



Bibliometric Analysis of Government Venture Capital

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Abstract

The bibliometric study aims to map and expand respective knowledge by establishing connections between important actors in academic research regarding the government venture capitals (GVCs). The scope is to analyze documents published on Scopus database starting from 2011 to 2020. Accordingly, the United States (U.S.) is the top country in all categories with China catching up. Alperovych, Quas, and Colombo are top co-authors. On the other hand, Leleux, Grilli, Lerner and Cumming are prolific authors. Articles by Grilli and Li Y are two most cited documents. Investments, venture capital, economics, public policy, and government are most co-occurrence index keywords. Research policy, venture capital, and journal of technology transfer, journal of business venturing and small business economics are top sources of cited documents. Closely associated themes with respect to the study of GVCs are government role in venture capital support, effective Innovation financing policies, performance differential, performance of portfolio companies, funding challenges and investment strategy, decision making model and critical success factors for IT startups. The analysis generated gaps and directions for future research consisting of fund's structure and

characteristics, key personnel's work experience and network, geographic location, investment horizon, shareholding rights.

Keywords: Venture capital, Government, Investments, Innovation, Entrepreneurship

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Introduction

Government venture capital (GVC) is an entity established, owned, funded and operated by a management team appointed by the government to provide venture financing to technology-based companies, mostly startups with long-term growth potential primarily when it promotes socio-economic advancement in the respective country. Various studies have shown that GVCs have significantly lower impact to the economy as compared to the private venture capitals (PVCs). Glaring differences between these two entities are in the set of objectives they pursue.

According to Kortum and Lerner (2000), many governments and regional authorities around the world mobilize and implement venture capital programs based on the measured increased impact of successful entrepreneurial activity that can be attributed directly to availability of venture capital. The funds at GVCs are dedicated funds to finance new or cutting-edge technologies that a given country wishes to pursue and master for mostly the socio-economic benefits. The GVC objectives are different from its private sector peers in the venture capital industry. Primarily because of its socio-economic or even security focused objectives such as creating innovation related jobs or mastering certain new or cutting-edge technologies for strategic purpose such as military, health or food security as indicated by the extant literature.

The share of global venture capital investment by sector in 2010 to 2019 indicates that IT software & services and healthcare dominated the investments of venture capital (Global Innovation Index, 2019). While there is no evidence to support that reception of vaccine treatment by country is influenced by the level of venture capital (VC) penetration, it is however suspected that entrepreneurial activities are a contributing factor behind it. The suspicion is based on the simplistic causal inference where higher gross development product (GDP) leads to higher venture capital penetration which in turn leads more active entrepreneurial activities.

Reports provided by the globally monitored innovation-based publications such as Global Innovation Index (GII) have the suggestive power to the creation of vibrant VC industry

where PVC and GVC firms are interconnected with each other notably in countries like the United States of America (US), Israel, Western European countries and lately China. As alluded in the opening paragraph, unlike its counterpart in the private sector, typical GVCs primary objectives are to support respective country's technology entrepreneurs which explained the underweight focus on financial returns but overweight on socio-economic contributions such as employment and mastery of certain selected new or cutting-edge technologies as practiced in Malaysia. In this sense, using bibliometric method to account for respective scientific publications according to methods as well as monitoring and studying relevant documents as an equally important research endeavor (Campbell, Picard-Aitken, Caruso, Valentim, & Al., 2010; Gumpenberger et al., 2012). This is so because bibliometric allow researchers to map and expand respective knowledge by establishing connections between important actors in academic research such as authors and institutions to name a few (Gumpenberger et al., 2012; Vogel, 2014).

Bibliometric method is a great tool to begin a research journey when evaluating a particular field of study (Bornmann, 2014; Campbell et al., 2010) by selecting documents relevant to the chosen topic within the field of study. Through this "filtering" process, researchers able to discover valuable research articles that can be used as a base for decision making regarding direction of research and pressing areas needed further investigation in the literature so on so forth (Bornmann, 2014; Gläser, 2015). While there are considerable number of published articles on venture capital but the study of bibliometric analysis on government venture capital in specific is lacking. Since bibliometric studies are about reliability and relevancy of sources of results in a given field thus in keeping the importance of government venture capital as a field of study, this bibliometric research extract and review articles from literature and perform analyses by enumerating citations, occurrence and bibliographic coupling. The process leads to the discovery of prominent topics and research gap in the field of study.

Research Methodology

This study applies bibliometric techniques, tools, and indicators. Traditionally, bibliometric studies focused on tracing prominent indicators in the academia namely publications and citations (Cronin, 2001). These two highly followed bibliometric indicators are then act as "anchor" to organize other indicators around them namely scientific performance of organizations, agencies, and countries (Narin & Hamilton, 1996). As always, bibliometric studies include patterns built upon data in the chosen databases. Patterns presented consisting of bibliographic coupling – co-citation and co-occurrence – and citation analysis of articles. Despite quantitative nature of bibliometric studies, they also report on qualitative aspect by way of methodological review. This is important to provide a complete view of the chosen topic hence turning it into manageable entity (Wallin, 2005).

Conceptually, this bibliometric study is about understanding the structure, evolution and trend of government venture capital. To this end, briefly, the procedure begins with deciding on what field to study which then Scopus is chosen as platform of search. Data is collected based on the defined criteria which then reviewed, saved and exported. VOSviewer is used to import the data to complete the analysis resulting in parameters and network. Methodological review further grouped the documents into dominant themes which give rise to discussion and implication section. The process ends with conclusion of the study.

Government venture capital firms and government venture capital are two commonly used terminologies to describe government venture capital. In this research, we adopt government venture capital or GVC. To measure GVC performance, the performance of its portfolio companies is normally used as proxy performance. For this bibliometric analysis, we use keywords “government” and “venture” and “capital” and then analyze them in stages as recommended by Otávio José de Oliveira, Fernando Juliani, & Nunhes (2019). Fig. 1 presents steps in which each parameter is explained subsequently.

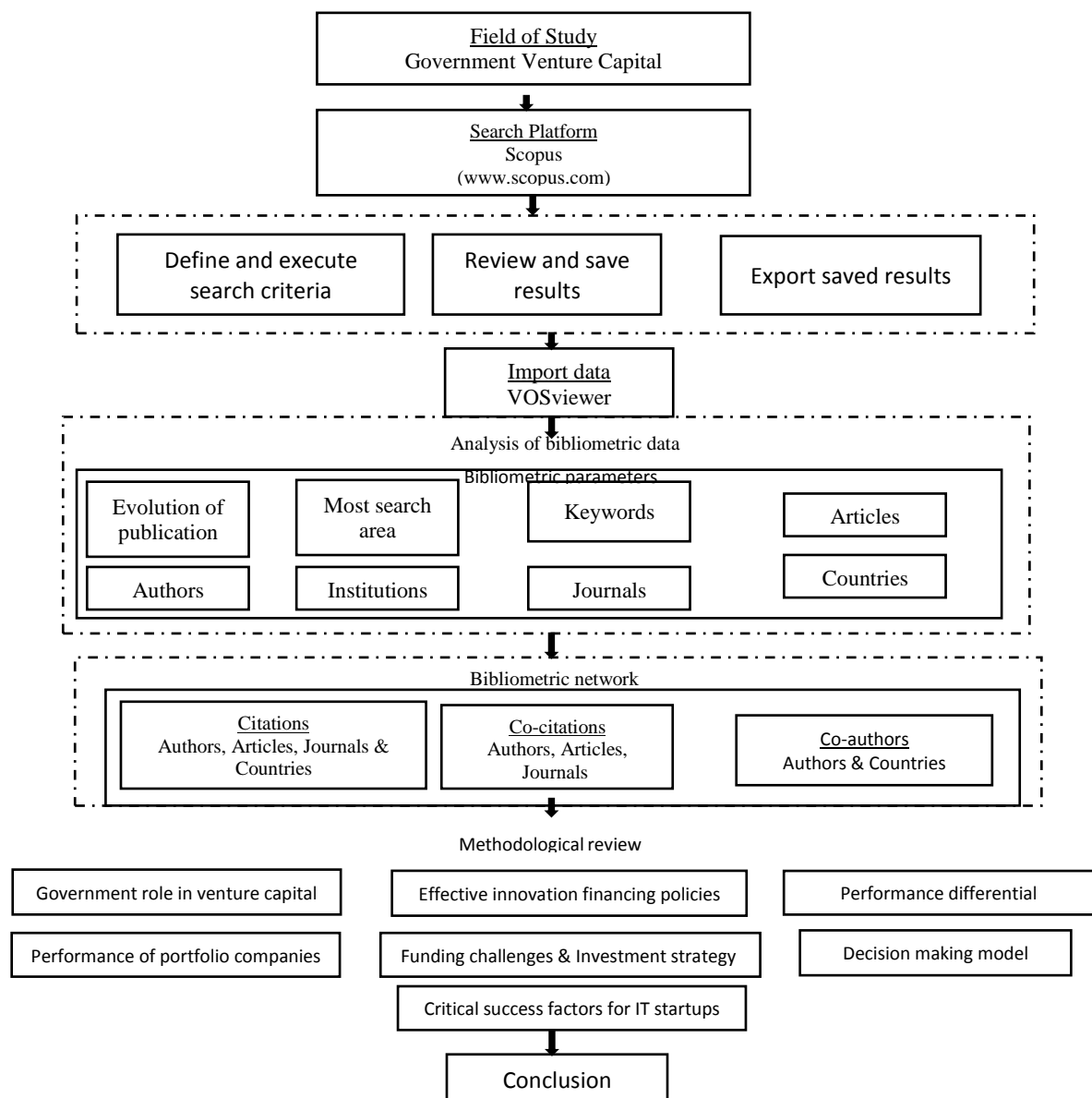


Figure 1: Stages of the bibliometric analysis to identify research gaps and trends.

The field study of GVC falls between the intersection of finance, business, management, accounting, economics and econometrics. Between 2008 and 2019, several researchers provided several definitions of GVC with the latest being “government-established, owned and operated venture capital firms” by Zhang and Mayes (2018). Prior to that, Grilli and Murtinu (2014) defined it as government-managed venture capital while Alperovych et al. (2015) and Colombo et al. (2016) defined it as governmental venture capital, Buzzacchi et al. (2013) as public ownership of VC firms and as government-owned venture capital firms by Bottazzi, Da Rin and Hellmann (2008). In this research, I expanded the definition by Zhang and Mayes (2018) to a “Government venture capital (GVC) is an entity established, owned, funded and operated by a management team appointed by the government to provide venture financing to technology-based companies, mostly startups with long-term growth potential primarily promotes socio-economic advancement in the respective country” because it encapsulates every aspect what GVC is understood by the public at large, and how it operates.

Every search platform offers varying respective tools to mine scientific data. Thoughtfully, we have chosen Scopus (www.scopus.com) over Web of Science (WoS) (www.webofknowledge.com) due to mostly our familiarity with the search platform. Through Scopus, we can access numerous robust databases and reasonable search filters namely Elsevier (www.sciencedirect.com), Emerald (www.emeraldinsight.com), Springer (www.springerlink.com), Wiley (www.wiley.com), and Taylor & Francis (www.tandfonline.com), among others. Scopus allows us to define and execute search criteria, review and save results and then export the saved results.

Table 1 presents eligibility criteria where decision on which documents should be included and excluded are made.

Table 1. Decision criteria for choosing research documents

Access type	Document type	Subject area	Publication year
Open access	Articles	Finance, Business, Management, Accounting, Economics and Econometrics	2011-2020

The search strategy to select documents use keywords “government” and “venture” and “capital” from Scopus databases and review them if they are published between the year 2011 to year 2020. Based on the keywords search, 620 documents from Scopus database were extracted. Selected documents are published in journal, book and conference proceeding; and in English language which further excluded another 109 documents. Final tally of 304 documents have been selected consisting of articles (242), book chapter (44) and conference papers (18) as presented in Table 2 below.

Table 2. Keywords search criteria for the study of “government venture capital”.

	Inclusion criteria	Exclusion criteria
Database	Scopus	Other databases
Publication period	2011 to 2020	Articles published before 2011 and in 2021
Document type	Articles (final and in press), book chapter and conference papers	
Source type	Journals, books and conference proceedings	Trade journals, book series and conference proceedings
Subject area	Finance, Business, Management, Accounting, Economics and Econometrics	Social science, Engineering Environmental Science
Language	English	Other languages

As for data analysis, we used Visualization of Science (VOS)" mapping software¹ to map searched criteria alongside with Excel, where it is used to organize data into visual presentation formats as listed in the following section and sub-sections. Other than the "Visualization of Science (VOS)" mapping software² to map searched criteria, Excel is also used to organize data into appropriate visual presentation formats.

Findings and Discussions

The results are described in the following sub-sections starting with the evolution of publication in this area of research.

Evolution of Publication

Over the years, the evolution of publication shown an upward trend between 2011 and 2020, indicating increased interest in the broad research area of venture capital as presented in Fig. 2. Specifically, this helps finding new ways to articulate some clear principles for maximizing the success of public funds. This comes on the back of increased interest from global public policy makers focusing on entrepreneurship to drive innovation (Global Innovation Index, 2019; Maletič et al., 2019). A host of developing countries see venture capital financing activities to directly promote innovation to reduce over reliance on natural resources as a source of income as illustrated by the United Arab Emirates (UAE) (Hendi, Chapter 14, Global Innovation Index, 2019) and also to solve for the paradox typically associated with countries abundance with natural resources as illustrated by effort made by the Equity Group Holdings Plc in Kenya (Mwangi, Chapter 13, Global Innovation Index, 2019).

¹ <https://www.vosviewer.com/>

² <https://www.vosviewer.com/>

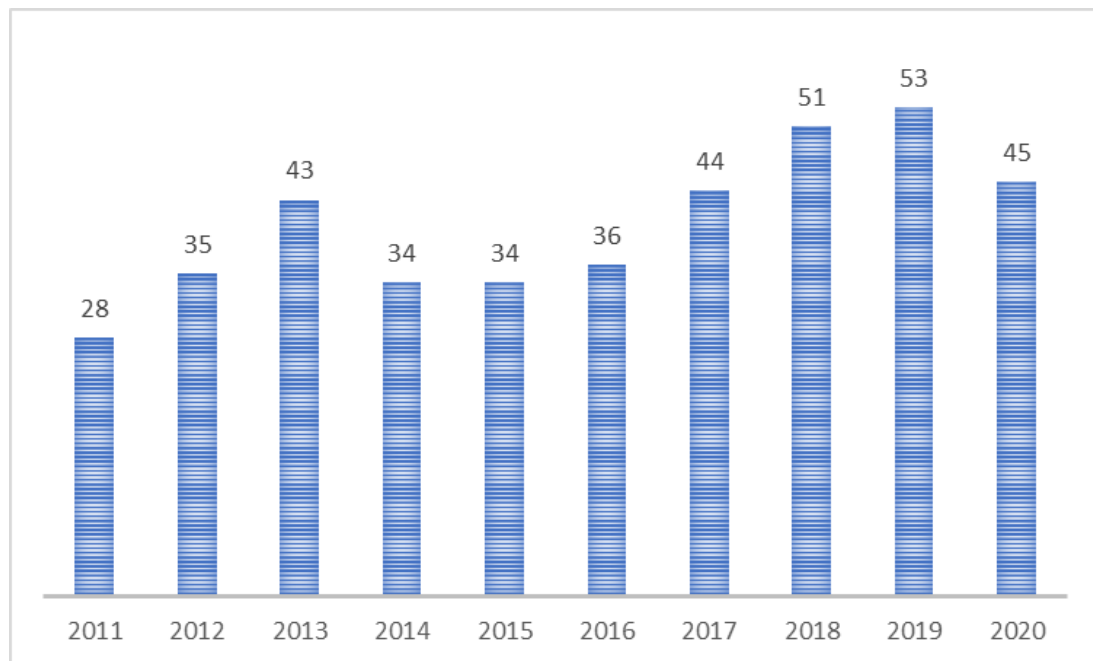


Figure 2. Documents by year

Co-occurrence of Keywords Analysis

Chronologically, as illustrated by the density visualization in the Fig. 3.1, venture capital, investments and innovation are the three keywords found in the literature regarding government venture capital even though keyword government does appear, but it does not have the greatest total link which could be due to the way the keyword search was organized. The keyword search of government venture capital was not clustered together as one word but instead treated as individual word i.e., “government” and “venture” and “capital” instead of “government venture capital”. The reason for that is in the extant literature regarding government venture capital, oftentimes the subject is studied in comparison between government venture capital (GVC) and private venture capital (PVC) and any other type of venture capital such as corporate venture capital (CVC). Furthermore, there is little academic examination dedicated to GVC hence by treating the keyword search individually, it widens the coverage of relevant documents.

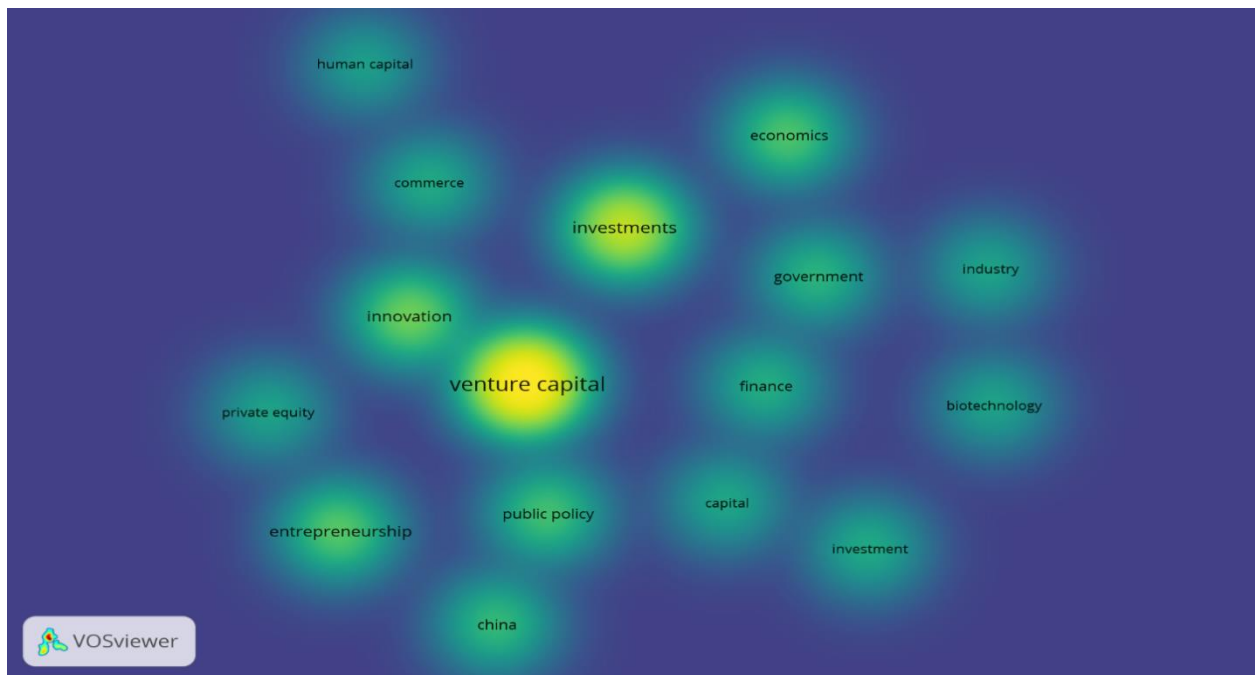


Figure 3.1: Co-occurrence by all keywords

In addition, Fig. 3.2 shows 16 authors' keywords associated with the government venture capital representing clusters of topic relevance to the said subject. Interestingly though the word "China" appear on both all keywords and authors' keywords, suggesting the emergence of China as a country relevant to the study of government venture capital.

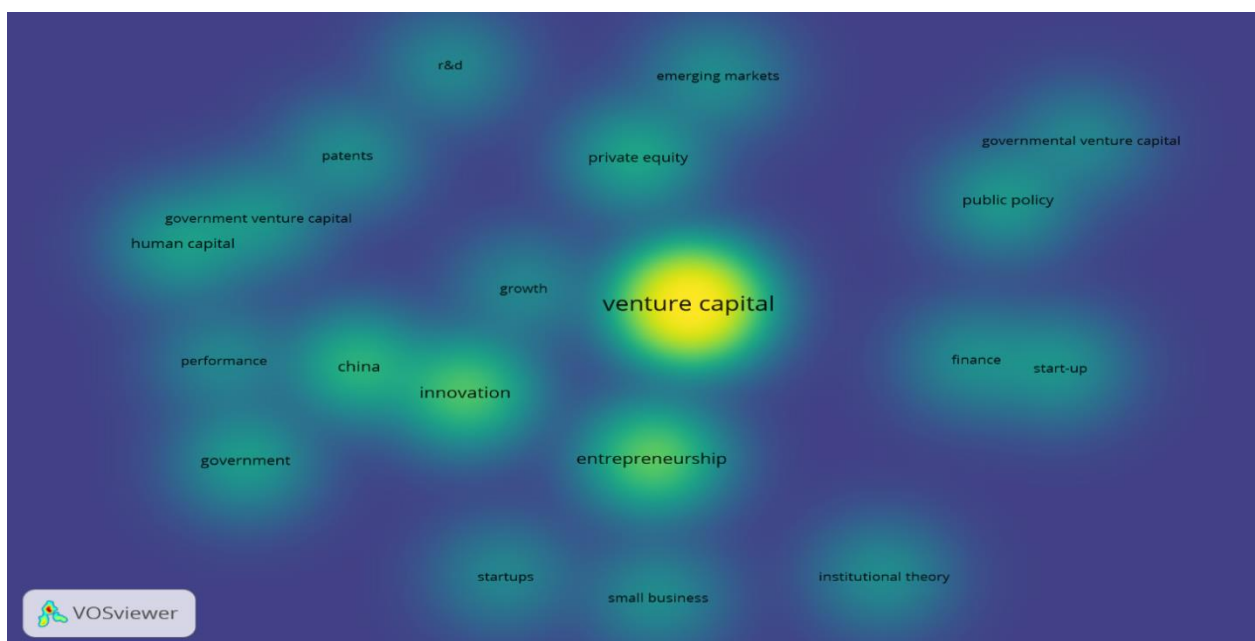


Figure 3.2: Co-occurrence by author keywords

To conclude, government venture capital is a subset subject under venture capital which typically feature in the discussions of investments, economics, biotechnology, innovation, government and public policy as illustrated in the Fig.3.3 below.

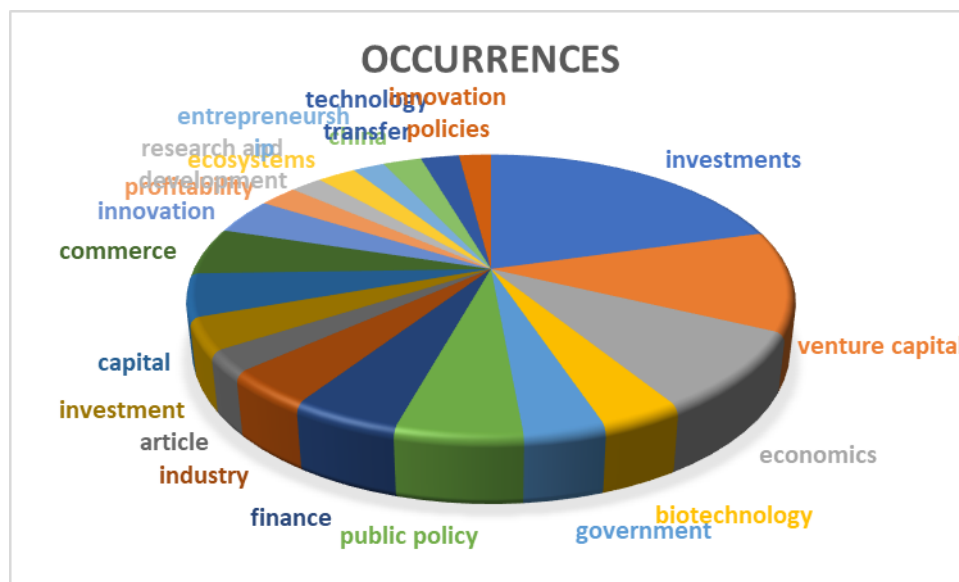


Figure 3.3: Co-occurrence by index keywords

Co-authorship Analysis

The impact of a journal in a research field is determined by the number of articles published, the number of citations and total link strength. These three criteria are organized by country and organization; and presented in the following tables:

Table 3. Co-authorship by organization

Organization	Documents	Citations	Total link strength
politecnico di milano, department of management, economics and industrial engineering via r. lambruschini 4/b, milan, 20156, italy	2	89	0
college of innovation, thammasat university, anekprasong 3 bldg., prachan rd., bang emlyon business school, france	5	74	1
york university - schulich school of business, 4700 keele street, toronto, on m3j 1p3	3	45	1
ghent university, belgium	2	29	0
harvard business school, united states	2	16	1
academic center carmel, shaar palmer 4, haifa, 33031, israel	2	6	0
college of business administration, tui university, 5665 plaza drive, ca 90630, united universidad politécnica de cartagena, spain	2	5	2
	2	0	0

Table 4. Co-authorship by documents and citations

Country	Documents	Citations	Total link strength
united states	72	933	32
united kingdom	38	338	20
china	32	313	12
canada	20	406	13
india	16	20	5
italy	16	501	7
australia	13	77	4
south africa	13	52	1
france	11	120	9
south korea	10	19	0
thailand	10	73	3
spain	8	76	4
netherlands	7	59	4
germany	6	39	4
malaysia	6	13	0
russian federation	6	21	2
belgium	5	64	4
indonesia	5	11	0
new zealand	5	36	1
sweden	5	107	1
taiwan	5	7	0

Table 5. Co-authorship by total link strength

Country	Documents	Citations	Total link strength
united states	72	933	32
united kingdom	38	338	20
canada	20	406	13
china	32	313	12
france	11	120	9
italy	16	501	7
india	16	20	5
australia	13	77	4
spain	8	76	4
netherlands	7	59	4
germany	6	39	4
belgium	5	64	4
thailand	10	73	3
russian federation	6	21	2
south africa	13	52	1
new zealand	5	36	1
sweden	5	107	1
south korea	10	19	0
malaysia	6	13	0
indonesia	5	11	0
taiwan	5	7	0

Citation Analysis

Further inspection on the selected documents with respect to citation by article reveals a list of authors with most cited documents as presented in Table 5. Sources of documents presented in Table 6, while the summary of the top five most cited documents is presented in Table 7.

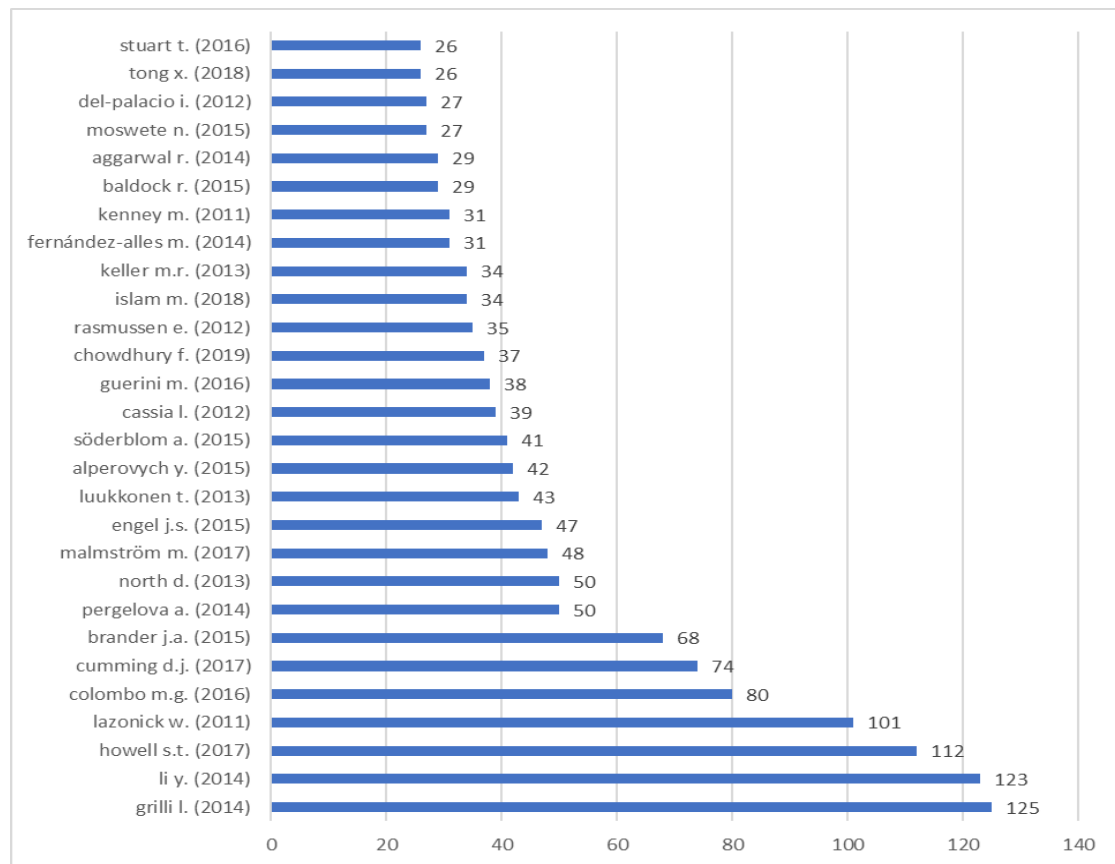


Figure 4: Most cited articles

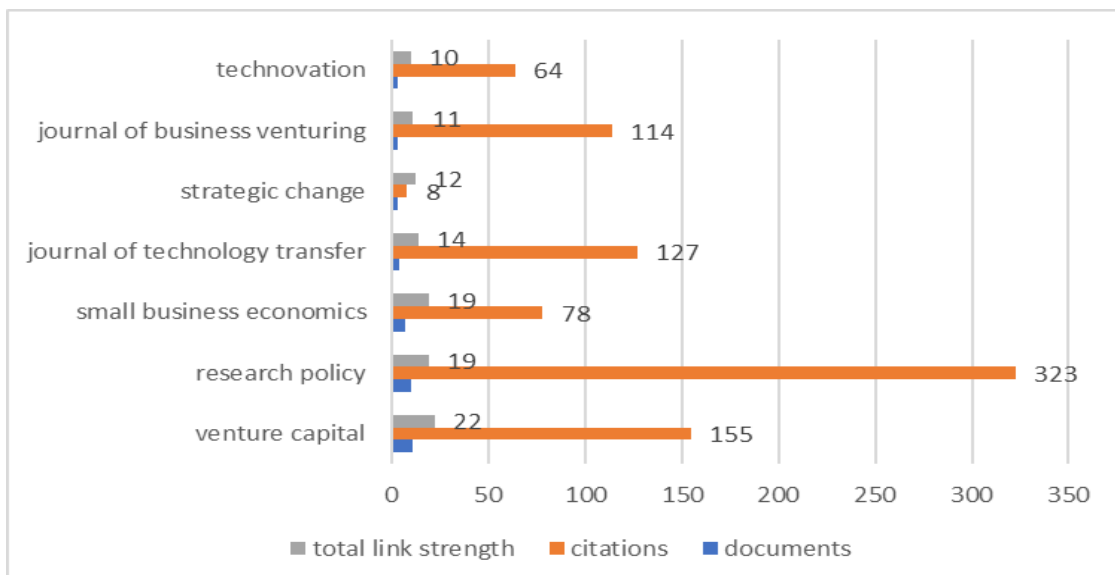


Figure 5. Sources of cited documents

Table 6. Main Information analyzed from the top 5 most cited articles

Authors	Objective	Findings	Research Method	Literature gaps
Luca Grilli, Samuele Murtinu (2014)	Evaluate impact on high-tech entrepreneurial firms' growth as a result of investment made by either GVCs or IVCs.	<ol style="list-style-type: none"> 1. Investment impact by IVCs is superior to GVCs when it comes to building growth for firms with respect to sales and employees. 2. When investing alone, GVC's impact tend to be lacking. 	<ol style="list-style-type: none"> 1. Econometric framework using VICO dataset. 2. Matching procedure by using a propensity score method to match each VC-backed firm to a similar non-VC backed firm 3. The impact of GVC and IVC investments on firm growth is investigated through the estimation of a series of augmented Gibrat law panel data models. 	Several relevant aspects such as fund's structure and characteristics, key personnel's work experience and network, geographic location, investment horizon, shareholding rights remain to be investigated. Take fund's structure and characteristics for instance, further research on this subject is expected to benefit and improve effectiveness of government policies regarding innovation.
Yuan Li & Haowen Chen & Yi Liu & Mike W. Peng (2014)	Investigate entrepreneur's relationship focus area to develop new business opportunities.	<ol style="list-style-type: none"> 1. Focusing on inter-firms' relationship is more beneficial to develop new businesses. 2. The correlation between developing new businesses and management business network can be moderated through organizational learning. 	<ol style="list-style-type: none"> 1. Data were obtained through a face-to-face interview survey. 2. Multi-item scales were used to operationalize all the constructs. A 5-point Likert scale from 1 = totally disagree to 5 = totally agree was used to measure the items. 	This paper focuses on the relationship between new venture firm with other firms, and venture firm with government. As extension to this study, implications of managerial practices driving these relationships are area worth investigated in the future.
Sabrina Howell (2017)	Evaluate R&D subsidies on patenting and revenue impacts.	<ol style="list-style-type: none"> 1. The odds of subsequent funding rise to a factor of two if firm receiving award at early stage. Impacts of revenue and patents are equally positive. 2. Even stronger impact on fund strapped firms. 	Review of SBIR grant program in the United States.	This paper discovers that disbursing small and one-time basis grants are perceived to be way effective than few bigger grants in stimulating innovation through young technology firms. The impact of this one-time basis to firms at different stage of technology development has yet been studied.
William Lazonick, Öner Tulum (2011)	Solve the "Pisano puzzle", and determine conditions influencing sustainability of biopharmaceutical industry in the U.S.	<ol style="list-style-type: none"> 1. IPO subscriptions on biopharmaceutical companies with no ready commercial product. 2. Government investments as the pull factor. 	Review of the US biopharmaceutical financing model and sustainability of the US biotech business model.	This paper discovers the financialized business model is specified to the US biopharma, its applicability however has yet to be investigated in different geographical setting.
Massimo G. Colombo, Douglas J. Cumming, Silvio Vismara (2016)	Describe how various financial support from governments affecting in-country technology space.	Generally, the financial support initiatives are a failure with few exceptions spotted around the world.	Review of GVC funds around the world.	This paper formulates a robust design of investment processes tailor-made to GVC funds. Its effectiveness has yet to be tested and confirmed in any geographical setting.

Co-citation analysis

For co-citation where authors whose documents are cited together with another authors otherwise known as prolific authors, respected analysis is presented in a network visual map

of Fig. 3.5. Leleux, Grilli, Lerner and Cumming are prolific authors. Fig. 3.5.2 visualizes co-citation by journal. All documents studied are organized in four main clusters namely financial economics (red), business venturing (green), international business (blue) and technovation (yellow).

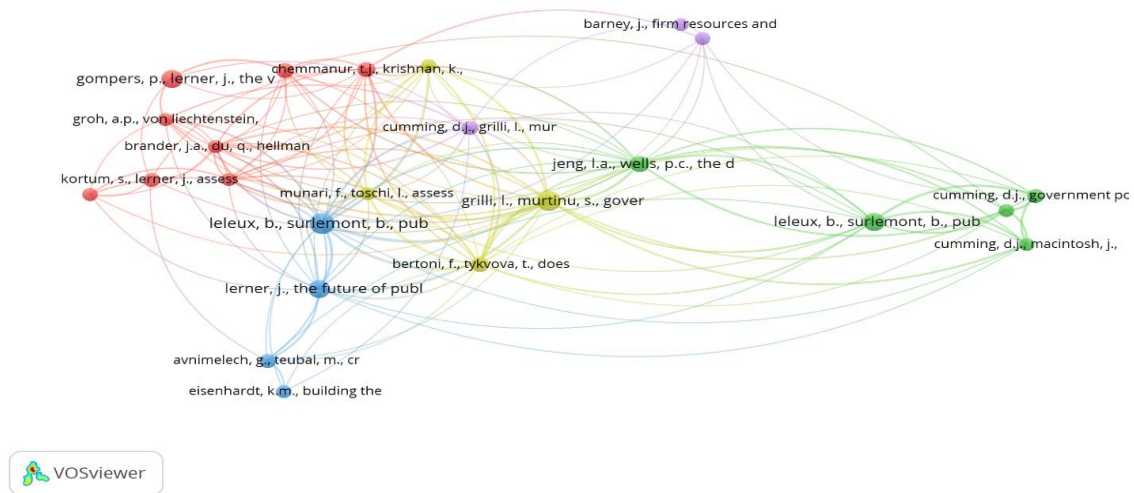


Figure 3.5.1: Network visualization map of most prolific authors

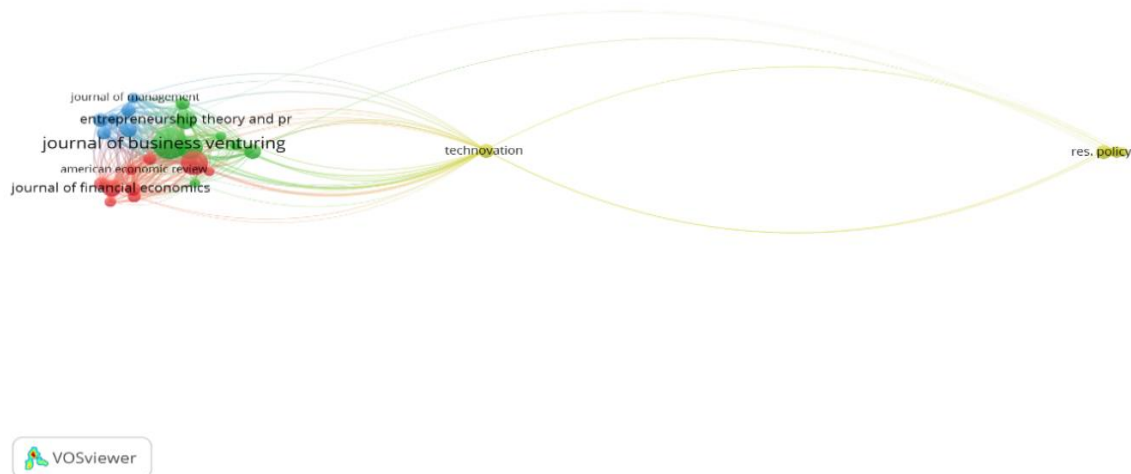


Figure 3.5.2: Network visualization map of co-citation analysis by journal.

Bibliographic Coupling Analysis

This analysis helps to identify opportunities and gaps exist in the field of study (Xu et al., 2020) as presented in the Table 8 and, visual presentation of it is presented in Fig. 3.6 below.

Table 7: Clusters of bibliographic coupling

Cluster 1 (Red)	C	TLS	Cluster 3 (Blue)	C	TLS	Cluster 5 (Purple)	C	TLS
Soderblom et al. (2015)	41	77	Stuart T.; Wong Y. (2016)	26	63	North et al. (2013)	50	107
Pergelova et al. (2014)	50	83	Grilli J.; Murtinu S. (2014)	125	338	Demirrel P; Parris S. (2015)	17	95
Li Y. et al. (2014)	123	26	Brander et al. (2015)	68	190	Klonowski D. (2012)	22	75
Malmstrom et al. (2017)	48	24	Luukonen et al. (2013)	43	116	Rasmussen E.; Sorheim R. (2012)	35	89
Engel J.S. (2015)	47	15	Islam et al. (2018)	34	82	Karsai J. (2018)	5	163
Kenney M. (2011)	31	15	Howell S.T. (2017)	112	59			
			Svesson R. (2013)	15	65	Cluster 6 (Beige)	C	TLS
						Afful-dadzie E.; Afful-dadzie A. (2019)	16	145
Cluster 2 (Green)	C	TLS	Cluster 4 (Light Green)	C	TLS	Bertoni et al. (2019)	7	190
Aggarwal R; Goodell J.W.	29	49	Cumming et al. (2017)	74	232			
Scheela W.; Jitra Panun T. (2012)	23	54	Colombo et al. (2016b)	80	253	Cluster 7 (Light Brown)	C	TLS
Grilli et al. (2018)	17	204	Cumming D. (2014)	19	165	Santisteban J.; Mauricio D. (2017)	9	49
Bonini S; Alkan S. (2012)	24	64	Alperovych et al. (2015)	42	283			
Wonglimpirayat (2013b)	9	123	Cumming et al. (2018)	14	160			
Wonglimpirayat (2016)	12	146	Guerini M; Quas A. (2016)	38	343			
			Zhang Y.; Mayes D.G. (2018)	7	154			

*C- Citation, TLS – Total Link Strength

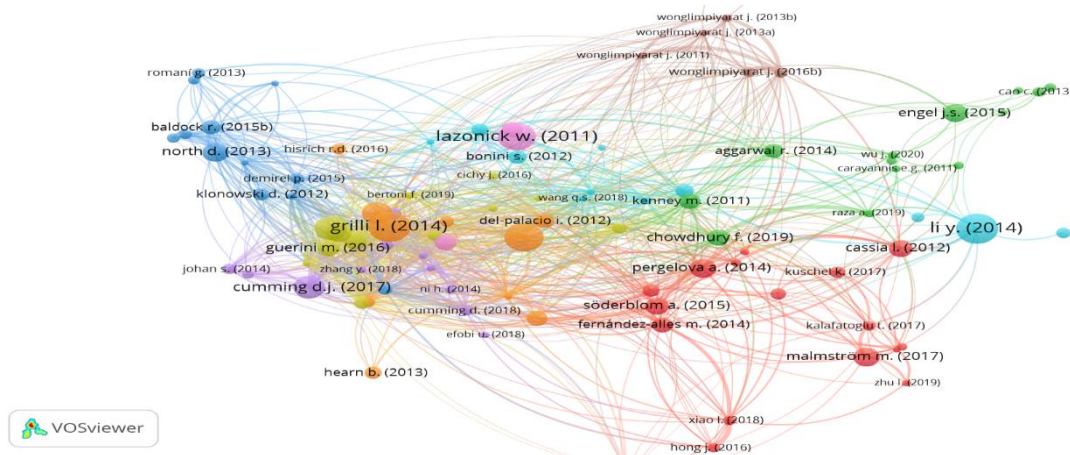


Figure 3.6. Document Bibliographic Coupling

Discussion and Implication

Cluster is presented by respective color as illustrated in Fig. 3.6 which collectively identified as main themes of this bibliometric analysis. The main themes were revealed in the post methodological review exercise. Main theme is revealed by identifying mutual topic consistently discussed across several documents. These main themes later organized into Table 9 where each of the theme is deliberated under its own paragraph below.

Table 8: Main themes

			Main Themes			
Government role in venture capital support	Effective Innovation financing policies	Performance differential	Performance of portfolio companies	Funding challenges and investment strategy	Decision making model	Critical success factors for IT startups

Cluster 1 – Government Role in Financial Venture Support

The research articles grouped under this cluster discuss venture capital role in the national system of innovation (Kenney, 2011). Government through its policy on innovation and entrepreneurship able to stimulate economic growth (Engel, 2015). In doing so, the financial venture support through government venture capital must focus on new firms (Pergelova & Angulo-Ruiz, 2014) and equal distribution between female and male entrepreneurs (Malmström, Johansson, & Wincent, 2017). This is because access to financial and human capital tend to have influence and effect substantially bigger and longer than subsidy (Söderblom, Samuelsson, Wiklund, & Sandberg, 2015).

Cluster 2 – Effective Innovation Financing Policies

The research articles grouped under this cluster discuss effective innovation financing policies by government is possible to create thriving high-tech clusters as demonstrated by the Yozma program in Israel (Wonglimpiyarat, 2016). On the flip side, ineffective policies manifested by uncoordinated inter-governmental agencies and failure to establish strong link with established high-tech hub such as Silicon Valley in US tend to lead to the underperformance of government venture capitals in some emerging economies (Wonglimpiyarat, 2013). Prior to having effective GVCs, governments may want to address prerequisites to effective innovation financing policies namely the political and legal system. These systems should precede the VC industry establishment for it to benefit from entrepreneurship and innovation because their effectiveness provide investor with protection (Aggarwal & Goodell, 2014; Bonini & Alkan, 2012). Informal dimensions such as social capital is expected to be able to exert prominent effect to the success of VC industry (Grilli, Mrkajic, & Latifi, 2018). Cultural dimensions such as on uncertainty avoidance and masculinity is also cited as factors in getting access to financing which also explains government favoritism toward selected firms. Greater

national wealth and better investor protection however tend to lead to greater access to financing (Aggarwal & Goodell, 2014).

Cluster 3 – Performance Differential

The research articles grouped under this cluster discuss performance differential for government funded companies. In China, probability of receiving innovation grants are better for companies who artificially inflated certain numbers in their accounts leading to a conclusion that fraud is a source of performance differential for emerging markets (Stuart and Wang, 2015). Co-investing or syndicated investment is a performance differential for GVC, because when GVC co-invest with IVC, it yields positive effect on sales growth. GVC on its own is doubtful to produce the same results in supporting high-tech entrepreneurial firms (Brander, Du, & Hellmann, 2015; Grilli & Murtinu, 2014). Another performance differential is grant or R&D subsidies where government grants are treated as good early-stage signal for startups in the promising industries. Recipients of grants stand 12% higher chance to receive successive funding from VC (Islam, Fremeth, & Marcus, 2018). Subsequently, another article reviewing the famous SBIR grant program, early-stage startups with R&D subsidies award have approximately twice the probability of receiving next round venture funding if the grant is used to fund technology prototyping. Which consequently has large and positive impacts on patenting and revenue (Howell, 2017). Next, performance differential with regards to patent performance, nature of government contract terms is important because it determines the financing duration. If the contract terms run up to commercialization, the duration are longer as compared to for contract terms for R&D only (Svensson, 2013). Put simply, the gist of these articles discussed activities that can be used to build predictive performance criteria (signals) when screening for entrepreneurial companies by GVC in the pre-investment phase.

On the other hand, while screening the right criteria is enormously important activities with respect to the performance of GVC, that is however forms one part of performance differential of GVC, the other part is post-investment value-added activities because these two are significant activities that take place at GVC. When compared to IVC contributions in the value-added activities aspect, GVC contributions is significantly lower which includes organizing the operation of portfolio companies, assisting with business development, and preparing them for exit (Luukkonen, Deschryvere, & Bertoni, 2013).

Cluster 4 – Performance of Portfolio Companies

The research articles grouped under this cluster discuss the performance of portfolio companies of government venture capitals. Their performances are often taken as a result of activities taken place at GVC, hence act as proxy performance to GVC. Exit Performance wise, PVCs' are better than GVCs' even after controlling for endogeneity concerns, selection bias, omitted variable bias, legal and institutional differences across countries and over time (Cumming, Grilli, & Murtinu, 2017). Not only that, in term of VC life cycle and in going public, GVCs' tend to short-lived the PVCs' as indicated by the study done in the Chinese

market despite the advantages enjoyed by the former (Cumming et al., 2017; Zhang & Mayes, 2018). Further, they tend to display significant reductions in productivity when measured against their peers in the PVCs (Alperovych et al., 2015). Despite efforts made by governments around the world to close equity gap experienced by young innovative firms, success is elusive and hard to come by with very few exceptions as demonstrated by the IIF of Australian. This necessitates a closer examination on the investment process involving GVCs (Colombo et al., 2016).

For optimal design on the performance of portfolio companies, GVCs need to understand the spillovers caused by the externalities. These spillovers could be in the form of finance, destination of the investment is made for, and stages of portfolio companies lifecycle (Cumming, Johan, & Zhang, 2018). For starters, improving capabilities at selection and certification are a good place to begin (Guerini & Quas, 2016).

Cluster 5 – Funding Challenges and Investment Strategy

The research articles grouped under this cluster discuss challenges faced by aspiring entrepreneurial technology companies in securing funding and government's investment strategy to address some of these challenges. Aspiring entrepreneurial technology companies demand for external finance is stronger when they are at early-stage R&D where working capital requirement is pressing. Without financing, growth is impossible for these technology companies. Hence the needs for government policy to address the pressing problems (North, Baldock & Ullah, 2013). Faced with this challenge, SMEs require government support especially with early stage projects because that could serve as a long-term signal to the private investors hence creating confidence for them to participate in this respective industry innovative activity (Klonowski, 2012; Pelin Demirrel & Stuart Parris, 2015).

Government respond is through universities where these higher institutions would fund technology initiatives developed in-house. First is the Proof-of-concept (POC) schemes because it reduces uncertainty surrounding technology-based product or services development. Second is funding pre-seed because it reduces uncertainty confronting organizations in what is deemed as promising venture. And third is seed funding in return for equity in early-stage projects. These three are investment strategies with ultimate objective to increase project attractiveness creating what is known as "spin-offs" (Rasmussen & Sorheim, 2012). These investment strategies are reflected in the GVC programs which inherently characterized by small, short and restrictive investment strategies however promote inefficient operation and deter institutional investors to participate (Judit Karsai, 2018).

Cluster 6 – Decision Making Model

The research articles grouped under this cluster discuss about decision making model that can be adopted by the GVC amid growing concern of inherent underperformance of portfolio companies of GVCs around the world. Part of the reason is attributed to the decision-making process when selecting aspiring entrepreneurial technology companies suitable for funding.

While criteria set mostly in line with the extant literature on screening criteria, but processing of the criteria remain an enigma given the uncertainty surrounding the future prospect for their growth. Improving the process fairness and transparency during selection using TOPSIS method because the set criteria is processed intuitively. In a nutshell, this method aggregates ratings made by a panel of decision makers (Eric Afful-Dadzie & Anthony Afful-Dadzie, 2016). From organizational ecology perspective, government policy decision to conceive GVC and provide funding especially to companies involve in biotechnology helps to attract PVC participation in the respective industry otherwise unattractive due to its known properties of long gestation period and commercial uncertainty. Such collaborative and supportive relationship between GVC and PVC are estimated to be beneficial to the growth of biotechnology industry in respective ecology (Bertoni, Colombo, & Quas, 2019).

Cluster 7 – Critical Success Factors for IT Startups

There is one article in this cluster relevant to the bibliographic analysis where the article is about systematic literature critical success factors of Information Technology (IT) startups. It identified 21 critical success factors grouped into three categories (organizational, individual and external) and 4 stages of development through which a Startup passes (seed, early, growth and expansion). In addition, the article found factors of founding team previous experience with startup and government support affect the seed stage; factor of venture capital affects the early stage; factors regarding clustering, technological/business capabilities of the founding team and venture capital affect the growth stage; and the clustering factor affects the expansion stage (Santisteban & Mauricio, 2017).

The analysis yielded gaps and directions for future research as provided in Table 3 and the main themes provided in Table 5 which have been enumerated in no particular order of importance or priority.

First, several relevant aspects such as fund's structure and characteristics, key personnel's work experience and network, geographic location, investment horizon, shareholding rights remain to be investigated. Take fund's structure and characteristics for instance, further research on this subject is expected to benefit and improve effectiveness of government policies regarding innovation.

Second, as mentioned in the preceding paragraph on the subject of key personnel's work experience and network which equally applicable to GVC staffs and portfolio companies alike, clearly prioritizing relationship venture ecosystem is one of the key contributors to firm performance. Spending more time and effort on nurturing relationship with other firms are found to have positive effect on firm performance as opposed to prioritizing the relationship with the government. As an extension to this study, implications of managerial practices driving these relationships are area worth investigated in the future. This area falls within at least three main themes namely performance differential, decision making model and critical

success factors for IT startups which ultimately affecting the fourth theme, performance of portfolio companies.

Third, as suggested that disbursing small and one-time basis grants are perceived to be way effective than few bigger grants in stimulating innovation through young technology firms. This one-time basis can be replicated for the same firm albeit different stage of technology development. This goes to show that post-investment phase is crucial in adding value to young technology firms because grants received are used to reduce technological uncertainty which makes them a more viable investment opportunity. This area falls within the main themes of performance differential, decision making model and performance of portfolio companies.

Fourth, through the lenses of innovative enterprise theory it is shown how strategic control, organizational control and financial commitment undermine innovation as illustrated by the BP industry in the U.S. In the highly financialized business model shows how those in the collective strategic positions can make speculative and manipulative decisions to increase firms' stock price at the expense of organizational learning to produce commercial drugs. Even though this financialized business model is specified to the US biopharma, its applicability however has yet to be investigated in different geographical setting. This area falls within the main themes of government role in venture capital support, performance differential, funding challenges and investment strategy, decision making model and performance of portfolio companies.

Last but not least, designing a robust investment processes dedicated to GVC funds remain an urgent topic for scholars and policy makers. This design includes selection and treatment of portfolio companies. With the JOBS Act³, at least in the US, equity crowdfunding has started making its way into entrepreneurial finance. This type of equity financing provides the platform for investing publics to get a piece of action in young innovative firms. This area falls within the main themes of government role in venture capital support and funding challenges and investment strategy.

Conclusions

Government venture capital is a topic that falls under the wider scholastic area of entrepreneurial finance and venture capital. Oftentimes the study of venture capital itself is an overlapped subject area of business, finance, management and economics with the use of econometrics method to predict/measure respective impact. The study of GVC performance can be broken into two parts namely pre-investment phase represented by screening for potential entrepreneurial companies and post-investment phase represented by value-added activities. Inferences drawn from the clustered documents of performance differential, screening practices and criteria used when selecting respective fund recipients as the

³ Jumpstart Our Business Startups Act

mediation factor. Value-added activities on the other hand are inferred as the moderating factor on the performance of portfolio companies.

Given the amount of decision criteria involve in this scholarly subject, it also attracts decision science researchers to study the decision-making model given the complexity and uncertainty of predicting the success potential of technology companies funded by the GVC, PVC, IVC or CVC which are equally categorized as venture capital investors. GVC however is distinctly different from the rest of its peers given the use of public funds as opposed to private funds by its peers. This use of public funds exposes GVC to the direct effect of the government policies on financing innovation. While these policies are purpose-build to cater for development of new or cutting-edge technologies, especially warranted in the biotechnology sector given its longer gestation period and greater commercial uncertainty where PVC, IVC and CVC are known to have less interest to participate unless there are GVC involvement with few exceptions such as when there is a clear and present commercial profit to be derived from respective cure such as vaccine for coronavirus (Covid19) where its pandemic is currently ravaging the global health and its state of economy.

The acquired results of this study contribute to adding more knowledge to the existing literature about government venture capital. Moreover, the results help to provide a clearer dashboard view of what is on offer as far as the study of government venture capital is concerned. The main themes help to organize main topics into appropriate headings allowing researchers in the entrepreneurial finance and others and policy makers around the world to zoom in and commission or conduct respective studies. As for policy makers around the world and management of GVCs, the reported results in this bibliometric analysis can be used as a reference when developing strategies and programs that help the survival, growth and development of entrepreneurial technology companies.

Conflict of Interest

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues including plagiarism, informed consent, misconduct, data fabrication and, or falsification, double publication and, or submission, and redundancy have been completely witnessed by the authors.

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