability | Natural log of EV and total debt | Dependent | 22.668 | 1.234 | 13.995 | 28.035 |
| $DEBT_{i,t}$ | Debt Ratio | Total Liabilities/Total Assets | Control | 44.744 | 20.722 | 0.708 | 154.536 |
| $SIZE_{i,t}$ | The size of the company | Natural log of Total Assets | Control | 22.205 | 1.293 | 17.879 | 28.341 |

**Source(s):** Table created by the authors

According to Ruta (2009), VAIC consists of Relational Capital Efficiency, Structural Capital Efficiency and Human Capital Efficiency, which we calculate as follows:

$$\text{VAIC} = \text{HCE} + \text{SCE} + \text{RCE} \tag{3}$$
$$\text{HCE (Human Capital Efficiency)} = \text{VA/HC}$$
$$\text{SCE (Structural Capital Efficiency)} = \text{VA/SC}$$
$$\text{RCE (Relational Capital Efficiency)} = \text{VA/RC}$$

where HC represents the amount of human capital investment of enterprises. Considering the availability, reliability and accuracy of public information, we use the cash paid to occupations and employees in the cash flow statement as the proxy variable of HC. SC represents the amount of structural capital investment of the enterprise. We chose the management expense in the income statement as the proxy variable. RC represents the amount of relational capital investment of an enterprise, which can be expressed as the process of value creation to promote the sales of products and services. The sales cost in the income statement is taken as the proxy variable. Moreover, the larger the value of each index, the higher the value-added effect of the corresponding type of capital and vice versa. After calculating the VAIC, we applied the cube root transformation to reduce skewness. We chose this transformation because it preserved the order of the values and considered the sign of VAIC, which can be positive and negative.

*4.1.2 Dependent variable.* The main dependent variable is EV. Combining the results of Arifatul *et al.* (2016), we decided to measure the EV based on the financial performance and market performance. The EV for our study includes the total fair value of the equity and the liability. Not only does this variable reflect the market performance of the companies but also the financial performance of the enterprises because the financial performance of the company can influence the market performance to some degree. We apply the natural logarithm to this variable to reduce skewness.

*4.1.3 Moderating variable.* The moderating variable is VC. We use an indicator variable to indicate whether the company has a VC investment. Following Chu *et al.* (2021) and Amini, Mohamed, Schwienbacher, and Wilson (2022), the indicator is one if a company has one or more VC institutions as its top ten shareholders during IPO. VC institutions are identified by searching for keywords used in Chu *et al.* (2021), such as "venture capital investment", "venture capital", "venture capital fund", "venture capital investment fund", "high and new investment", "innovation investment" and "financial innovation investment". The shareholders with no matching words but with venture investment as their main business are also defined as VC investment institutions.

*4.1.4 Control variables.* The control variables are enterprise capital structure and the size of the company in a specific year. The debt ratio, calculated as the company's total liabilities over total assets at the year end, may affect the financial performance of the company. The size of the company is measured by the natural logarithm of the total assets at the end of the year. These factors will affect both the IC and the EV (Belkaoui, 2003). Therefore, we control for these ratios to ensure that our results are more accurate.

### *4.2 Empirical model*

This paper uses a fixed-effects model on a panel dataset, along with a moderating effect analysis method to test the hypotheses in Section 3.

The model to test Hypothesis 1 can be constructed as follows:

$$EV_{i,t} = \beta_0 + \beta_{VC} VC_i + \beta_X X_{i,t} + \alpha_t + \gamma_i + \varepsilon_{i,t} \tag{4}$$

$$EV_{i,t} = \beta_0 + \beta_{IC} VAIC_{i,t} + \beta_{VC} VC_i + \beta_X X_{i,t} + \alpha_t + \gamma_i + \varepsilon_{i,t} \tag{5}$$

where $EV_{i,t}$ is the EV for each company $i$ and time $t$, where $t \in \{2009, 2010, \ldots, 2019\}$. $VAIC_{i,t}$ is the value of the VAIC for each company $i$ and year $t$. $X_{i,t}$ contains the control variables $DEBT_{i,t}$ and $SIZE_{i,t}$, which represent the debt ratio and size for each listed company $i$ and time $t$, respectively. $VC_i$ is the VC indicator. $\alpha_t$ and $\gamma_i$ represent the time and company fixed effects, respectively. $\beta_0$ is the constant term of the model. $\beta_j$ represents the regression coefficient of the model for variables $j = IC, X, etc$. Finally, $\varepsilon_{i,t}$ is the residual. The detailed calculation for each variable can be found in Table 1.

To test Hypothesis 2, we follow the moderating variable model and construct the following model:

$$EV_{i,t} = \beta_0 + \beta_{VC} VC_i + \beta_{IC} VAIC_{i,t} + \beta_I (VAIC_{i,t} \times VC_i) + \beta_X X_{i,t} + \alpha_t + \gamma_i + \varepsilon_{i,t} \tag{6}$$

where $VAIC_{i,t} \times VC_i$ is the interaction term and $\beta_I$ is the corresponding regression coefficient, which is visually represented in Figure 2.

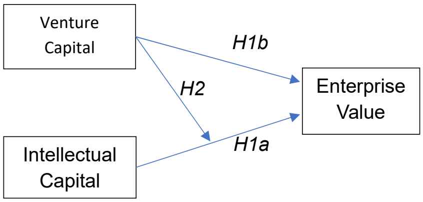
### *4.3 Multi-collinearity test and correlation test*

We conducted the multi-collinearity test and correlation test before the regression analysis. This paper tests the variance inflation factor (VIF) of each variable to judge whether there is multi-collinearity in the variables. The VIFs of VAIC, DEBT, SIZE and VC are 1.06, 1.34, 1.38 and 1.03, respectively, which are less than 10. This shows that there is no serious multi-collinearity in the independent variables, indicating that the regression model is effective and feasible.

Also, the correlation test preliminarily analyzed whether each variable was correlated and judged its correlation degree through the correlation coefficient between variables. Table 2 is the key data sorted out according to the original results. The role of $VC_i$ in the relationship between IC and EV needs to be tested by further multiple regression. The table shows that the control variables are strongly connected with the core variables.

*4.4 Results and discussion*

The central question of this paper we wanted to explore is the role of VC. For the dependent variable, we used EV for the current year and added a lagging effect for each year up to four years. The lagged-dependent variables are added because it is possible to take some time for the EV to reflect changes made in the independent variables. We find that VC has a positive long-term direct effect and a negative short-term direct effect on EV, as shown in Table 3. When VC's moderating effect is added to the empirical model, VC shows a negative effect on EV, which contrasts with the hypothesized positive effect, as shown in Table 5. We regard these as the main results of our paper. For completeness, we explain all the results and their corresponding hypotheses in the following paragraphs.




**Source(s):** Figure created by the authors

**Figure 2.** Empirical estimation model

**Table 2.** Correlation check

| Variables | $VAIC_{i,t}$ | $SIZE_{i,t}$ | $DEBT_{i,t}$ | $EV_{it}$ | $VC_{it}$ |
|---|---|---|---|---|---|
| $VAIC_{i,t}$ | 1.0000 | | | | |
| $SIZE_{i,t}$ | 0.1696*** | 1.0000 | | | |
| $DEBT_{i,t}$ | −0.0549*** | 0.4784*** | 1.0000 | | |
| $EVi,t$ | 0.1450*** | 0.8176*** | 0.2267*** | 1.0000 | |
| $VC_i$ | −0.0305*** | −0.1602*** | −0.1440*** | −0.1298*** | 1.0000 |

**Note(s):** * significance at 10%; ** significance at 5%; *** significance at 1%
**Source(s):** Table created by the authors

**Table 3.** Regression results for VC from Equation (4)

| Models | $EV_{i,t}$ | $EV_{i,t+1}$ | $EV_{i,t+2}$ | $EV_{i,t+3}$ | $EV_{i,t+4}$ |
|---|---|---|---|---|---|
| $VC_i$ | −0.0523*** (0.0142) | 0.0245* (0.0134) | 0.0430*** (0.0144) | 0.0498*** (0.0165) | 0.0575*** (0.0190) |
| $SIZE_{i,t}$ | 0.860*** (0.00462) | 0.756*** (0.00440) | 0.711*** (0.00474) | 0.678*** (0.00544) | 0.637*** (0.00622) |
| $DEBT_{i,t}$ | −0.0120*** (0.000269) | −0.00909*** (0.000255) | −0.00790*** (0.000272) | −0.00777*** (0.000310) | −0.00763*** (0.000352) |
| $\beta_0$ | 4.109*** (0.0975) | 6.434*** (0.0926) | 7.459*** (0.0995) | 8.292*** (0.114) | 9.338*** (0.130) |
| $\alpha_t$ | Yes | Yes | Yes | Yes | Yes |
| $\gamma_i$ | Yes | Yes | Yes | Yes | Yes |
| $N$ | 17,393 | 15,808 | 14,223 | 12,638 | 11,053 |

**Note(s):** * significance at 10%; ** significance at 5%; *** significance at 1%
**Source(s):** Table created by the authors

The regression result in Table 3 shows that VC has an interesting relationship with EV. In the current year, VC has a significant negative effect on EV. Then, it has a significant positive effect on the enterprise from year one to year four. This is intuitive because the company may need to go through extra effort in the initial year of obtaining venture funding (e.g. presentations, legal paperwork, etc.). They can only utilize the venture funding for the next few years to develop their business. Therefore, companies that have a VC background may see a decrease in the EV immediately, but this could lead to a positive increase in the future. This supports Hypothesis 1b. The control variables remain significant in this regression.

Table 4 shows that when adding $VC_i$ into the regression, $VAIC_{i,t}$ still has a significant positive effect on the EV of the companies from year one to year four, similar to the previous regression results. This supports the Hypothesis 1a.

Following the moderating variable model, we perform the regression of Equation (6) and show the result in the Table 5. The interaction term between the $VAIC_{i,t}$ and $VC_i$ is significantly positive on EV from one year later, which means that the moderating effect exists. Notice that the aggregate effect of VC on EV shall be $\beta_{vc} + \beta_I * VAIC_{i,t}$, not $\beta_{vc}$. The positive coefficient of the interaction term indicates that $VC_i$ has the moderating effect of improving the relationship between the $VAIC_{i,t}$ and EV, which supports Hypothesis 2. This could be due to companies that have VC may focus more on developing IC to improve factors that positively affect EV. While this does not directly contradict our hypothesis, explaining the intuition requires more efforts. To do so, we provided a detailed analysis of our economic model in Section 5.

### *4.5 Robustness test*

In this section, we performed a robustness test with an alternate definition of VAIC. Specifically, the human capital and structural capital are the same as we mentioned above. The Capital Employed Efficiency is calculated by the value-added divided by the book value of the net assets of the companies, which is represented as $VAIC_i'$. Table 6 shows that the

| Models | $EV_{i,t}$ | $EV_{i,t+1}$ | $EV_{i,t+2}$ | $EV_{i,t+3}$ | $EV_{i,t+4}$ |
|---|---|---|---|---|---|
| $VC_i$ | −0.0529*** (0.0142) | 0.0246* (0.0134) | 0.0429*** (0.0144) | 0.0495*** (0.0165) | 0.0570*** (0.0190) |
| $VAIC_{i,t}$ | −0.0154*** (0.00318) | 0.0138*** (0.00310) | 0.0177*** (0.00345) | 0.0162*** (0.00390) | 0.0188*** (0.00444) |
| $SIZE_{i,t}$ | 0.866*** (0.00478) | 0.751*** (0.00455) | 0.705*** (0.00488) | 0.673*** (0.00560) | 0.630*** (0.00639) |
| $DEBT_{i,t}$ | −0.0123*** (0.000274) | −0.00888*** (0.000259) | −0.00766*** (0.000276) | −0.00754*** (0.000314) | −0.00737*** (0.000357) |
| $\beta_0$ | 4.020*** (0.0991) | 6.511*** (0.0941) | 7.545*** (0.101) | 8.368*** (0.115) | 9.424*** (0.131) |
| $\alpha_t$ | Yes | Yes | Yes | Yes | Yes |
| $\gamma_i$ | Yes | Yes | Yes | Yes | Yes |
| $N$ | 17,393 | 15,808 | 14,223 | 12,638 | 11,053 |

**Note(s):** * significance at 10%; ** significance at 5%; *** significance at 1%
**Source(s):** Table created by the authors

**Table 4.** Regression results for Equation (5)

| Models | $EV_{i,t}$ | $EV_{i,t+1}$ | $EV_{i,t+2}$ | $EV_{i,t+3}$ | $EV_{i,t+4}$ |
|---|---|---|---|---|---|
| $VAIC_{i,t} \times VC_i$ | 0.0122 (0.0132) | 0.0756*** (0.0136) | 0.0781*** (0.0162) | 0.0893*** (0.0191) | 0.0935*** (0.0216) |
| $VC_i$ | −0.0779*** (0.0306) | −0.133*** (0.0313) | −0.123*** (0.0372) | −0.141*** (0.0439) | −0.143*** (0.0501) |
| $VAIC_{i,t}$ | −0.0161*** (0.00327) | 0.00991*** (0.00317) | 0.0142** (0.00353) | 0.0125*** (0.00398) | 0.0149*** (0.00453) |
| $SIZE_{i,t}$ | 0.866*** (0.00478) | 0.751*** (0.00455) | 0.705** (0.00488) | 0.673*** (0.00559) | 0.631*** (0.00639) |
| $DEBT_{i,t}$ | −0.0123*** (0.000274) | −0.00886*** (0.000258) | −0.00766*** (0.000275) | −0.00753*** (0.000314) | −0.00737*** (0.000357) |
| $\beta_0$ | 4.020*** (0.0991) | 6.508*** (0.0940) | 7.542*** (0.101) | 8.364*** (0.115) | 9.416*** (0.131) |
| $\alpha_t$ | Yes | Yes | Yes | Yes | Yes |
| $\gamma_i$ | Yes | Yes | Yes | Yes | Yes |
| $N$ | 17,393 | 15,808 | 14,223 | 12,638 | 11,053 |

**Note(s):** * significance at 10%; ** significance at 5%; *** significance at 1%
**Source(s):** Table created by the authors

**Table 5.** Regression results for Equation (6)

coefficients of interactions of the IC and VC are positive and significant, which means the moderating effect still exists and is consistent with our main result. However, VC's counterintuitive direct negative effect on EV is consistent throughout the robustness test. We developed a simple economic model in the next section to explain this phenomenon.

## 5. A model of R&D firms

The empirical analysis in Section 4 displays a roughly consistent result with the hypotheses developed from Section 3. In particular, VC has a positive direct effect on EV when its interaction with IC is not included. However, when the interaction effect is considered, VC is shown to have a significant negative direct effect on EV. How could the positive interaction effect be accompanied by a negative direct effect? To explain this, we consider a simple model of R&D firms to explore the roles of IC and VC in a firm's EV. In this model, we make a strong assumption that EV can be perfectly reflected by the enterprise's lifetime profit it can earn.

### *5.1 A representative firm's profit-maximization problem*

With an initial endowment ($w$), a firm has a new business idea that attracts some amount of VC ($v$). The firm has a maximum of two stages to survive: the R&D stage and the commercialization stage.

In the first stage of R&D, the firm has some IC stock ($h$) and takes a period of time ($n$) to improve the quality of the business idea, which is associated with the price of the potential product ($p$) developed from this idea. In the second stage, the firm commercializes the business idea and earns profits (if profitable).

We solve the firm's problem backward. Given the quality of the product, the firm in the second stage chooses production quantity ($q$) to maximize the total profit,

$$\max_q \pi = \int_n^T e^{-rt}[p(q,n)q - cq]dt, \tag{7}$$

where $p(q,n)$ is the price (or quality) of the product, which is a function of $q$ (due to the classic demand-supply relationship), conditional on the R&D inputs ($n$ given $h$) in the first stage; $T$ is the lifetime of the product ($T > n$); $r$ is the instant interest rate related to the discounting rate $e^{-rt}$; $c$ is the marginal cost of producing the product for the whole commercialization stage. For simplicity, we do not consider other fixed costs in the commercialization stage.

To illustrate the idea, we make some simplification: $r = 0$. Moreover, we assume the following linear relationship:

**Table 6.** Robustness test for Equation (6): alternate measurement of VAIC

| Models | $EV_{i,t}$ | $EV_{i,t+1}$ | $EV_{i,t+2}$ | $EV_{i,t+3}$ | $EV_{i,t+4}$ |
|---|---|---|---|---|---|
| $VAIC'_{it}$ | −0.000647 (−0.000789) | 0.00214$^{*}$ (−0.00121) | 0.00273$^{**}$ (−0.00123) | 0.00336$^{**}$ (−0.00138) | 0.00248$^{*}$ (−0.00144) |
| $VC'_i$ | −0.0618$^{**}$ (−0.0259) | −0.218$^{***}$ (−0.0405) | −0.221$^{***}$ (−0.0437) | −0.270$^{***}$ (−0.0406) | −0.293$^{***}$ (−0.0489) |
| $VAIC'it \times VC'_i$ | 0.0049$^{**}$ (−0.00726) | 0.0408$^{***}$ (−0.0113) | 0.0394$^{***}$ (−0.0124) | 0.0487$^{***}$ (−0.0129) | 0.0564$^{***}$ (−0.0137) |
| $SIZE_{i,t}$ | 0.878$^{***}$ (−0.00485) | 0.686$^{***}$ (−0.00769) | 0.691$^{***}$ (−0.00811) | 0.688$^{***}$ (−0.0087) | 0.691$^{***}$ (−0.00054) |
| $DEBT_{i,t}$ | −0.0130$^{***}$ (−0.000284) | −0.0055$^{**}$ (−0.00045) | −0.00590$^{***}$ (−0.00047) | −0.00598$^{**}$ (−0.00051) | −0.00641$^{**}$ (−0.00054) |
| $\beta_0$ | 3.762$^{***}$ (−0.102) | 7.700$^{***}$ (−0.162) | 7.594$^{***}$ (−0.17) | 7.663$^{***}$ (−0.183) | 7.646$^{***}$ (−0.196) |
| $\alpha_t$ | Yes | Yes | Yes | Yes | Yes |
| $\gamma_i$ | Yes | Yes | Yes | Yes | Yes |
| $N$ | 16,725 | 15,199 | 13,684 | 12,162 | 10,641 |

**Note(s):** $^{*}$ significance at 10%; $^{**}$ significance at 5%; $^{***}$ significance at 1%
**Source(s):** Table created by the authors

$$p(q,n) = hn - bq, \tag{8}$$

where $b$ is an associated exogenous parameter: for 1% increase in quantity, the price decreases by $b$%. Equation (8) reflects that when other things are equal, consumers are willing to pay a higher price for a product with better quality. Equation (8) also reflects the demand curve of the product.

Given (8) and the simplification $r = 0$, we can rewrite the second-stage objective function (7) as

$$\max_q \pi = [hn - c - bq]q(T - n). \tag{9}$$

Taking the first order condition (FOC) with respect to $q$, we can solve for the optimal production choice:

$$q^*(n) = \frac{hn - c}{2b}. \tag{10}$$

Substituting (10) into (9) we can rewrite the objective as a function of the first-stage choice variable $n$. This leads to the first-stage problem, in which the firm receives (exogenously) an IC stock ($h$) [1] and chooses the R&D duration ($n$) that maximizes the profit, namely

$$\max_n \pi = \left(\frac{hn - c}{2}\right)^2 \left(\frac{T - n}{b}\right), \tag{11}$$

subject to the budget constraints

$$\sigma hn \leq w + v, \tag{12}$$

where $\sigma$ is the average payment to each unit of IC stock for one unit of time on the R&D; we do not assume any other fixed costs of doing the R&D.

Taking the first derivative of $\pi$ in (11) with respect to $n$, we obtain

$$\frac{\partial \pi}{\partial n} = h\left(\frac{hn - c}{2}\right)\left(\frac{T - n}{b}\right) - \frac{1}{b}\left(\frac{hn - c}{2}\right)^2.$$

The first term, $h\left(\frac{hn-c}{2}\right)\left(\frac{T-n}{b}\right)$, on the right-hand side is the benefit of increasing one more unit of R&D, which comes from the improvement on the product's quality that boosts up the selling price. The cost of increasing this unit of R&D duration is the second term, $\frac{1}{b}\left(\frac{hn-c}{2}\right)^2$, which is the opportunity cost of losing one unit of time to sell the product. When the marginal benefit equals to the marginal cost, we solve for the optimal R&D duration

$$n^* = \frac{2}{3}T + \frac{c}{3h}. \tag{13}$$

To make $n^*$ be in the choice space $[0, w + v]$, given (12) we need to set the condition

$$\sigma\left(\frac{2}{3}hT + \frac{c}{3}\right) \leq w + v. \tag{14}$$

Moreover, a participation constraint shall be $p(n^*, q^*) \geq c$: the price shall be higher than the marginal cost. Using (8), (10) and (13), we can solve for this condition given by

$$hT > c. \tag{15}$$

It is obviously that this condition is satisfied if $c$ is sufficiently small.

Conditional (14) and (15) indicates a sufficient condition (16) for the optimal $n^*$ to be well defined:

$$c < \frac{w + v}{\sigma}. \tag{16}$$

We summarize the above results in Proposition 1.

*P1.* Consider a simple market with innovation-driven firms. A representative firm's profit-maximization problem is given by (9) and (11), subject to the R&D-affected demand curve given by (8). When (15) and (16) hold, there is an optimal R&D duration (n*) given by (13).

*5.2 Myopic firms and over-investment on R&D*

In the profit-maximization problem above, we implicitly assume that the firm is able to know the function $p(q, n)$ in advance. However, this assumption is strong due to market imperfections.

To consider a more realistic setting, we assume that the firm is "myopic" and focuses only on its short-term objectives. We make this assumption for two reasons. First, when doing R&D in the first stage, the R&D team is likely to focus on the quality of the product, rather than the profitability. Second, even though the firm is willing to take profitability into account, the true market state could be known only in the commercialization stage but hard to be known in the R&D stage. Thus, the first-stage objective is to do the "best" R&D, while the second-stage objective is to earn the most profit.

We still solve the problem backward. In the second stage, the problem is the same, and the solution (10) still holds. In the first stage, the firm chooses the R&D duration ($n$) to maximize the quality of the product; namely

$$\max_n p(n, q) = hn - bq, \tag{17}$$

subject to (12). Since $p(n, q)$ is linear in $n$, the myopic choice is to choose

$$\widehat{n}^* = \frac{w + v}{\sigma h}. \tag{18}$$

Given this new setting, we present Proposition 2 followed by its proof.

*P2.* If the firm is myopic with the short-term objectives subject to (9) and (17) respectively. When (15) and (16) hold, (a) the R&D is over-invested, and (b) the profit cannot be maximized.

Proof: Given (15) and (16), comparing (18) with (13) leads to $\widehat{n}^* > n^*$. This proves part (a).

We take the second derivative of $\pi$ in (11) with respective to $n$ and obtain

$$\frac{\partial^2 \pi}{\partial^2 n} = -\frac{3h}{2b}\left(\frac{hn - c}{2}\right) < 0. \tag{19}$$

Given that the second derivative $\frac{\partial^2 \pi}{\partial^2 n}$ is negative and $n^*$ is solved by the FOC, we can easily check out

$$\pi(q^*(\widehat{n}^*), \widehat{n}^*) < \pi(q^*(n^*), n^*).$$

This proves part (b).

*5.3 Comparative static: EV and the roles of IC and VC*

To illustrate the insight of "over investment" played by VC, we conduct comparative static conditional on (16). If we use the profit to proximate the EV, we have the EV given by

$$\pi(q^*(\widehat{n}^*), \widehat{n}^*) = \frac{1}{b}\left[\frac{(w+v)}{2\sigma} - \frac{c}{2}\right]^2 \left(T - \frac{w+h}{\sigma h}\right) \tag{20}$$

From (20), we can obtain the marginal contribution of IC stock ($h$) to the EV

$$\frac{\partial \pi(q^*(\widehat{n}^*), \widehat{n}^*)}{\partial h} = \frac{1}{b}\left[\frac{(w+v)-c}{2\sigma}\right]^2 \left(\frac{w+v}{\sigma h^2}\right) > 0, \tag{21}$$

where we have used (16).

The derivative in (21) shows a positive sign of the effect of IC stock ($h$) on the EV. This is consistent with Hypothesis 1, which is also supported by empirical evidence. The positive term for the RHS in (21) is IC's contribution to the EV through obtaining the same R&D quality but accelerating the R&D process. To spot this insight, recall that a myopic firm invests all its VC in the R&D stage, i.e. $w + v = \sigma h n$ from (18). Because of the assumed relationship $p = hn - bq$ specified in (8), investing all the VC leads to the same product quality, i.e. $hn = \frac{w+v}{\sigma}$, regardless of IC stock size. In return, a larger amount of IC stock (h) indicates a lower R&D duration (n), as given in (18). With the same product quality but a shorter R&D duration, this myopic firm benefits from a longer commercialization period of profit.

Regarding the role of VC, we have two results, summarized in Proposition 3.

*P3.* When (16) holds, we have (a) a direct negative effect of VC on the EV, and (b) a positive interaction effect between VC and IC on the EV.

Proof: Since $\frac{\partial \widehat{\boldsymbol{n}}^*}{\partial v} < 0$ from (18), given (19) we can easily checkout

$$\frac{\partial \boldsymbol{\pi}(\boldsymbol{q}(\widehat{\boldsymbol{n}}^*), \widehat{\boldsymbol{n}}^*)}{\partial \boldsymbol{v}} < \mathbf{0}. \tag{22}$$

This shows part (a).

Observing (21), it is also easy to check out

$$\frac{\partial^2 \boldsymbol{\pi}(\boldsymbol{q}(\widehat{\boldsymbol{n}}^*), \widehat{\boldsymbol{n}}^*)}{\partial \boldsymbol{h} \partial \boldsymbol{v}} > \mathbf{0}. \tag{23}$$

This shows part (b).

The negative term $\frac{\partial \boldsymbol{\pi}((\widehat{\boldsymbol{n}^*}),\widehat{\boldsymbol{n}^*})}{\partial v}$ in (22) indicates a negative direct effect of VC on EV. This piece of analytical result is consistent with the significant negative coefficient of VC in Table 5. At the same time, the positive term $\frac{\partial^2 \boldsymbol{\pi}((\widehat{\boldsymbol{n}^*}),\widehat{\boldsymbol{n}^*})}{\partial h \partial v}$ in (23) indicates a positive interaction effect between VC and IC on EV. This result is consistent with Hypothesis 2, which is supported by empirical evidence as shown in Table 5.

The intuition underlying (22) is traced to over-investment. When a firm receives an excessive amount of VCs and invests all of them in R&D, it benefits from the positive effect of increasing the price level of the product (due to the improvement of the quality), but it is also harmed by an accompanying negative effect of reducing consumers' demand for the product. The overall effect is that the negative effect dominates when over-investment is the case, thereby leading to a decrease in the profit.

The intuition underlying (23) is due to the substitution of IC for R&D duration. Observing (18), given the same change of VC, those firms with larger IC have a lower R&D duration increase, thereby suffering less from the over-investment effect. Our study implies that to some extent, a larger IC stock stops the firm from over-investing too aggressively.

## 6. Conclusion

This paper studies the relationship among VC, IC and EV. As the core resource of entrepreneurial enterprises to improve market competitiveness, IC has a significant positive effect on long-term EV, while a significant negative effect for the immediate year.

We also find that when VC's moderating effect is added to the empirical model, VC shows a negative effect on EV, which contrasts with the hypothesized positive effect. To better understand the role of VC, we developed an economic model in which innovative enterprises make a trade-off between R&D quality and commercialization duration, both of which are affected by VC investment. We propose an alternative view of VC. The model shows that not all VCs are good for enterprises. Too much capital may lead to over-investment [2]. When the R&D investment is too vast, the lifetime profit of an enterprise may be significantly lowered. The perceived EV may also be significantly reduced if EV can be reflected by the prediction of lifetime profit.

Our study has a few managerial implications. First, entrepreneurs shall thus pay particular attention to the accumulation of IC in their enterprises. Three channels to accumulate IC are human capital, structural capital and relational capital, each of which is a necessary component of IC measured in our study. Moreover, entrepreneurs must make wise use of VCs. The switch in the sign of VC after considering VC's interaction with IC implies a subtle effect of VC on improving EV. Entrepreneurs or enterprise managers shall try to find the optimal level of VC to hold. Neither over-investment nor under-investment would maximize EV. This research has several limitations. Our study only includes listed companies in China, but VCs usually start impacting firms before they become listed. Therefore, it is useful to extend this study to unlisted firms. We could not do this due to the limitation of data and computation resources. Another future research direction is to test the "over-investment" hypothesis. To complete this task, an important work is to find an appropriate measurement to estimate the lifetime profit of an enterprise.

### Notes

1. This reflects the element of "luck" in start-ups. While each start-up can choose the level of investment (i.e. R&D duration), it cannot control the efficiency of the investment. For example, each start-up is able to hire a team, but the actual productivity of the team is not revealed during the hiring process.
2. One real example of venture capital over-investment is the case of WeWork, a shared office space provider (https://www.theguardian.com/business/2019/dec/20/why-wework-went-wrong).

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## Appendix

To supplement our research, we also performed regression to separately show the influence of VAIC on EV.

The model to test the influence of VAIC can be constructed as follows:

$$EV_{i,t} = \beta_0 + \beta_{IC} VAIC_{i,t} + \beta_X X_{i,t} + \alpha_t + \gamma_i + \varepsilon_{i,t} \quad \text{(A1)}$$

where $EV_{i,t}$ is the $EV$ for each company $i$ and time $t$, where $t \in \{2009, 2010, \ldots, 2019\}$. $VAIC_{i,t}$ is the value of the VAIC for each company $i$ and year $t$. $X_{i,t}$ contains the control variables $DEBT_{i,t}$ and $SIZE_{i,t}$, which represent the debt ratio and size for each listed company $i$ and time $t$, respectively. $\alpha_t$ and $\gamma_i$ represent the time and company fixed effects, respectively. $\beta_0$ is the constant term of the model. $\beta_j$ represents the regression coefficient of the model for variables $j = IC, X, etc.$ Finally, $\varepsilon_{i,t}$ is the residual. The detailed calculation for each variable can be found in Table 1.

**Table A1.**
Regression results for IC from Equation (A1)

| Models | $EV_{i,t}$ | $EV_{i,t+1}$ | $EV_{i,t+2}$ | $EV_{i,t+3}$ | $EV_{i,t+4}$ |
|---|---|---|---|---|---|
| $VAIC_{i,t}$ | $-0.0243^{***}$ (0.00548) | $0.0317^{***}$ (0.00636) | $0.0236^{***}$ (0.00593) | 0.00733 (0.00552) | 0.00241 (0.00510) |
| $SIZE_{i,t}$ | $1.075^{***}$ (0.0284) | $0.533^{***}$ (0.0198) | $0.304^{***}$ (0.0177) | $0.168^{***}$ (0.0175) | $0.0405^{**}$ (0.0183) |
| $DEBT_{i,t}$ | $-0.0152^{***}$ (0.000872) | $-0.00149^{**}$ (0.000595) | $0.00102^{**}$ (0.000511) | −0.0000422 (0.000562) | $-0.0000992^{*}$ (0.000599) |
| $\beta_0$ | −0.462 (0.608) | $10.97^{***}$ (0.426) | $16.00^{***}$ (0.390) | $19.17^{***}$ (0.387) | $22.12^{***}$ (0.403) |
| $\alpha_t$ | Yes | Yes | Yes | Yes | Yes |
| $\gamma_i$ | Yes | Yes | Yes | Yes | Yes |
| $N$ | 17,393 | 15,808 | 14,223 | 12,638 | 11,053 |

**Note(s):** $^{*}$ significance at 10%; $^{**}$ significance at 5%; $^{***}$ significance at 1%
**Source(s):** Table created by the authors

The results from Equation (A1) in Table A1 indicate that the VAIC is positively and significantly correlated with EV one year later to four years later. This indicates that the companies should develop the HCE, RCE and SCE at the same time. More entrepreneurial enterprises are becoming high-tech enterprises that gather advanced knowledge, technology, experience and other capital (Chu *et al.*, 2021). VAIC is significantly negative in the current year. This is intuitive because the intangible asset needs some time to be reflected in the EV. For example, hiring a team means higher costs in the short-run, but could generate long-term gains if done correctly. This result also indicates that enterprises should pay more attention to the accumulation and management of various elements in production and operation activities, and choose the methods that are more suitable for their characteristics by considering the ways of influence between the elements so as to improve the coefficient of IC (Belkaoui, 2003). The control variables exhibit similar behavior in this regression.

**Corresponding author**
Pang Paul Wang can be contacted at: paul.wang@polyu.edu.hk