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Institutions, Digitization, Innovation and Venture Capital: Evidence from Europe and the Asia-Pacific

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ABSTRACT

The article examines the impact of information and communication technologies (ICT), innovation, and formal and informal institutions on venture capital (VC) investment. The analysis is based on 28-year data spanning 1990-2017 from 19 European and 13 Asia-Pacific countries using generalized two-stage least square instrumental variable technique. After controlling for endogeneity, the results show that ICT, innovation, and informal institutions hold a strong impact on VC investment. ICT and innovation exert a positive and significant influence on VC investment whereas formal institutions exert a positive yet insignificant effect on VC investment. Among the informal institutions, power distance and individualism exert significant and positive influence whereas uncertainty avoidance has significant and negative influence on VC investment. The interaction analysis demonstrates that the association between ICT and VC is strong when institutional quality is high. Moreover, the impact of innovation on VC is pronounced in highly digitized and highly uncertainty-tolerant environments. Explanation of VC capital investment also vary with geography as the effects of trend, ICT and uncertainty avoidance on VC investment are noticeable in the Asia-Pacific region whereas power distance is prominent in the European region. The article makes important contributions to the literature of VC by revealing novel interactions between formal and informal institutions, ICT and innovation depicted in a conceptual model. The study also brings in important highlights to the policy debate on VC development by showing how exactly VC investments are tangled with the different dimensions of institutional and technological environment.

Keywords

Venture Capital, Private Equity, Formal Institutions, Informal Institutions, National Cultures, Innovation, ICT

JEL Classification

L32, L33, G24

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1 Introduction

Venture capital (VC) originated in the US more than 70 years ago, but it was only in the late 1970s and early 1980s that it became institutionalized. Later, it spread to Western Europe and other parts of the world including Asian economies. The world VC market survived the Dot-Com bubble and then the 2008 financial crisis despite the risky nature of such investments. Today, the world VC industry stands at around US$2 trillion in terms of dry power[1]. The US VC investment reached US$130 billion in 2018 surpassing the Dot-Com era for the first time (PitchBook-NVCA, 2018). US and some of the Western European economies have more established VC markets but in rest of the world, there is still cross-country disparity in VC activity. Researchers have explored different factors influencing the development of VC markets around the globe, however, most of those studies have examined the established markets. In their analysis of 314 VC research articles since 2011, 52% of articles still rely on US VC data based on meta-analysis of 314 VC prior studies (Tykvova, 2017). Asian VC market has grown tremendously after the 2000 high-tech market crash. For example, Asia-Pacific region experienced VC investment twice than its European counterpart in 2015 (see Figure 1-A and 1-B). There might be different institutional patterns in the economies that have nascent VC markets particularly Eastern Europe and some of the Asian markets. But this is not the sole reason to re-visit VC investment.

The primary motivation of the paper is as follows. VC is a knowledge and information intensive market which is affected by factors related to information asymmetry and knowledge creation. The factors tied by common features of information and knowledge include ICT, patents, and institutions. ICT has become essential part of the modern life. The landscape of the world business has changed, and digitally powered technology firms dominate the world business. The top three billionaires crossing US$100 billion mark for the first time in World history in personal wealth are the owners of digital firms namely Microsoft, Amazon, and Facebook[2]. Most of the VC determinants research have used data of web1.0 era before the transformation of internet in the context of web2.0 (Aldrich, 2014; see the Appendix 1 for previous studies and the periods covered). ICT makes VC processes more efficient through cost reduction and information symmetry, on the one hand, and boost entrepreneurial activities on the other hand.

Patents catalyze entrepreneurial activity and promotes demand side of VC. Institutions also impact VC markets because "they reduce transaction costs, provide information under uncertainty, and stabilize expectations about the behavior of others" (Risse, 2000, p.4). North

[1] Dry Powder includes venture capital, buyout, real estate, and infrastructure (Bain & Company, 2019)

[2] While Bill Gates and Jeff Bezos had already passed the US$100 billion-mark, Mark Zuckerberg became the third billionaire passing that milestone in August 2020. URL: https://www.bloombergquint.com/markets/zuckerberg-s-fortune-surpasses-100-billion-with-facebook-surge#:~:text=(Bloomberg)%20%2D%2D%20Mark%20Zuckerberg's%20net,of%20its%20TikTok%20competitor%20Reels. Accessed on September 5, 2020.

(1991) argues that institutions are created to reduce uncertainty and maintain order and therefore determine transaction and productions costs. Formal institutions are not only associated with VC but also with ICT. For example, studies have found that ICT, particularly, e-governments reduce corruption (Sturges, 2004; Srivastava, Teo and Devaraj, 2016) and that formal institutions are important to take advantage of ICT (Andrés, Amavilah, & Asongu, 2017). While innovation and formal institutions are well studied in the extant research, ICT and informal institutions have been less recognized previously. Only a few studies have explored the impact of informal institutions (Li & Zahra, 2012) and the ICT (Khan *et al.*, 2020).

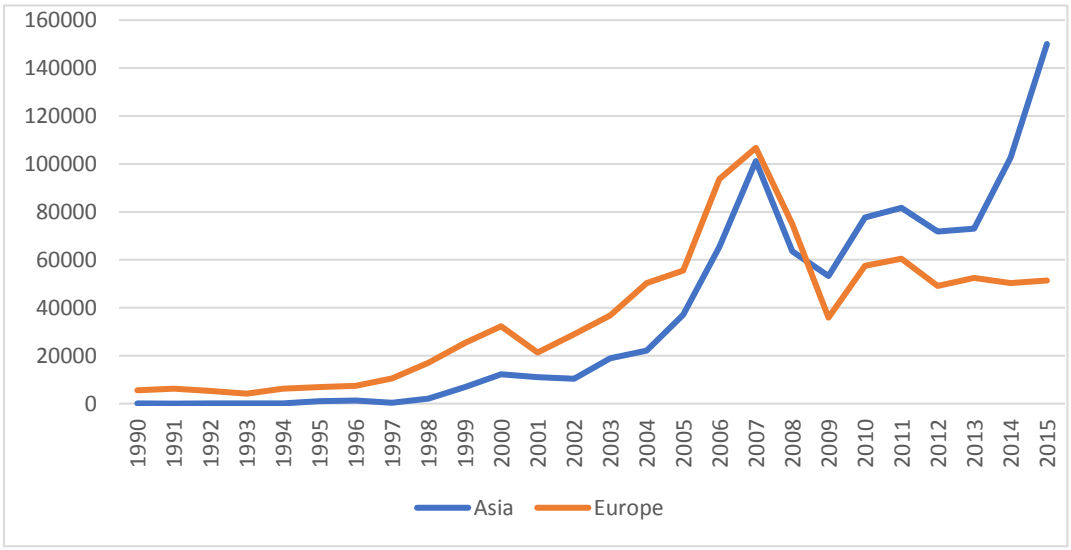

Figure 1(A): VC Investments in USD in Asia-Pacific and Europe 1990-2015

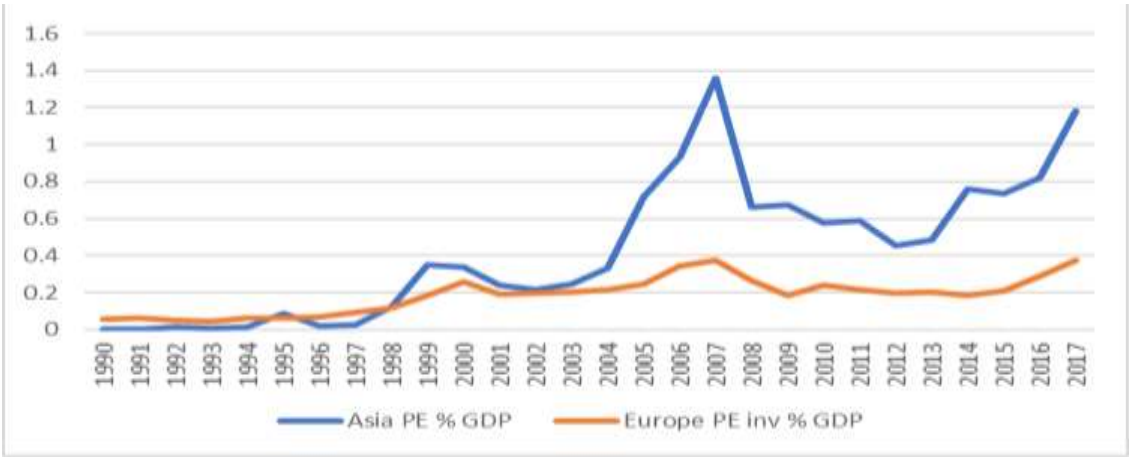

Figure 1(B): VC Investments % GDP in Asia-Pacific and Europe 1990-2017 (Source: Asia-Pacific data from AVCJ, European Data from Eurostat and EVCA Yearbooks).

Note: - The chart is based on 13 Asia-Pacific Countries and 19 European Countries included in the study

Within the literature on VC, previous research lacks the moderating role of institutions. There is a scope for research on how informal institutions affect decisions in the VC market as VC processes take place in an environment of uncertainty and VCs invest in ventures that are opaque. In that context, culture of uncertainty avoidance might have an impact on the chance that a patent is translated into an innovative product that subsequently attracts VC. Furthermore, the effect of ICT embeddedness may vary with formal institutions as institutions protect rights of minority shareholdings and property rights. Moreover, it is also likely that ICT may have impact the association between innovation and VC as ICT acts as efficiency-enhancing technology that can create a competitive advantage for SMEs through product innovation (Higón, 2012). The current study examines the impact of formal and informal institutions, innovation and ICT on VC investments in Europe and Asia. It also examines how these factors interact with each other in their influence on VC activity. The present study also examines how different factors vary in their impact on VC investment across the two regions i.e. Europe and Asia-Pacific.

Before proceeding to the next section, it is important to define VC. VC and private equity are two closely related concepts. Strictly, in the US, VC involves only seed, start-up, and expansion investments whereas private equity includes VC, buyouts, consolidations, and turnarounds. Outside the US, the concept of VC and private equity converge, and VC is usually referred to what is called private equity in US context (Jeng and Wells, 2000). In Europe, many VC firms offer equity investments would be called private equity financing in the US (Black and Gilson, 1998). The concept gets further complicated in Japan where venture capitalists (VCs) extend loans based on interest rather than equity alone. In the current study, consistent with Wright, Pruthi and Lockett (2005), we take the broader definition of VC, which covers seed, start-up, later stage, expansion, growth, replacement and buyouts which is synonymous to private equity. The current article cites both VC and private equity literature – or in other words literature of venture capital in both narrower sense and broader sense – which is a standard practice in academic work on VC (Kumar and Orleck, 2002).

2 Hypothesis Development

2.1 Formal institutions

Formal institutions consist of constitutions, laws, and property rights (North, 1991). Since institutions differ across regions, they exert varying influences. For example, investment patterns of various investor types are enormously different in the US from those practiced in Europe (Bertoni and Colombo, 2015). Groh and von Liechtenstein (2009) find that corporate governance and the protection of investors' rights have positive impact on the attractiveness of

a VC investment in a country. Rule of law and government effectiveness have a negative effect on cleantech VC activity (Cumming, Henriques and Sadorsky, 2016). Freedom from corruption has a significant negative effect on early stage VC (Cherif and Gazdar, 2011). M&A investment volume, the shareholder suits index, and the legal rights index have a significant positive effect on VC investment (Groh and Wallmeroth, 2016). Armour and Cumming (2006) find that temperate bankruptcy laws for entrepreneurs trigger demand for risk capital.

Institutions also affect international allocations. Ragosa and Warren (2019) show that regulatory support measures and feed-in tariffs, coupled with political stability, are strong drivers of cross-border investment in renewable energy in developing countries. Guler and Guillén (2010) find that host countries' characteristics such as technological, legal, financial, and political institutions attract international venture capital firms to invest in those destinations. They posit that these institutions offer technological opportunities, protect property rights, catalyze exits, and bring legal stability, respectively. In a survey of limited partners world-wide, Groh and Liechtenstein (2011) find the protection of property rights is the primary concern while allocating capital internationally.

H-1: Quality of formal institutions are likely to have a direct significant positive effect on VC investments.

2.2 Informal Institutions

Informal institutions consist of "sanctions, taboos, customs, traditions, and codes of conduct" (North, 1991, p.97). In the current study, we take Hofstede's national cultures as informal institutions. Surprisingly, informal institutions have received little attention from VC scholars. Black and Gilson (1998) refute the role of culture in the development of VC markets. However, Kenney, Han and Tanaka (2003) and Kumar and Orleck (2002) show, that the cultural factors influence the development of VC. Kenney, Han and Tanaka (2002) contend that Korean entrepreneurs insist on deals that eventually lead to transfer of control back to their family, indicating a strong collectivist culture. Li & Zahra (2012) find that formal institutions interact with Hofstede cultural dimensions, particularly, uncertainty avoidance and collectivism.

In the current research, we will use Hofstede cultural dimensions to examine the impact of culture on VC. Hofstede dimensions of national cultures are frequently used to investigate the influence of culture in business and economics research. Initially found in IBM study, the four cultural dimensions include uncertainty avoidance, power distance, individualism, and masculinity. Uncertainty avoidance is defined as "the extent to which the members of a culture feel threatened by ambiguous or unknown situations" (Hofstede, Hofstede and Minkov, 2010, p.191). Countries high on uncertainty avoidance resist change and innovation because people have rigid beliefs and do not welcome new ideas. Moreover, security is an important

component in individual motivations. Societies that are high on uncertainty avoidance rely more on written rules and regulations, rely on informal structures to deal with uncertainty, and show less tolerance for ambiguity and change (Kreiser *et al.*, 2010). This might have implications for VC development as societies that are more uncertainty tolerant are prepared to take more entrepreneurial risks (Spencer and Gómez, 2004).

H-2: Uncertainty avoidance is likely to have a significant negative impact on VC investments.

Power distance represents the degree to which less powerful people in a hierarchy expect and accept the influence of more powerful people (Hofstede, Hofstede and Minkov, 2010). This dimension may be an important factor influencing the relationship between VCs and entrepreneurs, given the notion that control has an element of struggle over power. VCs and entrepreneurs could have issues over the control of the firm in societies where power sharing is resisted. At the time of deal structuring, entrepreneurs are likely to hand over control more easily in high power distance societies compared to entrepreneurs in low power distance cultures.

H-3: Power distance is likely to have a significant positive impact on VC investments.

Hofstede's individualism represents the cultural norms regulating actions in society pertaining to interdependence of people. To what extent do they support or depend on each other based on their blood relationship, community feelings, or friendship. In collectivist societies, personal relationships, friendships, family connections, and networks play a significant role. Moreover, violations of promises and rules/norms are corrected by shame mechanisms (Hofstede, 2012). In collectivist societies, firms rely more on informal institutions than formal markets (World Development Report, 2002). This might have implications for VC development. For example, in collectivist societies, entrepreneurs may want to pass their business on to their children and therefore resist handing over control to the VC firm (Spencer and Gómez, 2004). Thus, it is hypothesized:

H-4: Individualism is likely to have a significant positive impact on VC investments.

Hofstede (2020) notes that "in masculine countries people "live in order to work", managers are expected to be decisive and assertive, the emphasis is on equity, competition and performance and conflicts are resolved by fighting them out"[3]. In a masculine society, people are assertive and want to be the best, and perhaps these attitudes could be problematic considering the issue of control between the VCs and entrepreneurs. Additionally, the competition between individual firms could be fierce and therefore collective action and cooperation which is essential for VC development might be a problem at industry level. Cooperation is essential to develop VC as the key of VC institutionalization in the US in the

[3] Available at https://www.hofstede-insights.com/country/south-africa/ accessed on September 5, 2020. The date shows the date of access not the date of publication on the website as it does not mention any date of publication.

1980s was the high level of cooperative behavior (Bruton et al., 2005). Thus, a masculine culture is likely to be problematic for VC development. The formal hypothesis is:

H-5: Masculinity is likely to exert a significant negative impact on VC investment.

2.3 ICT

Another important element of an entrepreneurial environment is the information and communication technology (ICT) that has changed the landscape of business and technology in the last two decades, the period in which VC has also flourished enormously. ICT has enhanced financial participation (Pradhan, Arvin, Nair, Bennett & Bahmani, 2017) financial access, inclusion (Asongu & Acha-Anyi, 2017; Gabor & Brooks, 2017) and improved financial development (Pradhan, Arvin and Norman, 2015; Asongu and Moulin, 2016; Pradhan *et al.*, 2018; Lechman and Marszk, 2019)[4]. Financial systems are deemed as information systems (Ocampo, 2018). VC investment is knowledge-intensive instrument where such investors highly depend on information about the portfolio companies before and after the investment is finalized (Carey, Prowse, Rea & Udell, 1993). Thus, internet is not only the tool that has made VC and VC processes more efficient, but it has also created the most dynamic entrepreneurial environment. So far, VC studies have ignored the power of internet and related technologies while in this research, we expect it to have a strong influence on the VC investment. Formally it is proposed that:

H-6: ICT is likely to have a significant positive impact on VC investments.

2.4 Innovation and technological opportunity

Schertler (2007) finds a strong positive impact of number of patents, number of R&D researchers and R&D expenditure on VC investments. Besides, the impact of total knowledge capital in terms of volume is not highly significant. Also, government-financed knowledge capital has weak explanatory power for the size of VC investments, probably due to commercial applications (Keuschnigg and Nielsen, 2003) or due to its long-term focus which is translated into commercial applications in more than two years. Schertler (2007), however, finds that business-financed GERD does not affect the volume of investments. Schertler (2003) also finds that human capital endowment plays a positive role in VC development. However, according to Da Rin, Nicodano and Sembenelli (2006), R&D has no effect on early stage and high-tech VC investment. We expect a positive impact of innovative potential (represented by patents) to have positive impact on VC investment because innovative activities boost entrepreneurial activities that ultimately attracts VC investment. More formally it is hypothesized:

H-7: Innovation is likely to have a significant positive impact on VC investments.

[4] For detailed literature read (Lechman and Marszk, 2019).

2.5 ICT and formal institutions

There are studies showing that formal institutions have an impact on ICT adoption. Martinez & Williams (2010) support the institutional view to explain ICT adoption and shows that formal institutions exert influence on ICT adoption and therefore electronic commerce. The institutional view is based on the premise that quality institutions stimulate the confidence of private actors in the ability of government to set and enforce 'rules of the game' for protection of commercial transactions (Shareef, Kumar and Kumar, 2008; Martinez and Williams, 2010). Research also shows that ICT and institutional quality play a mediating role between electronic government and corruption (Adam, 2020). More importantly, studies demonstrate that institutions have moderated the impact of ICT on development and anti-corruption practices. Andrés, Amavilah, & Asongu (2017) also show that formal institutions are essential to promote ICT adoption for development. Sassi & Goaied (2013) show that the effect of ICT diffusion on corruption in African economies depends on the rule of law. Therefore, it is expected that institutions may also moderate the effect of ICT on VC. Hence, we formulate the following hypothesis:

H-8: The effect of ICT on VC investments is likely to vary significantly with quality of formal institutions

2.6 ICT, informal institutions and innovation

The key point in this section is that the impact of innovation on VC investment is moderated by culture of uncertainty avoidance and ICT. The rationale is that all these are important from information, knowledge and risk-taking point of view. As pointed out in Khan et al. (2020) that VC is an information-problematic and knowledge-intensive industry so much that VCs had to rely on informal informants (Fiet, 1995; Lockett *et al.*, 2002). VCs highly depend on pre-investment information to avoid adverse selection and post-investment information to evade moral hazard (Wright and Robbie, 1998). They invest in opaque, high risk, high growth-potential SMEs with little or no transactional history. Since uncertainty in private placements is relatively high, public intermediation is more reluctant to commit resources to such ambiguous transactions. Resultantly, such private investments involve more due diligence and monitoring compared to other financing alternatives (Carey et al., 1993). ICT has made information sharing very easy that has facilitated processes of information collection for industry selection, firm selection, deal origination, monitoring and exits.

There is also evidence that ICT has a positive impact on firm innovativeness. For example *Hall et al*. (2013) demonstrate that investment in ICT and R&D have a strong impact on innovation and productivity in manufacturing firms in Italy. Ollo-López & Aramendía-Muneta (2012) also show that ICT enhances innovation in the glass, ceramics, and cement concrete

industry. Therefore, it is expected that ICT may moderate the impact of innovation on VC investment. The proposition is as follows:

H-9: Impact of innovation on VC investments is likely to vary significantly with level of ICT.

Culture also has a significant impact on innovation (Efrat, 2014). Three of the Hofstede's cultural dimensions have relevance to innovation, namely, uncertainty avoidance, individualism, and power distance. However, there is strong theoretical relevance of uncertainty avoidance to VC research because of importance of information and knowledge in the VC processes particularly where innovative start-ups and innovative products are involved. Naturally, investors in high uncertainty avoidance cultures would commit more time and money to secure deals than their counterparts in high uncertainty tolerance cultures. There is evidence in previous research that innovation varies with culture of uncertainty avoidance. High uncertainty avoidance exerts a negative influence on innovation (Shane, 1995), innovation diffusion takeoff (Tellis, Stremersch and Yin, 2003) and new product adoption (Yeniyurt and Townsend, 2003). Uncertainty avoidance has a negative relationship with innovation diffusion and that the impact of uncertainty avoidance changes from negative to positive in later stage diffusion (He and Lee, 2020).

The key argument is that cultures where people can deal better with uncertainty are better at converting basic research into innovative start-ups and risk-taking. Subsequently, the more there is tolerance for ambiguity and the more there is research and innovation, the more there will be demand for VC. The underlying theory is that such uncertainty tolerance facilitates the process of converting patents into vibrant start-ups and start-up opportunities provide fuel to the VC market. Thus, it is hypothesized as follows:

H-10: The impact of innovation on VC investment is likely to vary significantly with uncertainty avoidance.

2.7 The Conceptual Model

Formal and informal institutions, ICT and innovation are likely to have a significant direct impact on VC investment. In addition to direct effect, formal institutions also moderate the association between ICT and VC investment. The key reason is the institutional theory that strong protection of property rights of private actors in the cyberspace get more ICT compared to weak legal systems. As discussed earlier in Section 2.5, if ICT vary with institutions, then there is an expectation that institutions impact the relationship between ICT and VC investment. On the other hand, informal institutions and ICT moderate the impact of innovation on VC investment.

The rationale is that VC is an information intensive market. VC needs information technology when it invests in risky businesses converting patents into innovative products and certainly such processes would be more facilitated in a culture that is tolerant of uncertainty. The conceptual model depicted in Figure 2 shows the relations between formal institutions, information institutions, ICT, innovative potential and VC. The arrows indicate the direction of the influence of independent variable on dependent variable (direct impact represented by black lines) or on relationship between another independent variable and dependent variable (indirect impact represented by blue lines).

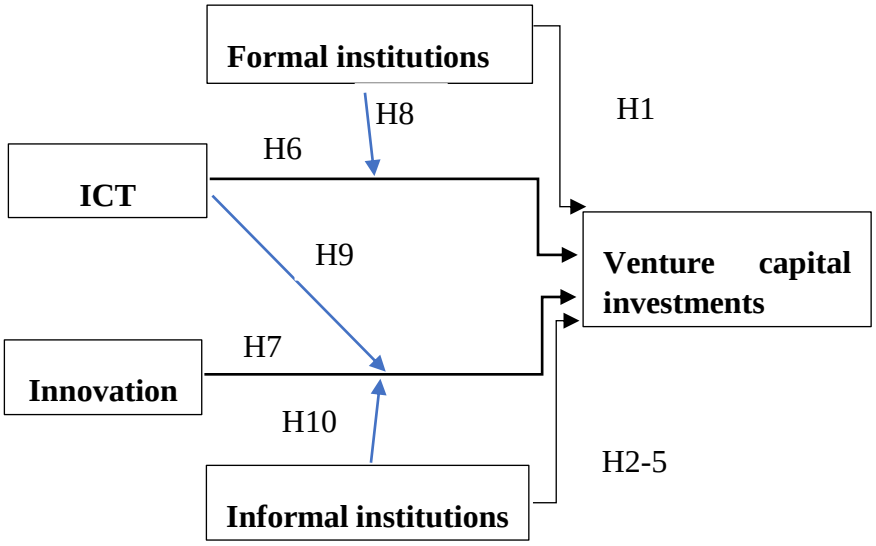

Figure 2: Conceptual Model (Source: Author)

2.8 Regional Disparities

We are also interested to know if there are any regional differences. We expect differences as the Asian context is different in several respects. Most prominent of them are high income inequalities and poverty and lower per capita income in Asian context (Aoyagi and Ganelli, 2015) compared to Europe. While GDP growth has been controlled for, other factors may have led the investors of the two regions to respond to different market and institutional stimuli. The overall cultural and institutional context not captured in this study might also be in play that makes Asian VC activity distinct from the European one. It will, thus, be useful to conduct regional analysis to take in to account those contextual differences for the sake of interest.

2.9 Control Variables

VC researchers have investigated the favorability of an environment for investment across countries using different factors. They find liquidity of stock markets and IPOs (Black and Gilson, 1999; Jeng and Wells, 2000) exert a strong effect on VC markets as they facilitate exits from such investments though the impact varies across different stages of investments

(Schertler, 2003a; Schertler, 2003b; Schröder, 2009). Tax rates also matter. Some show that taxation negatively determines VC (Cherif and Gazdar, 2011) while others aver that taxation is of little or no importance as an explanatory variable in determining VC (Romain and Pottelsberghe, 2004). Research using US and the Asian data show a lesser impact of taxation while studies taking European countries observe taxation as the significant determinant. This indicates a regional disparity. Labor market rigidities also restrict VC investment, particularly the European markets. Employment protection legislation (Cherif and Gazdar, 2011; Bonini and Alkan, 2012). Yet some show positive impact of labor market rigidities (Schertler, 2003a; Bozkaya and Kerr, 2014).

Fundamental changes in economic situations such as high-tech bubble and 2008 financial crunch have dramatic effects on VC financing particularly risk preferences and investment strategies (Ning, Wang and Yu, 2015). Previous research has also shown that GDP growth rate contributes positively to the promotion of VC (Cherif and Gazdar, 2011). Others show that GDP is not linked to VC development (Jeng and Wells, 2000; Kumar and Orleck, 2002). The article also takes in to account the currency exchange rate. VC investments include both national and cross border investments. International investors calculate their investments and returns in US dollars. They convert US dollars into local currencies while investing in portfolio companies and back into US dollars to receive proceeds upon exits (Minardi *et al.*, 2017). Although, Minardi *et al.* (2017) find no evidence that currency exchange rates have any significant influence on VC returns in the long term in Brazil, it is still not clear how much is the effect of the exchange rate over the years on country's VC investment. We expect a negative effect of the exchange rate on VC investment. Considering this, the present article uses the recently introduced novel financial development index[5], GDP growth, taxation, employment, and exchange rate as control variables. Financial development index, GDP growth and employment are expected to exert a positive impact on VC activity whereas taxation and exchange rate are expected to have negative impact on VC activity.

Moreover, following Li & Zahra (2012), this study uses bubbles and trend variables as control variables. Bubbles variable captures the cyclical fluctuations caused by Dot Cot bubble during 1999-2000 and market crash triggered by property prices in 2007-2008. Bubbles is a dummy variable equal to one for the years 1999, 2000, 2007 and 2008. Trend has been introduced to capture the impact of all other variables that vary over time but have not been considered in the regressions.

[5] Which consists of financial markets index and financial institutions index. Further, the financial markets index consists of access, depth, and efficiency of financial markets whereas financial institutions index consists of access, depth and efficiency of financial institutions.

3 Methodology

3.1 Model Specification and Robustness tests

The Wooldridge test for autocorrelation in panel data shows the first order autocorrelation is insignificant. The Breusch-Pagan/Cook-Weisberg test for heteroskedasticity rejects the null that there is constant variance in the data or in other words indicate the presence of heteroskedasticity. To tackle endogeneity, both Durbin-Wu-Hausman and Wu-Hausman F tests were conducted using ivendog routine in Stata Stata 15.0 which shows the presence of endogeneity in GDP growth. This is consistent with the findings of Ning, Wang and Yu (2015) showing that GDP growth is endogenous regressor of VC investment. Fixed effects estimator is not an option because the cultural regressors are time-invariant and that it does not tackle endogeneity. GMM is the most suitable estimator in the presence of endogeneity and heteroskedasticity (Roodman, 2009). However, this method has limitations particularly in panels with larger T and smaller N. Our sample consists of 32 countries and 28 years of data enough for instruments to outnumber groups even after using collapse option – that reduces number of instruments — in Stata 15.0. In longer time periods and small group size, the number of instruments explode in System GMM estimations making it inconsistent (Roodman, 2009) which is the key reason to avoid System GMM. Breusch and Pagan Lagrangian multiplier test was conducted for random effects and the result suggests the use of random effects against pooled OLS. Following Li & Zahra (2012), the article uses generalized two stage least square (G2SLS) IV estimator to tackle endogeneity.

3.2 Econometric Model

Consider the following random effects model:

$$VCI_{it=}\beta_1 + \beta_2 \mathrm{P}\,PR_{it} + \beta_3 ICT_{it} + \beta_4 Patents_{it} + \beta_6 GDPGR_{it} + \beta_5 Culture_i + \beta_6 Z_{it} + \mu_i + e_{it}$$

The subscripts "i" signifies countries and "t" represents time in years. VCI_{it} denotes venture capital investment as percent of GDP which is the dependent variable that varies across countries and time. β_1 is the intercept whereas β_2 to β_6 measure the slopes of explanatory variables. The exogenous predictors that change across countries and over time include protection of property rights denoted by $\mathrm{P}\,PR_{it}$, ICT symbolized by ICT_{it} and patents as percent of population represented by $Patents_{it}$.

GDP growth, symbolized as $GDPGR_{it}$, is the endogenous variable instrumented with gross capital formation (GCF) as percent of GDP. GCF, also called gross domestic investment or investment ratio consists of "outlays on additions to the fixed assets of the economy plus net

changes in the level of inventories"[6]. In the 'neoclassical growth models in a closed economy', it equals savings ratio (Barro, 1996). In line with the basic Solow model, the ratio of investment to output bears positive impact on economic growth by virtue of equilibrium level of output per effective worker (Long and Summers, 1991; Mankiw, Romer and Weil, 1992; Barro, 1996). Adams (2009) show that gross domestic investment exerts a positive impact on GDP growth. This offers theoretical base to the GCF % GDP as an instrument for GDP growth.

The cultural variables are represented by $Culture_i$ that vary only across countries but not over time. Control variables, denoted by Z_{it}, include time trend, a dummy variable to capture market crashes of 1999-2000 and 2007-2008 labeled as "bubbles", tax burden, employment, exchange rate and financial development index. Cross-sectional errors are denoted by μ_i and observation-level error is represented by e_{it}.

The data used in this study have been gathered from various sources and covers period from 1990 to 2017 (Appendix 2). Data for VC investment % GDP has been extracted from AVCJ, Eurostat and EVCA Yearbooks. The data of ICT variables, GDP growth, patents, and gross capital formation (GCF) % GDP have been sourced from Word Bank database. Data of financial development index has been obtained from IMF while data on exchange rate and employment have been taken from Penn World Tables Version 9.1 (Feenstra, Robert and Timmer, 2015). Tax burden, property rights, and business freedom data have been borrowed from Heritage Foundation whereas data for the variable legal system and property rights has been obtained from Frazer Institute which was available only for 1990, 1995 and 2000-2017. Data of cultural variables come from Hofstede, Hofstede and Minkov (2010). The data pertains to 19 European countries and 13 Asia-Pacific countries. The European countries include Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Hungary, Ireland, Italy, Netherlands, Norway, Poland, Portugal, Romania, Spain, Sweden, Switzerland, United Kingdom. The Asia-Pacific countries are Australia, China, Hong Kong, India, Indonesia, Japan, Malaysia, New Zealand, Philippines, Singapore, South Korea, Thailand, and Vietnam.

4 Results

4.1 Summary Statistics

Summary statistics have been presented in Table 1. The sample consists of 896 observations. However, due to missing observations, some of the variables such as tax burden and property rights display lesser observations that will lead to a reduction in the total number of observations and these observations vary across different models. All the time invariant

[6] Definition taken from World Development Indicators, World Bank

variables have been log transformed except financial development index and patents % population which are already narrow in range.

Internet use, financial development and trend show the highest correlation with VC investment which is the dependent variable. Some of the variable display high correlation. For example, power distance has correlation magnitude of 0.68 with property rights and individualism. There is no concern of multicollinearity among the variables as variance inflation factor is near 3 or less in all the models used in this study. Patents and uncertainty avoidance are also highly correlated with VC investment. Uncertainty avoidance and masculinity are negatively correlated whereas individualism is positively correlated with VC investment. The instrumental variable i.e. gross capital formation is highly correlated with endogenous variable GDP growth.

Table 1: Summary statistics

Variable	Observations	Mean	Standard deviation	Minimum	Maximum
VC investment % GDP	805	-2.14	1.67	-12.72	1.85
Bubbles	896	0.14	0.35	0.00	1.00
Trend	896	14.50	8.08	1.00	28.00
Tax burden	729	4.12	0.27	3.40	4.54
Employment	896	3.84	0.13	3.52	4.24
Exchange rate	896	1.89	2.69	-6.10	10.02
Financial development index	896	0.58	0.20	0.00	1.00
Property rights	729	4.19	0.47	2.30	4.58
Internet use	857	2.45	2.54	-9.86	4.58
Patents % population	869	0.56	0.80	0.00	4.19
Uncertainty avoidance	896	58.34	24.90	8.00	104.00
Individualism	896	52.88	23.98	14.00	90.00
Masculinity	896	50.72	21.49	5.00	95.00
Power distance	896	54.41	22.95	11.00	104.00
GDP growth	790	1.12	0.83	-2.78	2.68
Gross capital formation % GDP	890	3.21	0.21	2.53	3.84

Table 2: Matrix of correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
(1) VC investment % GDP	1.000															
(2) Bubbles	0.121	1.000														
(3) Trend	0.386	-0.227	1.000													
(4) Tax burden	0.033	-0.048	0.255	1.000												
(5) Employment	0.198	-0.006	0.173	0.062	1.000											
(6) Exchange rate	-0.139	-0.006	0.027	0.367	-0.069	1.000										
(7) Financial development	0.398	0.038	0.155	-0.219	0.436	-0.406	1.000									
(8) Property rights	0.153	0.007	-0.087	-0.377	0.192	-0.445	0.621	1.000								
(9) Internet use	0.481	-0.051	0.634	-0.070	0.289	-0.266	0.522	0.373	1.000							
(10) Patents % population	0.224	-0.009	0.031	0.193	0.365	0.247	0.374	0.300	0.254	1.000						
(11) Uncertainty avoidance	-0.279	0.024	0.008	-0.142	-0.316	0.013	-0.078	-0.002	0.066	-0.007	1.000					
(12) Individualism	0.100	-0.006	-0.022	-0.589	-0.085	-0.501	0.337	0.568	0.296	-0.163	0.066	1.000				
(13) Masculinity	-0.180	-0.005	0.023	0.376	-0.150	0.055	-0.055	-0.123	-0.110	0.119	0.179	0.012	1.000			
(14) Power distance	-0.027	0.012	0.039	0.537	-0.339	0.345	-0.486	-0.675	-0.351	-0.107	0.058	-0.698	0.096	1.000		
(15) GDP growth	-0.007	0.092	-0.158	0.304	-0.086	0.227	-0.331	-0.373	-0.333	-0.061	-0.268	-0.366	0.034	0.352	1.000	
(16) Gross capital formation % GDP	-0.077	0.066	-0.049	0.276	0.254	0.356	-0.182	-0.367	-0.247	-0.141	-0.100	-0.443	0.073	0.289	0.400	1.000

4.2 Empirical Results

The main results have been presented in Table 3 with reduced form equations in Column 1 and 3, while the second stage regressions in Column 2 and 4. GDP growth has been instrumented with the gross capital formation (GCF) % GDP. In addition to their theoretical relevance presented in Section 3.2, the effect of the instrument is quantitatively very large and statistically very significant in the reduced form equation with large F statistic as shown in Column 1 and Column 3 of Table *3*. Moreover, the weak instrument test was performed for the instrumental variable using condivreg routine in Stata 15.0. The overall F statistic is 40 and the confidence intervals of the three size corrected tests (i.e. Conditional LR, Anderson-Rubin, and LM Score) are wider compared to the asymptotic 95% confidence intervals of the GDP growth. This indicates that GCF variable does not suffer from weak instrument effect. But the p values of the three tests are not significant at 10% which is a bit of a concern. To address the concern, the coefficients and standard errors of GDP growth using IV 2sls regressions were obtained. These coefficients and standard errors were not significantly different from the magnitudes in the condivreg test results confirming that the instrument is not weak.

Column 2 shows that the trend variable is highly significant, indicating that the VC industry has grown vigorously during the period under investigation. Property rights display an insignificant positive impact on VC investment rejecting Hypothesis 1. Among the informal institutions, uncertainty avoidance has a strong negative while power distance has a strong positive impact on VC investment confirming hypotheses 2 and 3. A country 10 percentage points higher on uncertainty avoidance experiences a decrease of 0.24 percentage points in VC investment. An increase of 10 percentage points in power distance worth about 0.28 percentage points increase in the VC investment. Individualism is significant only at 10% whereas masculinity is not significant. Thus Hypothesis 4 is partially supported whereas Hypothesis 5 is not supported. Internet use and patents show strong and positive impact on VC investment supporting the Hypothesis 6 and Hypothesis 7. With 10 percentage point increase in individuals using internet in a country, the VC investment increase by 2.7 percentage points while 10% increase in patents worth about 3.2 percentage points increase in VC investment. The second stage regression in Column 4 has excluded the trend variable as it is highly correlated with internet use (0.63 in Table 2 and 0.75 in pairwise correlation). Though the internet use is significant in Column 2, its coefficient improves after removing trend variable from equation in Column 4. All the models with internet use will be presented without the trend variable to avoid potential collinearity.

4.3 Interaction Analysis

There is a strong interaction between formal institutions and ICT in their impact on VC investment. To test the Hypothesis 8, Column 1 in Table 4 introduces the interaction term for property rights (Heritage Foundation) and internet use. The interaction worth about 2 percentage points share in the VC investment if the former changes by 10 percentage points. The positive sign indicates that internet use positively interacts with property rights supporting

Hypothesis 8. The corresponding interaction plot in Figure 3(a) signifies that internet use significantly improves VC activity in environments of strong property rights.

Table 3: Impact of institutions, ICT, innovation, and culture on country-level amount of venture capital investments % GDP

	G2sls			
	First stage	Second stage	First stage	Second stage
	(1)	(2)	(3)	(4)
Constant	2.326	0.945	2.647*	-1.971
	(1.432)	(5.433)	(1.391)	(5.454)
Bubbles	0.111	0.702***	0.151**	0.588***
	(0.0704)	(0.164)	(0.0657)	(0.172)
Trend	-0.0134**	0.0471***		
	(0.00610)	(0.0146)		
GDP growth		-0.369		-0.522
		(0.632)		(0.641)
Tax burden	0.489***	-0.651	0.426***	-0.187
	(0.151)	(0.671)	(0.146)	(0.658)
Employment	-1.221***	-0.590	-1.296***	-0.0787
	(0.310)	(1.279)	(0.302)	(1.242)
Exchange rate	-0.0320**	0.0186	-0.0371***	0.0309
	(0.0136)	(0.0427)	(0.0133)	(0.0429)
Financial development index	-0.571***	1.591	-0.607***	1.845
	(0.210)	(1.155)	(0.206)	(1.183)
Property rights	-0.206**	-0.225	-0.175*	-0.382
	(0.0887)	(0.331)	(0.0895)	(0.332)
Internet use	-0.0131	0.269***	-0.0510***	0.384***
	(0.0195)	(0.0771)	(0.0146)	(0.0793)
Patents % population	0.0276	0.432***	0.0495	0.321*
	(0.0415)	(0.149)	(0.0400)	(0.180)
Uncertainty avoidance	-0.00819***	-0.0240***	-0.00827***	-0.0241***
	(0.00127)	(0.00785)	(0.00126)	(0.00704)
Individualism	-0.00326*	0.0132*	-0.00353*	0.0149*
	(0.00189)	(0.00775)	(0.00188)	(0.00783)
Masculinity	-0.00173	-0.00852	-0.00184	-0.00879
	(0.00145)	(0.00598)	(0.00145)	(0.00574)
Power distance	-0.00104	0.0275***	-0.00157	0.0302***
	(0.00222)	(0.00659)	(0.00218)	(0.00639)
Gross capital formation % GDP	1.173***		1.189***	
	(0.119)		(0.120)	
#Observations	641	622	641	622
#Countries		32		32
R-squared	0.388		0.383	
Wald		207.8		163.9

Note: - Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. GDP growth has been instrumented with GCF % GDP. Column 1 is the reduced form equation for G2sls IV regression in Column 2 and similarly Column 3 presents first stage regression for G2sls IV estimation in Column 4.

Table 4: Impact of formal institutions, ICT, innovation, and culture on country-level amount of venture capital investments % GDP: Interaction analysis

	G2sls					
	(1)	(2)	(3)	(4)	(5)	(6)
Constant	-1.004	-7.094**	-2.472	6.730	-4.217	-0.0180
	(5.122)	(3.137)	(3.241)	(5.139)	(3.992)	(4.863)
Bubbles	0.560***	0.380***	0.435***	0.541***	0.514***	0.708***
	(0.155)	(0.130)	(0.154)	(0.144)	(0.153)	(0.142)
Trend						0.0834***
						(0.0139)
GDP growth	-0.208	0.472	0.0387	-0.0985	-0.0210	-0.146
	(0.598)	(0.598)	(0.552)	(0.523)	(0.572)	(0.590)
Tax burden	-0.252	-0.196	-0.338	-0.236	-0.424	-0.341
	(0.644)	(0.686)	(0.599)	(0.646)	(0.598)	(0.528)
Employment	-0.199	0.721	0.103	-0.168	0.289	-0.791
	(1.183)	(0.997)	(0.985)	(1.014)	(0.947)	(1.101)
Exchange rate	0.0313	0.0524	0.0774	0.0159	0.0317	0.0603
	(0.0460)	(0.0458)	(0.0561)	(0.0419)	(0.0408)	(0.0389)
Financial development index	1.466	1.290	0.584	1.551	1.419	2.931***
	(1.056)	(1.041)	(0.955)	(0.948)	(1.033)	(0.930)
Patents % population	0.301*	0.263**	0.310**	0.307**	-1.540***	1.398***
	(0.165)	(0.129)	(0.131)	(0.147)	(0.372)	(0.233)
Uncertainty avoidance	-	-0.0129**	-	-	-	-0.00885
	0.0213***		0.0177***	0.0197***	0.0194***	
	(0.00663)	(0.00604)	(0.00619)	(0.00674)	(0.00622)	(0.00581)
Individualism	0.0148**	0.0192**	0.0183**	0.0151**	0.0173**	0.0202***
	(0.00751)	(0.00805)	(0.00806)	(0.00667)	(0.00723)	(0.00576)
Masculinity	-0.00751	-0.00664	-0.00657	-0.00785	-0.00622	-0.0119**
	(0.00539)	(0.00662)	(0.00616)	(0.00543)	(0.00458)	(0.00468)
Power distance	0.0313***	0.0315***	0.0343***	0.0291***	0.0282***	0.0206***
	(0.00654)	(0.00743)	(0.00623)	(0.00655)	(0.00569)	(0.00497)
Internet use	-0.312*	-0.630**		-2.201***	0.341***	
	(0.167)	(0.292)		(0.675)	(0.0722)	
Property rights	-0.651*				-0.0672	-0.519
	(0.340)				(0.287)	(0.324)
Property rights×Internet use	0.200***					
	(0.0569)					
Legal system property rights		-0.997	-1.896**			
		(0.723)	(0.803)			
Legal system & property rights×Internet use		0.619***				
		(0.177)				
Mobile subscriptions			-1.025***			
			(0.308)			
Legal system & property rights×Mobile subscriptions			0.907***			
			(0.203)			
Business freedom				-2.545***		
				(0.853)		
Business freedom ×Internet use				0.643***		
				(0.174)		
Patents % population×Internet use					0.456***	
					(0.0913)	
Patents % population× Uncertainty avoidance						-
						0.0137***
						(0.00333)
#Observations	622	521	524	622	622	625
#Countries	32	32	32	32	32	32
Wald	296.6	358.3	563.8	224.3	405.1	635.8

Note: - Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. GDP growth has been instrumented with GCF % GDP. The table show only second stage regressions for G2sls IV estimation.

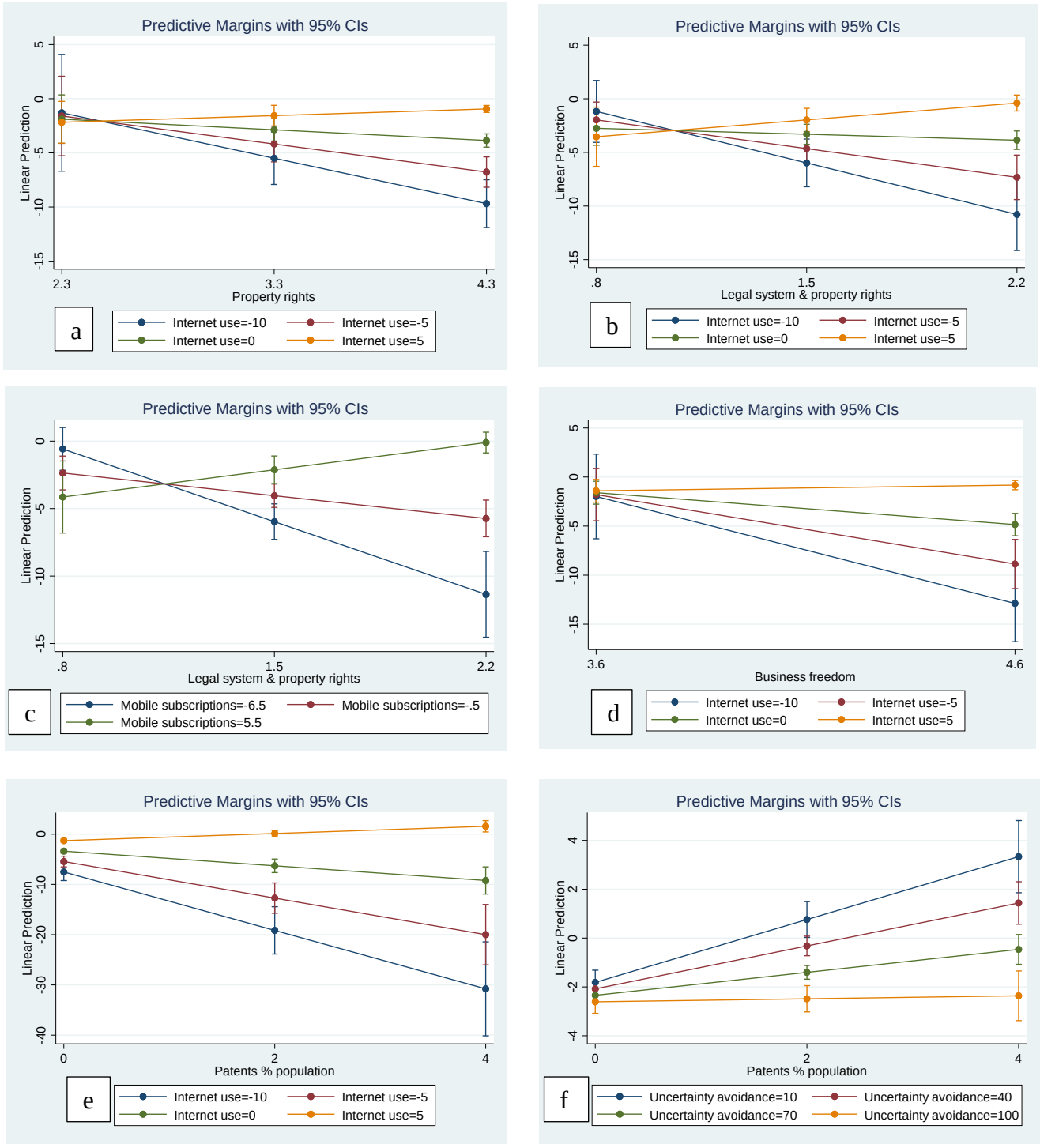

Figure 3: Interaction Plots (Source: Author)

For robustness, Column 2 shows the interaction of internet use with legal system and property rights (Frazer Institute) followed by interaction of interaction of internet use and mobile subscriptions in Column 3. An interaction term for internet use and business freedom (Heritage Foundation) has been shown in the Column 4. All of them demonstrate similar pattern confirming that the results of interaction between formal institutions and ICT are robust to different measures of ICT and different measures and sources of formal institutions. The significant negative sign of ICT variables in the first four columns show that they play a negative role in absence of strong institutions. The interaction terms are significantly positive which indicates that institutional quality favorably impacts the effect of ICT on VC investment. To improve VC activity, it is ideal to have favorable ICT environment and strong formal institutions at the same time.

The graphs further help to interpret these interactions (see also Figure 3a to 3d). The orange line in Figure 3 (a) depict high digital environment whereas the blue line show that ICT is less embedded in society. The wide gaps between the lines between the highest and lowest internet use on the right-hand side of the graph represent the ICT differential in high property rights environments. This shows that ICT exerts highest positive impact on VC when property rights are strong. Rest of the graphs representing formal institutions (i.e. from Figure 3b to 3d) follow the same pattern and have similar interpretations. Overall, we conclude that strong formal institutions makes it sure that there is transparency in the electronic transactions protecting consumers from online market frauds particularly in e-commerce (Shareef, Kumar and Kumar, 2008) that promotes demands side of VC.

The impact of interaction term for patents and internet use has been reported in Column 5. As expressed in Hypothesis 9, the effect is positive which indicates that ICT favorably impacts the relationship between innovation and VC activity. The negative coefficient of patents suggests that they play negative role in the absence of ICT. The interaction plot in Figure 3 (e) shows VC activity is at highest point when patents and internet use are high, thereby supporting Hypothesis 9.

Finally, a significant positive interaction term for uncertainty avoidance and patents indicates that VC thrives in uncertainty tolerant environments number of patents % population are high. The blue line in Figure 3 (f) representing a high level of uncertainty tolerance moves up as patents on horizontal line moves from 0 to 2 and 2 to 4. This indicates that patents generate more VC activity in low uncertainty avoidance (or high tolerance) countries. The result supports Hypothesis 10.

4.4 Comparing Asia-Pacific with Europe

To compare the two regions, the variables suspected to be different in the two regions have been examined through their interaction with the dummy variable representing region that equals 1 for Europe and 2 for Asia-pacific. Separate regressions for Europe and Asia-Pacific region would suffer from small sample bias (and thus avoided) particularly for the time-invariant cultural regressors that vary only across space but not time. Table 5 presents the interaction terms for region and selected variables. In Column 1, the positive coefficient of

interaction of regional dummy with trend indicate that Asia-Pacific region has experienced strong VC investment activity in the given period compared to Europe which is also indicated by Figure 1.

Table 5: Interaction of region with selected variables: Dependent variable is VC investment % GDP.

	G2sls			
	(1)	(2)	(4)	(5)
Constant	2.488	0.997	-1.071	1.333
	(6.057)	(5.920)	(4.706)	(5.377)
bubbles	0.753***	0.747***	0.687***	0.693***
	(0.157)	(0.162)	(0.157)	(0.159)
Trend	-0.0484	0.0613***	0.0469***	0.0481***
	(0.0376)	(0.0154)	(0.0151)	(0.0146)
GDP growth	-0.433	-0.447	-0.392	-0.368
	(0.539)	(0.572)	(0.599)	(0.626)
Tax burden	-0.285	-0.468	-0.566	-0.801
	(0.699)	(0.705)	(0.546)	(0.668)
Employment	-1.049	-0.466	-0.908	-1.005
	(1.307)	(1.252)	(1.147)	(1.293)
Exchange rate	0.0177	0.0428	0.0687	0.0453
	(0.0467)	(0.0465)	(0.0467)	(0.0405)
Financial development index	1.673	2.029*	2.096*	1.999*
	(1.164)	(1.228)	(1.075)	(1.032)
Property rights	-0.0639	-0.142	-0.256	-0.157
	(0.374)	(0.364)	(0.309)	(0.304)
Internet use	0.198**	-0.328	0.248***	0.264***
	(0.0829)	(0.280)	(0.0705)	(0.0729)
Patents % population	0.292*	0.307*	0.453***	0.340**
	(0.154)	(0.172)	(0.125)	(0.162)
Uncertainty avoidance	-0.0224***	-0.0244***	0.0262	-0.0343***
	(0.00746)	(0.00772)	(0.0189)	(0.0106)
Individualism	0.0129*	0.0144*	0.0161***	0.00456
	(0.00747)	(0.00760)	(0.00608)	(0.0100)
Masculinity	-0.0105*	-0.0104*	-0.0119**	-0.00465
	(0.00573)	(0.00611)	(0.00496)	(0.00591)
Power distance	0.0232***	0.0272***	0.0174**	0.0762***
	(0.00817)	(0.00746)	(0.00783)	(0.0224)
Region	-1.083**	-0.976*	2.116***	1.680**
	(0.421)	(0.530)	(0.728)	(0.716)
Region× Trend	0.0737***			
	(0.0253)			
Region× Internet use		0.308**		
		(0.148)		
Region× Uncertainty avoidance			-0.0342***	
			(0.0104)	
Region× Power distance				-0.0348**
				(0.0154)
#Observations	622	622	622	622
#Countries	32	32	32	32
Wald	306.4	251.9	312.2	364.2

Note: - Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. GDP growth has been instrumented with GCF % GDP. The table show only second stage regressions for G2sls IV estimation.

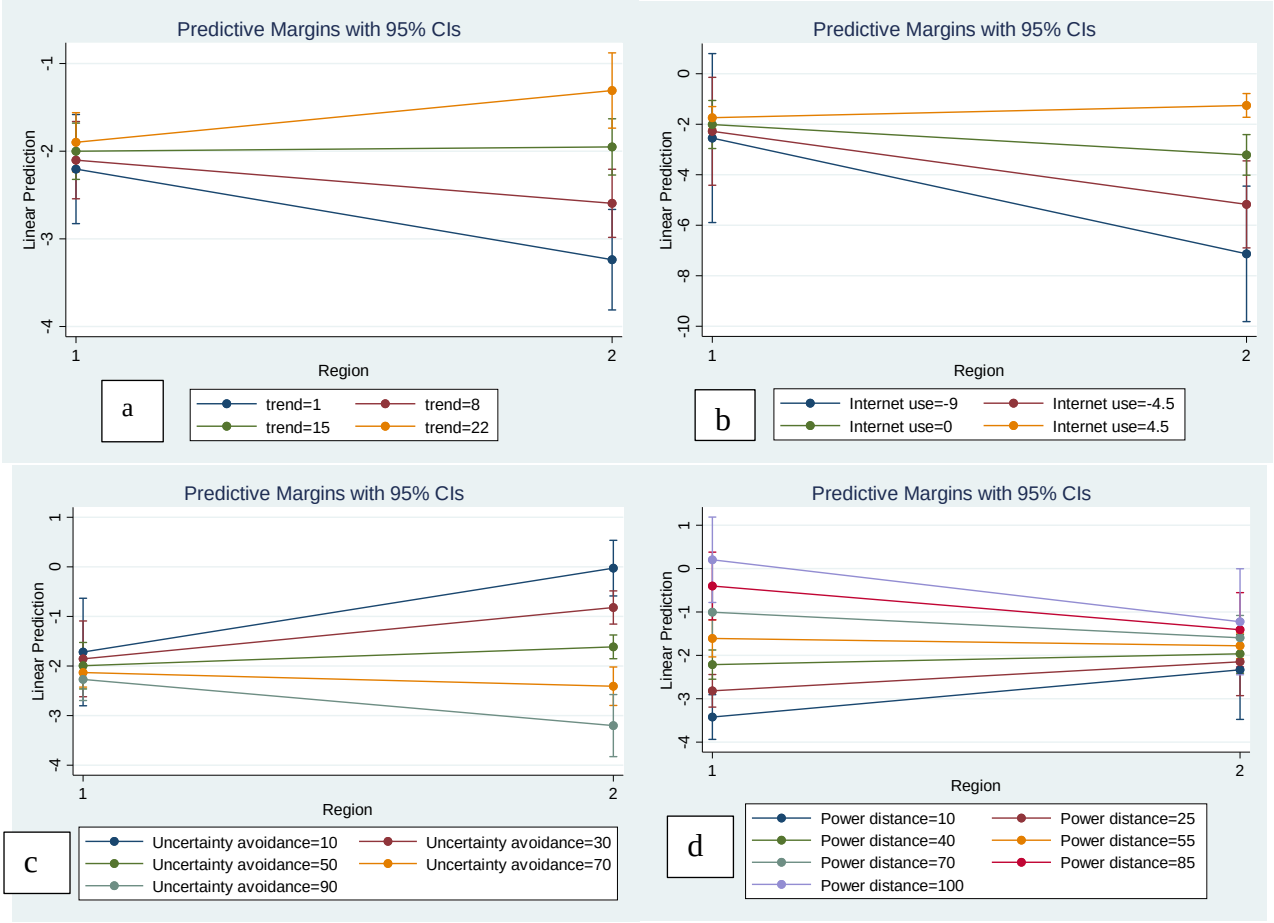

Figure 4: Interaction of region with selected variables: Dependent variable is VC investment % GDP (Note: - The figures are based on regression results in Table 5.)

The interaction of the regional dummy and internet use in Column 2 is also significant at 5% indicating that internet use is more pronounced in Region 2 compared to Region 1. Column 3 introduces the interaction term for regional dummy with uncertainty avoidance which is statistically significant at 1%. The negative sign indicates that as we jump from Region 1 to Region 2, the uncertainty avoidance exerts more negative impact on VC investment. The interaction term for regional dummy and power distance also demonstrate negative impact. As we move from Region 2 to Region 1, the impact of power distance on VC increase by .05 percentage points whereas the impact of internet use decrease by .31 percentage points.

To better interpret, these interactions have been visualized in Figure 4a to 4d. Region 1 represents European countries whereas Region 2 on the right-side show Asia-pacific region. In Figure 4 (a), as we move from Region 1 to Region 2, the lines get wider up- and down-wards. Blue line represents the early periods i.e. in and around 1990, whereas orange line depicts the

most recent period i.e. in and around 2017. Compared to Europe, Asia-Pacific experienced significantly lower VC investment in earlier years but significantly higher in most recent years.

With some variation, the same pattens have been demonstrated by internet use that it matters more in Asian than in Europe to predict VC investment. In Europe, internet use differential makes not much difference in VC activity as it does in Asia-Pacific. Like others, uncertainty avoidance has been depicted by different colors with blue line representing the lower uncertainty avoidance (i.e. high uncertainty tolerance) whereas grey color line represents high uncertainty avoidance. The figure shows that Asia-Pacific countries with lowest uncertainty avoidance (right end of the blue line) have experienced the highest VC investment and Asia-Pacific countries with lowest uncertainty avoidance have invested the lowest in VC. VC investment varies slightly with change in uncertainty avoidance across countries in the European region. On the other hand, the uncertainty avoidance differential in Asia Pacific region predicts significantly larger variation in VC investment. Power distance, on the other hand, has strong and positive impact on VC investment in Europe than in the Asian-Pacific region and that European countries high on power distance invest more VC than all other countries in both the regions.

5 Discussion and Conclusion

In summary, the current paper has examined the impact of formal and informal institutions, ICT and innovation on VC investment. Informal institutions are proxied by uncertainty avoidance, power distance, individualism, and masculinity. The results show that patents, ICT, power distance and individualism exert significant effect on VC investment whereas the uncertainty avoidance demonstrate strong and negative influence on VC. The impact of formal institutions and masculinity are insignificant unlike hypothesized. The impact of ICT on VC investment varies with formal institutions, while the influence of innovation on VC investment varies with ICT and informal institutions. These relationships were presented in hypotheses and depicted in the conceptual model in Figure 2. The study concludes that institutional quality is more important when coupled with digitization of a country. Moreover, patents can be further exploited to generate knowledge-based economy and innovative entrepreneurship attracting VC investment if a country is high on uncertainty tolerance and experiences more digital activity.

While the impact of patents on VC is already established in the literature (Schertler, 2007), the stronger impact of ICT on VC confirms the recent findings by Khan *et al.* (2020) who found ICT to have a strong effect on early stage and later stage VC[7]. Financial systems – and for that matter VC – are information systems (Ocampo, 2018) and VC is information-problematic industry (Fiet, 1995; Lockett *et al.*, 2002), VC processes involve more due

[7] They have used narrower definition of VC.

diligence and monitoring compared to other financing alternatives (Carey et al., 1993). Certainly, ICT has facilitated VC processes of information collection for deal selection, deal origination and structuring, monitoring, and valuations. The other aspect of ICT is that it enhances deal flow by creating entrepreneurial opportunities (Melissa, Hamidati and Saraswati, 2013).

The impact of informal cultural institutions on VC is also pronounced. Uncertainty avoidance exerts a negative impact on VC because such cultures create circumstances where entrepreneurs and VCs repel each other to reach a risky deal. Similarly, masculinity also exhibits a negative influence on VC because masculine environments are hostile and less cooperative whereas VC development needs cooperative behavior at least between the VCs and the entrepreneur. However, the impact is insignificant. Consistent with our hypothesis, power distance has significant and positive impact on VC investment because in high power distance cultures entrepreneurs easily handover control to VCs compared entrepreneurs in low power distance cultures. Also, individualism demonstrates significant and positive influence on VC. The reason is that the strong role of family as an institution may refrain entrepreneurs from handing over control to VC (Spencer and Gomez, 2004). Moreover, we argue that collectivist cultures promote informal businesses because firms rely more on informal institutions than formal markets (World Development Report, 2002) and informal businesses do not attract formal VC.

Formal institutions have an insignificant positive influence on VC investment against the hypothesized significant positive impact. However, its moderating influence on the association between ICT and VC is highly significant as hypothesized. While high quality institutions protect the property rights of business actors, they cannot create entrepreneurial opportunities and deal flow for venture capital. ICT, on the other hand, boosts entrepreneurial activities and performance (Asongu and Nwachukwu, 2018; Zhang and Li, 2018) strengthening the demand side of VC and that ICT grows when institutional quality is high. This gives us striking evidence that institutional quality alone is not important for VC development unless it is coupled with digitization reflecting the technology-dependent nature of VC.

The explanatory power of interaction term for innovation and informal institutions is also very important. The association between patents and VC investment is adversely affected by uncertainty avoidance. This means that patents cannot be converted into innovative driven entrepreneurship in an environment where security is preferred over risk-taking (Spencer and Gómez, 2004). One possible explanation is that lower uncertainty avoidance enhances the pace of innovation diffusion (Van Den Bulte and Stremersch, 2004). Even if the rate of patents is high in uncertainty avoidance cultures, such patents do not attract VC because uncertainty-avoidant entrepreneurs would not venture into risky projects to convert patents into innovative start-ups or products. Ultimately, this reduces the deal flow for venture capital. Another interpretation is that VCs as entrepreneurs would also avoid investing VC in risky projects in environments where there is tendency to avoid uncertainty by culture.

Moreover, as hypothesized, the effect of innovation is conditional upon ICT use. One possible interpretation is that unless there is widespread use of digital technology in a country, entrepreneurs are not able to fully exploit the innovative potential that would, otherwise, create entrepreneurial activity and deal flow attracting VC. This is in line with existing entrepreneurship theory supporting the view ICT has a positive impact on entrepreneurship. Higón (2012) find that ICT acts as efficiency-enhancing technology that can create a competitive advantage for SMEs through product innovation. In other words, at an aggregate level, ICT increases the chances that SMEs would attract VC because ICT enhances innovation (Ollo-López and Aramendía-Muneta, 2012; Hall, Lotti and Mairesse, 2013). Therefore, we can conclude that ICT helps entrepreneurs to exploit patents and that patents exert a positive impact on VC investment when ICT use is frequent.

Regarding the regional differences, uncertainty avoidance, internet use, and trend are more noticeable in their impact on VC investment in the Asia-Pacific region than in Europe. On the other hand, the impact of power distance is more prominent in Europe than in the Asia-Pacific region. The high impact of the interaction term for trend and regional dummy indicates that the Asia-Pacific region has experienced more VC investment during the time under study compared to Europe. The same is evident in Figure 1 that shows Asian countries have experienced more VC activity than its European counterpart. The regional disparities indicate structural and contextual differences such as income inequality and other cultural and institutional factors not captured in this study that needs further scrutiny in future research.

The novel contribution of this research is that such interaction analysis has never been conducted previously. Khan et al. (2020) show that the impact of domestic credit on VC investment vary adversely with ICT embeddedness in enterprises. Li & Zahra (2012) show that formal institutions have a positive impact on VC investment and this effect weakens in countries high on uncertainty avoidance. Khan, Ferrier, and Khan. (2020) show that formal institutions favorably moderate the impact of financial development on venture capital fundraising. The current research is the first in investigating the moderating effect of formal institutions on the relationship between ICT and VC investment. Additionally, it examines for the first time the moderating role of ICT and uncertainty avoidance on the association between innovation and VC investment. Furthermore, it presents a conceptual model to explain VC investment in context of formal and informal institutions, ICT and innovation. Finally, the present research uses gross capital formation as an instrument for GDP growth in VC investment research for the first time. The instrument is theoretically relevant and passes statistical tests of weak instruments.

The article suggests strong policy recommendations. Without taking the contextual and institutional environment into account, policy to boost entrepreneurship and venture capital would be less effective (Li and Zahra, 2012). Institutional quality must be coupled with high adoption and diffusion of ICT as it offers substance to the VC market in the form of more

entrepreneurial activities and high deal flow. While patents are important to develop VC market, they attract more VC when an economy has a strong digital base and experiences lower uncertainty avoidance.

There is also a scope for future research on other aspects of VC such as exits from VC investments. Research has demonstrated that digital technologies have resulted in massive improvements and an enormous increase in trading volumes. For instance, in the last ten years, the US has experienced an almost twelve-fold increase in annual stock turnover between 1988 and 2008 and increase in stock market capitalization to GDP from 58% in 1988 to 163% in 1999 (Stockhammer, 2013). Such digitization might have a strong impact on VC exits as well. Moreover, there is a need to see how the conceptual model used in this research applies to the exits from VC investments. The conceptual model repositions the role institutions and innovation play in technology dependent VC markets.

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Appendix 1: Previous Studies on VC Research

Authors	**Region/Countries**	**Period**	**Factors influencing VC**
Jeng and Wells (2000)	21 countries (US, Europe, Japan and Australia)	1986-1995	IPO and labor market rigidity
Bonini and Alkan (2012)	16 countries (US, Europe, Japan and Australia)	1995-2002	Favorable sociopolitical, entrepreneurial environment and legal system
Black and Gilson (1998)	US, Japan and Germany	1992-1995	Stock-market centered capital market
Kumar and Orleck (2002)	9 countries (USA and Europe)	1986-1999	Exit options, cost capital, legal traditions, patent regulation, and the transparency of markets
Ning, Wang and Yu (2015)	US	1995-2011	Stock market, GDP growth rate and industry production index have positive impact on VC; Global financial crises also affect VC
Félix et al. (2013)	23 European nations	1992–2003	GDP growth, interest rate, IPO, M&A, Market-to-Book Ratio and R&D have sig positive influence Unemployment, Stock Market Capitalization and TEA have negative impact
Groh and Wallmeroth (2016)	118 emerging and developed markets	2000-2013	M&A Investment Volume, Disclosure Index, Shareholder Suits Index, Legal Rights Index, Bribery & Corruption Index, Innovation Index and IP Protection have positive effects on VC inv
Groh and Liechtenstein (2009)	27 European countries	2000-2005	Corporate governance and the protection of investors' rights have positive impact on the attractiveness of a country for VC investment
Da Rin, Nicodano, and Sembenelli (2006)	14 European countries	1988-2001	Stock market; capital gains tax and labor regulation have impact on high-tech investment while capital gains tax has also impact on early stage investment
Romain and Pottelsberghe (2004)	16 OECD countries	1990-2000	Interest rates, stock of knowledge and the number of triadic patents affect positively and significantly the relative level of VC
Baygan and Freudenberg (2000)	OECD countries	1990-2000	Barriers to entrepreneurship
Cherif and Gazdar (2011)	21 European nations	1997–2006	Market capitalization, research and development expenditures, GDP growth and unemployment
Bozkaya and Kerr (2014)	US, UK, and Europe	*1990–2008*	Labor market expenditures (as the mechanism for providing worker insurance)
Cumming et al. (2016)	31 countries of four continents	1996-2010	Increase in oil prices, media coverage, formal institutions (particularly rule of law and government effectives) have sig positive effect while uncertainty avoidance has negative effect on cleantech VC activity
Cumming and Knill (2012)	34 countries from Asia, Europe, North America and South America	2000-2008	More stringent securities regulations – particularly disclosure requirements – positively affect VC supply
Armour and Cumming (2006)	US and 14 EU countries	1990-2002	Temperate bankruptcy laws for entrepreneurs promote VC investment while government programs crowd out.
Schertler (2007)	15 Western European countries	1991–2001	Countries' knowledge capital i.e. number of patents, or the number of R&D researchers, or gross domestic expenditures on R&D.
Schertler (2003b)	14 Western European countries	1988-2000	liquidity of stock markets, human capital endowment, and labor market rigidities affect early stage VC
Li and Zahra (2012)	61 countries	2000-2011	Informal institutions of uncertainty avoidance and collectivism moderate the impact of formal institutions on VC.

Appendix 2: Data descriptions and sources

Variables	**Description**	**Source**	
VC Investment % GDP	It includes seed, start-up, later stage, expansion, growth, and buyout investments.	AVCJ, Eurostat, EVCA Yearbooks	1990-2017
Internet use	Individuals using internet per 100 population	World Bank	1990-2017
Mobile subscriptions per 100 people	Mobile cellular telephone subscriptions are subscriptions to a public mobile telephone service that provide access to the PSTN using cellular technology.	World Bank	1990-2017
Financial development index	It is an index that includes financial markets index and financial institutions index.	IMF	1990-2017
Exchange rate	Exchange rate, national currency/USD	Penn World Tables (Feenstra, Robert and Timmer, 2015)	1990-2017
GDP growth	Annual percentage growth rate of GDP. Aggregates are based on constant 2010 U.S. dollars.	World Bank	1990-2017
Employment	Number of persons engaged divided by total population	Penn World Tables (Feenstra, Robert and Timmer, 2015)	1990-2017
Patents % population	Patent applications (resident and non-resident) are worldwide patent applications filed through the Patent Cooperation Treaty.	World Bank	1990-2017
Tax burden	Tax burden is a composite measure that reflects marginal tax rates on both personal and corporate income and the overall level of taxation as a percentage of gross domestic product (GDP). On the 100-point scale, the highest score indicates the favorability of a taxation system.	Freedom of the World (Heritage Foundation)	1995-2017
Property rights	Property rights is the sub-index of rule of law and measures the degree to which a country's laws protect private property rights and the extent to which those laws are respected. An ideal country with 100 score means that private property is guaranteed by the government.	Heritage Foundation	1995-2017
Business Freedom	It measures the extent to which the regulatory and infrastructure environments constrain the efficient operation of businesses, particularly ease of starting, operating, and closing a business. The business freedom score for each country is a number between 0 and 100, with 100 indicating the freest business environment.	Heritage Foundation	1995-2017
Legal System and property rights	It is the comprehensive index that covers judicial independence, impartial courts, protection of property rights, military interference in rule of law and politics, integrity of legal system, legal enforcement, regulatory costs of the sale of real property, reliability of police, and business costs of crime. It is based on scale 0 to 10, the highest representing highest quality institutions.	Frazer Institute	1990, 1995, 2000-2017
Uncertainty avoidance	The index measures the degree to which people feel ambiguous situations and take measures to deal with uncertainty. Score of 0 on represents high uncertainty tolerance whereas 100 score shows the society is doing best to cope with uncertainty.	(Hofstede, Hofstede and Minkov, 2010)	Time-invariant
Individualism	Individualism represents the lifestyle or culture where people live without much dependence on others opposite to collectivism where people live in an integrated system. Score of 100 is assigned if country is highly individualistic and 0 to highly collectivistic.	(Hofstede, Hofstede and Minkov, 2010)	Time-invariant

Power distance	Power distance is the degree to which targets are susceptible to the influence/power of agents. Score of 0 on power distance means targets do not accept the influence of agents whereas the score of 100 reflects that people in the society as targets completely conform to the views of the agents.	(Hofstede, Hofstede and Minkov, 2010)	Time-invariant
Masculinity	A society is called masculine when men are "more assertive, tough and focused on material success" than women who are more "modest, tender and concerned with quality of life" (page.140). Country-level highest gap in the gender roles is assigned score of 100 whereas gender roles greatly overlapped is assigned score of 0.	(Hofstede, Hofstede and Minkov, 2010)	Time-invariant
Gross capital formation % GDP	Gross capital formation (formerly gross domestic investment) consists of outlays on additions to the fixed assets of the economy plus net changes in the level of inventories.	World Bank	1990-2017