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INTERNATIONAL SCIENTIFIC RESEARCH ON VENTURE CAPITAL: A BIBLIOMETRIC AND MAPPING ANALYSIS FROM THE PERIOD 1978–2020

JEL: O16, G38

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Abstract: The aim of this study is to explore the relevance of scientific production on venture capital using bibliometric and mapping tools.

We performed a search in Scopus, involving any document published between 1978 and 2020. We used bibliometric indicators to explore documents production, dispersion, distribution, time of duplication, and annual growth, as Price's law of scientific literature growth, Lotka's law, the transient index, and the Bradford model. We also calculated the participation index of the different countries and institutions. Finally, we explored the co-occurrence and thematic networks for the most frequently used terms in venture capital research through bibliometric mapping.

A total of 1,230 original articles were collected from the timeframe 1978–2020. The model confirms that Price's law is not fulfilled. Scientific production was better adjusted to linear growth ($r = 0.9290$) than exponential ($r = 0.9161$). Literature on venture capital research has increased its growth in the last 43 years at a rate of 7.9% per year, with a production that doubles its size every 9.1 years. The transience index was 79.91%, which indicates that most of the scientific production is due to a lot of authors with a small number of publications on the research topic. Bradford's law shows that the scientific production in this area is widely distributed in multiple journals, and Lotka's law indicates that the author's distribution is heavily concentrated on small producers. The United States of America (USA) and the University of Pennsylvania present the highest production, contributing 31.22% and 1.63% of the total production of research on venture capital.

The venture capital task has undergone a linear growth, with a very high rate of transience, which indicates the presence of numerous authors who sporadically publish on this topic. No evidence of a saturation point was observed in the scientific production analyzed, which makes it possible to conclude that the research in venture capital will continue to be in demand by the scientific community.

Keywords: *venture capital, scientific production, bibliometric indicators, bibliometric mapping, collaborative networks*

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INTRODUCTION

The venture capital was born by the mid of the last century as a medium to finance high-risk companies. The first true venture capital firm was American Research and Development (ARD), established in 1946 [1]. The main problem with companies that are at their first stage of life is that investor may find too risky to invest with no control on the use of the funds.

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So, entrepreneurs face difficulties to obtain resources for their business.

From the point of view of economic analysis, this is the typical principal-agent problem, as the interest of the investor and the investee may differ. In general, the venture capital may be concerned that the entrepreneur knows more about his or her quality/ability than the venture capital [2]. The way to reduce this principal-agent problem was to give equity in exchange for the funds (instead of stocks). This is how venture capital appeared.

Along these almost 80 years of existence, the venture capital operations have increased strongly, and many different investment operations come under this name. Nowadays, we distinguish between *venture capital* and *private equity*.

Under *venture capital*, which is the provision of capital in a company that is in the start-up or early development stage, we find two different types of investment:

- a) Seed capital: early investment in business ideas or newly created companies with a service or product yet to be launched in the market and, therefore, without sales.
- b) Start-up capital: investment for the establishment of the company (company registration, website, office...) and start-up of its activity when, even with sales, the EBITDA of the company is negative. The capital provided is higher than in seed capital investments.

Meanwhile, *private equity* refers to the capital contribution aimed at growing or already consolidated companies. There are four types of private equity investment.

- a) *Growth capital*: Financing the growth of a profitable company. The funds can be used to acquire fixed assets, increase working capital for the development of new products, or access to new markets. These are larger investments with less uncertainty due to the existence of historical data.
- b) *Replacement capital*: The private equity firm takes over part of the current shareholder base. It is frequent in family businesses and in succession situations. It also occurs in some opportunities for the sale of assets or non-strategic branches of activity of very large companies, where their

managers or other external parties seek financial support from private equity as part of a spin-off project and subsequent independent development.

c) *LBO (Leverage Buyout)*: It is the purchase of companies in which a substantial part of the transaction price is financed with borrowed funds, partly guaranteed by the acquired company's own assets, and another part with capital contributed by the investors in the transaction, who become the owners. In these transactions it is usual for the target company to have consistent, stable, and sufficiently high cash flows to be able to pay the interest and repay the principal of the debt.

d) *Turnaround capital*: Investment in companies experiencing difficulties over an extended period of time and in need of financial resources to implement major transformations necessary for their survival. It usually involves an operational restructuring that covers all aspects of the company (facilities, personnel, products, etc.).

Besides, there is an informal venture capital or private venture capital through the known as "business angel."

As we can see, it is difficult to establish the limits to venture capital and its boundaries have been changing along the years, but if there is a common feature among the companies that use this financial vehicle is the technological component of most of them. So this is a very common financial vehicle in the digital entrepreneurial environment, as the literature shows [3, 4].

The high increase in corporate venture capital also led to changes in the way of using the funds. One of the most interesting changes in its use is buying new ideas and products rather than be developed internally through R&D in the companies.

To analyse the importance of venture capital, we can take a look at the figures provided by the OECD regarding the venture capital investments (*Figure 1*). The statistics correspond to the aggregation of investment data according to the location of the portfolio companies, regardless of the location of the private equity firms. Data for Europe includes only venture capital

investments (seed, start-up, and later stage) by formal fund managers including private equity funds making direct private equity investments, mezzanine private equity funds, co-investment funds, or rescue/turnaround funds. Investments by business angels, incubators, infrastructure funds, real estate funds, distress debt funds, primary funds-of-funds, or secondary funds-of-funds are excluded. The investment amount only captures the equity amount that is invested by formal fund managers and not the value of the entire financing round. Growth capital or buyout investments in current or formerly venture capital-backed companies are also not included.

This graph shows the growth rate of venture capital in some selected OECD economies. In most cases, the growth over the last 10 years is above 100%.

If we look at the number of deals, according to World Bank [6], United States experienced a year-on-year growth rate of 18,1% for the period 2013 to 2018, with Luxembourg the highest average growth rate (120%), and Cyprus the lowest (-100%). The World Bank also offers an index (1–7) about how easy is for entrepreneurs with innovative but risky projects to find venture capital, being 1 extremely difficult and 7 extremely easy. In 2018, the USA was first in this rank

with an index of 5.24, China's index was 4.42, and EU countries had indexes below 4. Although it is commonly accepted that venture capital (the availability of funds to new companies) affects positively the business environment and the economic growth ([7] among others), according to the world bank index and, from the perspective of entrepreneurs that need the funds, there is still a long way ahead for this financial vehicle.

According to CB Insights, the global market volume for corporate venture capital investments in 2020 amounted to more than \$73.1 billion and has a steady upward trend [8]. At the same time, the role of the state in regulating and stimulating the venture capital market is becoming more and more noticeable [9, 10]. If previously the dominant paradigm was to provide market participants with maximum freedom of action and it was assumed that self-regulation would lead to maximum benefits within the framework of a liberal approach, now government structures are increasingly becoming the main initiators of the launch of support programs, implementing tasks to stimulate investment in high-tech sectors of the Industry 4.0.

Fiscal measures are one of the most popular and frequently used tools for stimulating the innovative activity of companies by the state.

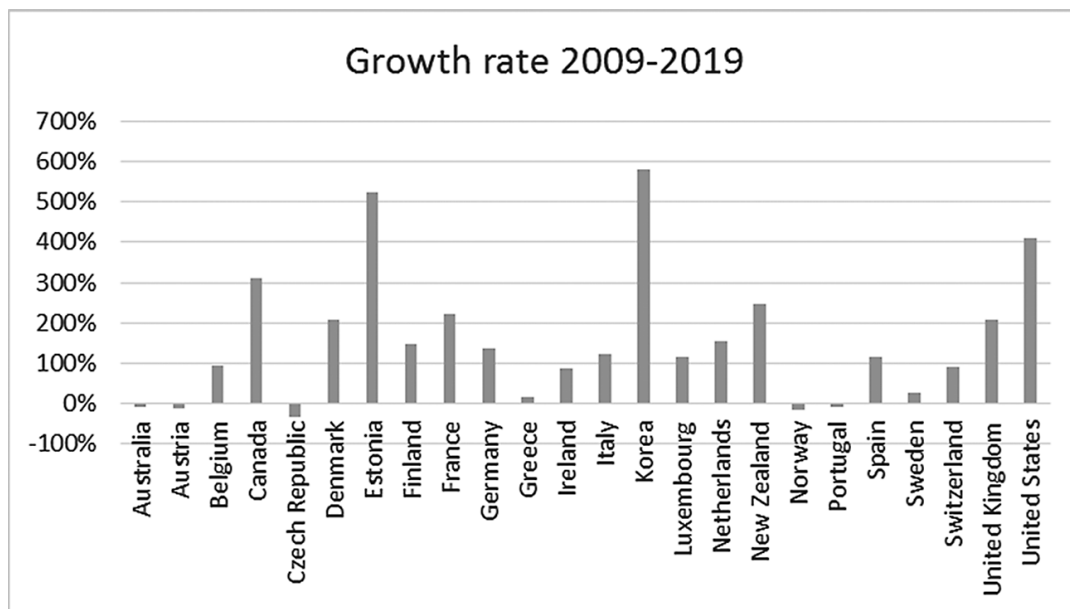


Figure 1. Growth rate of venture capital in some OECD countries from 2009–2019

Source: OECD Statistics [5]

However, it is not universal and encourages the professional and scientific community to continue looking for alternative or additional mechanisms for developing the venture capital market.

The quantity and quality of articles published in peer-reviewed scientific journals indexed in different databases are constantly increasing. Bibliometrics analysis includes collecting, processing and managing quantitative bibliographic data from scientific publications [11], and their statistical indicators allow measurement of the growth, size and distribution of scientific literature on the purpose of interest during a given time period. It is the most commonly used tool to identify important discoveries and studies which have had a disproportionate influence in a particular field [12]. Studying the origin, format, type, and citation count of published journal articles provides an insight into the quantity and scholarly impact of research produced within a certain field, as well as serving as a source of information to prioritize research funding in this era emphasizing cost-effectiveness.

Our group has used a bibliometric approach to study the evolution of scientific literature in different areas of the science [13–28], but, to the best of our knowledge, there is not such work applied to the field of knowledge of venture capital. There has indeed been a recent Delphi process on the usefulness and expected changes of venture capital within the research area, highlighting the role that venture capital research might pose on the ongoing structural changes in the industry and decision-making processes. Hence, in this article, we examine the patterns and trends of published venture capital-related research worldwide.

MATERIAL AND METHODS

Data Source

The initial data search was conducted through two databases, considered the most prestigious in the field of scientific research: SCOPUS (Elsevier BV, Amsterdam, The Netherlands) and the main collection of Web of Science (WoS) (Institute for Scientific Information (ISI) and Clarivate Analytics, Philadelphia, USA). According to the search strategy, a larger set of references was retrieved for SCOPUS, and therefore it was chosen to

carry out the digital file selection. Additionally, SCOPUS was preferred over PubMed because it indexes journals with high scientific quality and provides a unique citation report function.

Search strategy

Remote downloading techniques were used to select references published since there is a chronological continuity of the documents. To obtain the records we have used the main descriptors “*corporate venture fund*”, “*corporate venture capital*”, “*corporate venture capital fund*” joined by the Boolean operator OR limited in the Title, Abstract and Keywords field. As secondary descriptors we use “*venture* AND government* AND support* AND invest**”, “*venture* AND state* AND support* AND invest**”, “*venture* AND government* AND incentiv* AND invest**”, “*venture* AND state* AND incentiv* AND invest**”, “*venture* AND government* AND promotion AND invest**”, “*venture* AND state* AND promotion AND invest**”, limited to the same fields as in the previous search. Both descriptors were joined with the Boolean operator OR. Within the SCOPUS database there is continuity of documents published since 1978 ($n = 1,230$) and with WoS since 1990 ($n = 810$). Data were extracted from databases at one day (March 30th, 2021) to avoid bias because of daily updating in the database.

This study took into account all original articles, brief reports, reviews, editorials, letters to the editor, and so on; also, the duplicated documents were eliminated.

Data categorization

After downloading the metadata and exact bibliographic details of all venture capital publications, the results were analyzed according to the following criteria: chronological distribution, country of origin, affiliation, sources and authors of the documents, keywords and descriptors used. The methodology applied in this study was comparable to recent bibliometric studies of our group [24–28].

Bibliometric indicators

For this analysis, we used the most common bibliometric indicators: price index, doubling

time, annual growth rate, price transience index, Lotka's law and the Bradford zones.

Price's law was chosen as the main bibliometric indicator of production. It is the most widely used method/indicator to analyze productivity in a specific discipline or country. To assess whether the growth of scientific production in this field follows Price's Law of Exponential Growth, we carried out a linear adjustment of the data obtained and another adjustment to an exponential curve.

Time of duplication and the annual growth rate is related to the growth of a subject of study. The former is an indicator that informs us of the time required for the scientific production of a given subject to double. The form of growth was studied from the equation of Egghe and Ravichandra [29], being represented mathematically as $C(t) = cg^t$, where $C(t)$ is the total number of documents produced at time t ; c and g represent the estimated constants of the observed data, taking into account that $c > 0$, $g > 1$, and $t \geq 0$; and t is the number of chronological years studied in the research period ($t = 0, 1, 2, \dots, n$). The model not only provides an average rate of growth but also offers a rate of duplication. To estimate the duplication time (D) of the scientific literature, the following equation is used: $D = LN(2) / LN(g)$.

As a bibliometric indicator for the dispersion of scientific literature, the Bradford zones' model has been applied [30]. To show the distribution of the existing literature, Bradford evidenced that the highest percentage of bibliographic production on a specific subject tends to be concentrated in a small number of journals. He proposed a template of concentric zones of productivity with decreasing density of information that allowed for a faster performance expanding the search outside its core. This model helps to determine which journals are preferred by researchers to publish on it, and therefore, the most specific ones on a subject or discipline. The number of journals on the nucleus (core) and successive zones are expressed by a ratio as $1, n, n^2, \dots$

To assess the influence of publications, we use the Impact Factor (IF). This indicator, developed by the Institute for Scientific Information (Philadelphia, PA, USA), publishes annually in

the *Journal Citation Reports* (JCR) section of the Science Citation Index (SCI). The IF is calculated considering the times a journal has been cited in the SCI database in the last two years and the total number of articles published in this journal in those same years. Despite its limitations (see [31] for an extensive review and discussion on the limits of impact factor and journal ranks), IF has traditionally been widely used to assess the prestige of scientific journals [32].

Moreover, Lotka's law, also named "the inverse square law of scientific production," was used to provide information on the author's distribution based on the number of publications done [33]. It analyzes the publication volume of authors, expressing that a large group includes many authors with a small number of articles, and a small group includes a few authors with a lot of publications. This law establishes that in the entire scientific community, the number of authors (A) who have published a number (n) of references in a period of several years of activity $A(n)$ is equal to the number of those who have published a single reference $A(1)$, in the same period of time, divided by the square of n . Its function is mathematically expressed as $An = Kn^{-b}$, $n = 1, 2, 3, \dots$, where An represents the probability that an author produces n publications on a subject, while K and b are parameters to estimate depending on the data. According to this law, if the studied period is long enough, and the bibliographic search is as complete as possible, "the number of authors that publish n papers is inversely proportional to n^2 ".

Another indicator that has been included is the author's productivity index (PI). PI allows the establishment of three levels of productivity: $PI = 0$ (transience index: authors with a single paper), $0 < PI < 1$ (those authors that published between 2 and 9 papers), and $PI \geq 1$ (very productive authors, with 10 or more papers).

In addition to the productivity index, we have used the h-index to quantify the authors' activity. This index is one of the bibliometric indicators most widely used to rate a researcher's performance success [34]. Nevertheless, the h-index also has its limitations, as it tends to penalize those authors that prioritize quality over quantity and do not publish extensively, while favouring

others with a more protracted career [35], who have managed to publish more [36]. The g-index was introduced to measure the global citation performance of a set of articles [37], together with the p-index, which stems from the interrelationship between the two, and is calculated as its coefficient [37, 38]: $p = h / g$.

Bibliometric mapping

Bibliometric mapping is an important research topic in the field of bibliometrics [39]. In this research, we have studied the keywords and co-occurrence networks for the most frequently used terms in the titles and abstracts of the publications related to venture capital over time. Each term is monstrated by a circle, where its diameter and the size of its label illustrate the frequency of the term, and its color reflects the most frequently encountered topics in this field [40].

The analysis of keywords is included within the classification of relational and multidimensional indicators [41]. By keyword analysis, we mean studying the co-occurrences or joint appearances of two terms in a given text to identify the conceptual and thematic structure of a scientific domain.

We have also analyzed bibliographic coupling, a measure that uses citation analysis to establish a similarity relationship between documents. Bibliographic coupling occurs when two articles reference a third common article in their references. Bibliographic coupling was introduced by Kessler as a method of grouping technical and scientific documents and facilitating scientific information and the retrieval of documents [42].

We have applied the mapping to identify the institutions and authors' collaborative networks, to determine which authors produce, how much, and how they relate and collaborate with each author via their institutions. These maps show the importance of using relational indicators in studies to analyze the scientific production of research groups to determine their publication dynamics, emphasizing measures such as centrality, density, and size of the network [43].

Finally, we have made strategic diagrams and thematic keyword networks according to their centrality values and density range [44]. When compiling bibliometric maps with the selected keywords, being the size of the keyword

tags proportional to the frequency of occurrences of the terms and their weight. The central conglomerate of the map indicates a high interrelation of the keywords that comprise it, while the clusters located at the edges of the maps indicate a lower interrelation of said keywords. The larger the circle, the higher the frequency of occurrence of the specific term, and the smaller the distance between two terms/circles, the higher the co-occurrence of the terms. Colors indicate clusters of closely related terms.

Statistical Analysis

Statistical analysis tests were performed using the Statistical Package for the Social Sciences (SPSS) version 23.0 to evaluate the growth pattern of research output. Furthermore, linear and exponential regression adjustments were compared for trends in publication. The software VOSviewer version 1.6.15 (Centre for Science and Technology Studies, Leiden University, The Netherlands) and Scimat, version 1.1.04 (University of Granada) were used to perform the bibliometric mapping [40].

RESULTS

Using the search criteria, we retrieved 1,230 documents in a 43 years period, from 1978 to 2020. The *chronological distribution* of the publication showed a notable increase in the number of articles generated in venture capital research (*Figure 2*), especially from 2001. In the last 13 years (2008–2020), about 70% of the records are concentrated, with the last three years standing out, with almost 21% of the documents.

To assess whether the scientific production on venture capital follows the Price law, a linear trend curve expressed in the following way $y = 2,0787x - 4126,7$ was created. Similarly, an exponential trend line was created according to the equation $y = 2E-95e^{0.1103x}$.

As reflected in *Figure 2*, the mathematical adjustment to a linear curve reveals a correlation coefficient of 0.929, indicating that this adjustment cannot explain 13.69% of the published records identified. On the other hand, the exponential adjustment of the measured values provides a 0.9161 coefficient and, therefore, a residual variability percentage of 16.07%. These

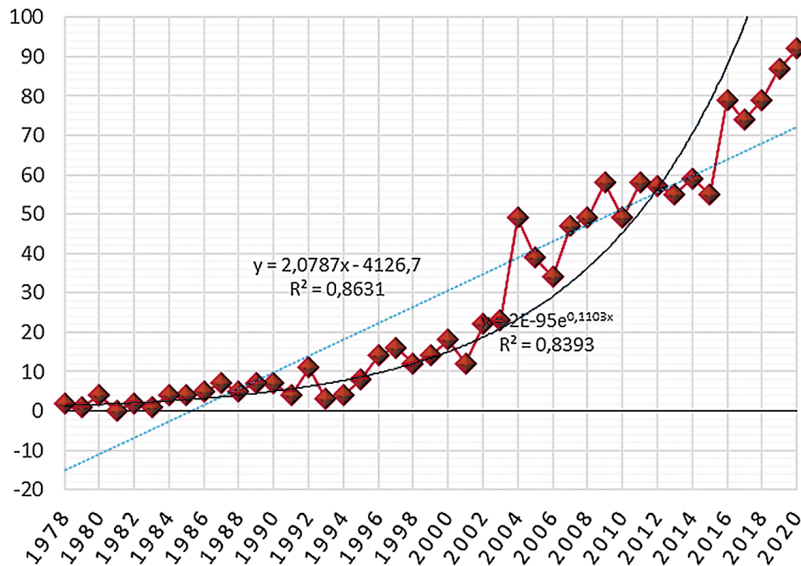


Figure 2. Evolution in the number of international scientific publications on venture capital. A linear adjustment of data and another adjustment to an exponential curve have been performed to verify whether the analyzed production fits Price's Law

Source: Compiled by the authors based on SCOPUS data as of March 30, 2021

results suggest that the repertoire analysed is more in keeping with a linear fitting than an exponential one. Therefore, it does not comply with the postulates of the Price Law, and the growth in the area of venture capital is linear.

Table 1 shows the parameters and values obtained from applying the exponential model by the non-linear regression method. The value of c and g are 3.951 and 1.079, respectively. With these values, the Egghe and Ravichandra Rao equation can be established, thus predicting the growth of the published literature on venture capital: $C(t) = 3.951 \times 1.079^t$.

From this method, we infer that the literature on venture capital has grown at a rate of 7.9% per year, with a production that doubles its size every 9.1 years. We have obtained that the model is explained at 94.2%.

After applying Lotka's law, the *distribution of the authors* was heavily concentrated on small producers, with a high index of transience (occasional authors) of 79.91% (Table 2). There is only 1 author (0.04% of the total) who has a $PI \geq 1$, which can be considered a large producer, i.e., he has published 10 or more papers in this field. The total number of authors for 1,230

papers was 2,688 authors, representing an index of co-authorship of 2.18. However, 34.96% of the documents are signed by a single author.

After manual filtering of the data, due to the lack of standardization of the authors' names, we can indicate that the two authors who most stand out for their production are Gary Dushnitsky, from the London Business School, and Christiana Weber, from Leibniz Universität Hannover, being responsible for 1.06% and 0.73% of the articles published on venture capital (Table 3). Likewise, the importance of the authors who have researched this topic is demonstrated, since although among the first 10, we only find 3 with an h-index above 25. If we take into account the p-index, there are 8 authors above 1.6. This means that they are authors with low productivity, but their articles are highly cited.

Table 4 shows the top 10 *most cited articles* during the 43-year period analyzed. These 10 articles accumulate 26.73% of all citations. The citation index represents the number of times an article has been referenced in other documents and is one of the most used tools to analyze research productivity. The total number of citations in the venture capital research area is 23,237,

Table 1

Values of the parameters obtained with the exponential model

Parameter	Estimate	Std. Error	95% Confidence Interval	
			Lower bound	Upper Bound
c	3.951	0.605	2.730	5.172
g	1.079	0.005	1.070	1.088

Correlations of parameter estimated

	c	g
c	1.000	-0.985
g	-0.985	1.000

ANOVA*

Source	Sum of Squares	df	Mean Squares
Regression	66415.321	2	33207.660
Residual	1926.679	41	46.992
Uncorrected Total	68342.000	43	
Corrected Total	33158.279	42	

Notes: Dependent variable: Docs

* R squared = 1 - (Residual Sum of Squares) / (Corrected Sum of Squares) = 0.942.

Table 2

Classification of authors based on productivity

	PI ≥ 1 (10 or More Articles)	0 < PI < 1 (2-9 Articles)	PI = 0 (1 Article)	Total
Number of authors	1	539	2,148	2,688
%	0.04	20.05	79.91	100.00

Notes: *PI, productivity index.

Table 3

Most productive authors

Author	N _e . Documents	%	h-index*	g-index	p-index	Affiliation
G. Dushnitsky	13	1.06	13	38	2.92	London Business School
C. Weber	9	0.73	9	20	2.22	Gottfried Wilhelm Leibniz Universität Hannover
T. Keil	8	0.65	22	46	2.09	University of Zurich
R. J. Dilger	7	0.57	2	9	4.50	American National Government
C.M. Mason	7	0.57	39	44	1.13	Adam Smith Business School
Y. Yang	7	0.57	7	20	2.86	University of Massachusetts Lowell
M.G. Colombo	6	0.49	40	74	1.85	Politecnico di Milano
R.T. Harrison	6	0.49	42	64	1.52	University of Edinburgh Business School
M. Maula	6	0.49	23	44	1.91	Aalto University
A. Wadhwa	6	0.49	8	30	3.75	Imperial College Business School

Notes: * SCOPUS 2020 data.

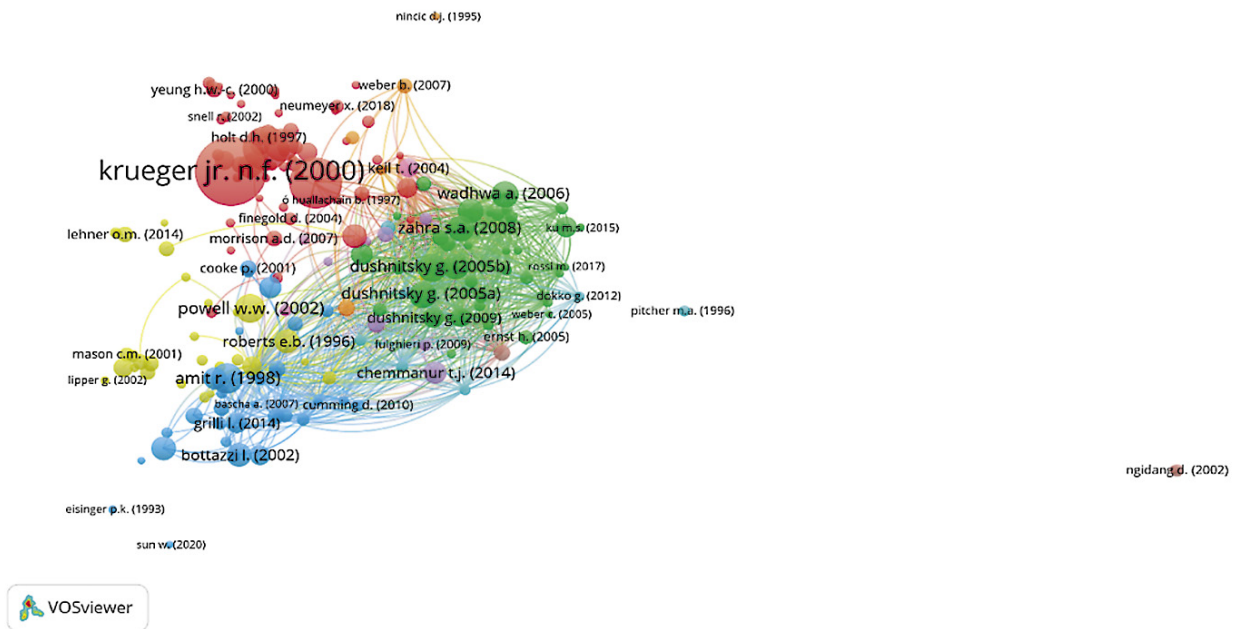


Figure 3. **VOSviewer bibliographic coupling documents**
 Source: Compiled by the authors based on SCOPUS data as of March 30, 2021

Table 4

Top 10 most cited articles

Article	Author	Source	Year	Citas	Pal*
<i>Competing models of entrepreneurial intentions</i>	Krueger et al.	<i>Journal of Business Venturing</i>	2000	2.103	9.05
<i>Internal capabilities, external networks, and performance: A study on technology-based ventures</i>	Lee et al.	<i>Strategic Management Journal</i>	2001	1.090	4.69
<i>Culture and entrepreneurial potential: A nine country study of locus of control and innovativeness</i>	Mueller et al.	<i>Journal of Business Venturing</i>	2001	793	3.41
<i>New venture internationalization, strategic change, and performance: A follow-up study</i>	McDougall et al.	<i>Journal of Business Venturing</i>	1996	405	1.74
<i>Why do venture capital firms exist? theory and Canadian evidence</i>	Amit et al.	<i>Journal of Business Venturing</i>	1998	351	1.51
<i>Public policies and the misuse of forest resources</i>	Repetto et al.	<i>Public Policies and the Misuse of Forest Resources</i>	1988	307	1.32
<i>The spatial clustering of science and capital: Accounting for biotech firm – Venture capital relationships</i>	Powell et al.	<i>Regional Studies</i>	2002	300	1.29
<i>When do incumbents learn from entrepreneurial ventures?: Corporate venture capital and investing firm innovation rates</i>	Dushnitsky et al.	<i>Research Policy</i>	2005	292	1.26
<i>A taxonomy of business start-up reasons and their impact on firm growth and size</i>	Birley et al.	<i>Journal of Business Venturing</i>	1994	289	1.24
<i>A profile of new venture success and failure in an emerging industry</i>	Duchesneau et al.	<i>Journal of Business Venturing</i>	1990	282	1.21

Notes: *Pal: Participation Index.

representing an average citation rate per document of 18.89. The bibliographic coupling of the documents is shown in *Figure 3*.

It should also be noted that the articles of the most productive author are not the most cited. Gary Dushnitsky's article is only in 7th place among the most requested publications. Similarly, the articles of authors who took 2–7 positions in the ranking of the most productive scientists (*Table 3*) were not included in the top 10 most cited articles, which means that the number of published documents has no direct correlation with their quality.

The map represented in *Figure 4* shows the **collaboration networks** between the authors. The diameter of the nodes is related to the productivity of each of the authors, the lines or links establish the existence of a relationship between a pair of authors, and the thickness of the lines refers to the intensity of the communication between two or more authors. In this way, we can verify there is hardly any collaboration between the authors in the research field on venture capital.

Table 5 shows the **distribution of journals** per Bradford zone. It should be noted that the

scientific production in this area is widely distributed in almost 800 different journals. The most used journals, although with a low participation index (Pal), are *Journal of Business Venturing*, with 3.01% of total production, and *Venture Capital* with 1.63%, which implies that there is no concentration of articles published in a small core of specialized journals. These more specialized journals in venture capital research present a high IF; out of the 10 most used journals, 6 have an IF > 4 (JCR2019), which shows the interest in this area of research (*Table 6*).

The **geographical and affiliation distribution** of the documents is presented in *Figures 5* and *6*. This analysis shows that 10 countries represent 71.96% of production, with the United States being the largest producer, with 31.22% of the documents. The Russian Federation provides 29 documents (2.36%). As far as the most productive institutions are concerned, we can say that most of the research on venture capital takes place in the universities sector. Thus, we find 12 universities or related centers among the top 20 positions. In this respect, the University of Pennsylvania stands out with 1.63% of the total

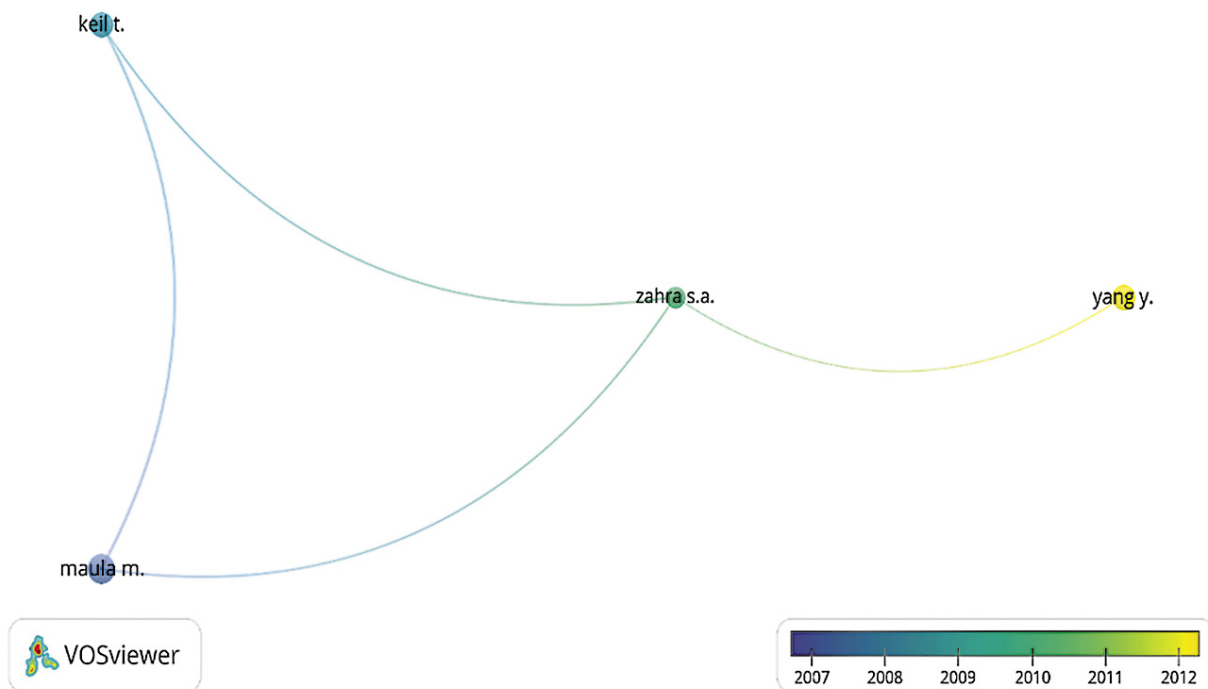


Figure 4. VOSviewer collaborative network of the most productive authors

Source: Compiled by the authors based on SCOPUS data as of March 30, 2021

Table 5

Distribution of journals in Bradford's zones

	<i>N° of journals</i>	<i>% of journals</i>	<i>N° of articles</i>	<i>% of articles</i>	<i>Bradford multiplier</i>
Core	72	9.06	390	31.71	
Zone 1°	116	14.59	232	18.86	1.61
Zone 2°	607	76.35	608	49.43	5.23
Total	795	100.00	1,230	100.00	3.42

Table 6

Journals with highest number of publications on venture capital

<i>Journal</i>	<i>N° of documents</i>	<i>Pal</i>	<i>Impact Factor</i>	<i>Country of origin</i>
<i>Journal of Business Venturing</i>	37	3.01	7.59*	United States
<i>Venture Capital</i>	20	1.63	1.844*	United Kingdom
<i>Proceedings of the International Astronautical Congress</i>	17	1.38	0.190**	United States
<i>Research Policy</i>	14	1.14	5.351*	The Netherlands
<i>Strategic Management Journal</i>	13	1.06	5.463*	United States
<i>Journal of Small Business and Enterprise Development</i>	10	0.81	0.504**	United Kingdom
<i>Journal of Commercial Biotechnology</i>	9	0.73	0.156**	United Kingdom
<i>Strategic Entrepreneurship Journal</i>	8	0.65	6.200*	United States
<i>Technological Forecasting and Social Change</i>	8	0.65	5.846*	United States
<i>Journal of Business Research</i>	7	0.57	4.874*	United States

Notes: Pal: Participation Index; *JCR2019 data; **SJR2019 data.

production of research on venture capital, and the University of Minnesota Twin Cities holds the second position (1.06% of the total production).

Collaboration between different institutions is a key factor in developing scientific

production in any area of knowledge. *Figures 7 and 8* show the collaboration networks between institutions and countries. In the first case, we find that the institution that establishes the greatest number of collaborations in this

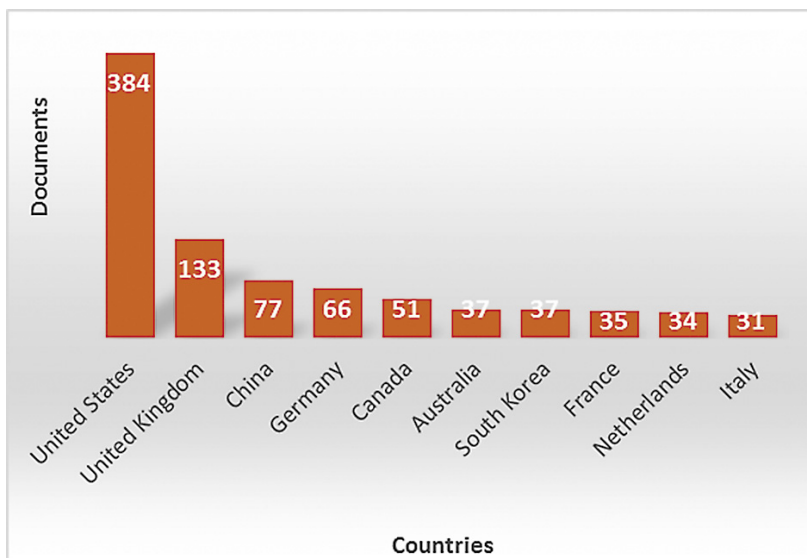


Figure 5. More productive countries in the generation of scientific literature on venture capital

Source: Compiled by the authors based on SCOPUS data as of March 30, 2021

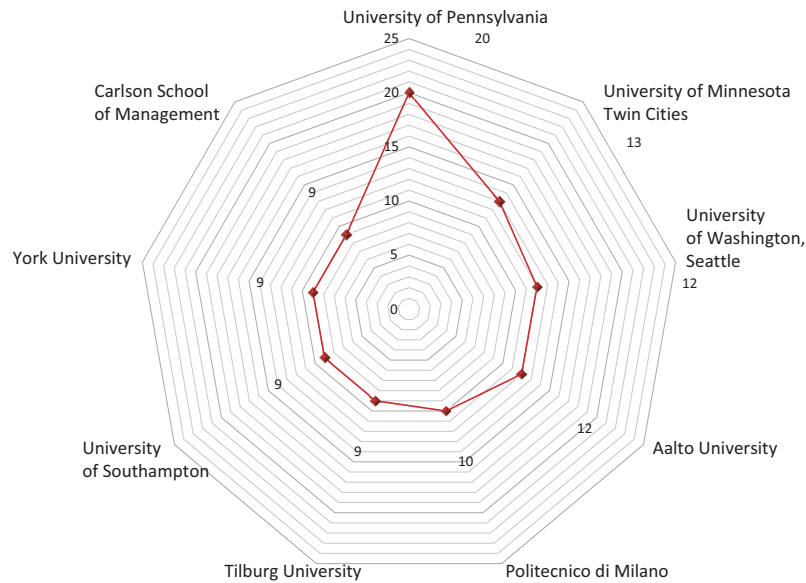


Figure 6. **More productive institutions in the generation of scientific literature on venture capital**

Source: Compiled by the authors based on SCOPUS data as of March 30, 2021

field of research is the University of Alberta (Canada). Regarding the networks between countries, we found the United States as the central purple cluster, and we saw how it establishes a relationship with the main countries in venture capital research, such as United Kingdom, China, Germany, South Korea. Note that Figure 7 does not show more productive

institutions in the generation of scientific literature on venture capital (Figure 6).

Table 7 shows the main **funding Agencies** that support venture capital research. The European Commission and the National Natural Science Foundation of China are the agencies that have been mentioned in a greater number of documents of the analyzed repertoire as

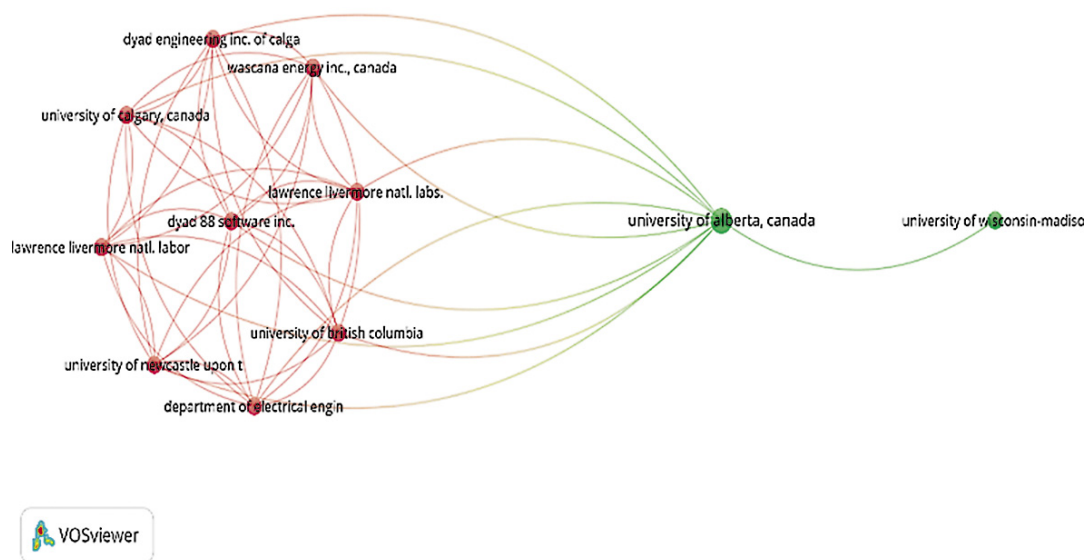


Figure 7. **VOSviewer map of collaboration of the most productive institutions**

Source: Compiled by the authors based on SCOPUS data as of March 30, 2021

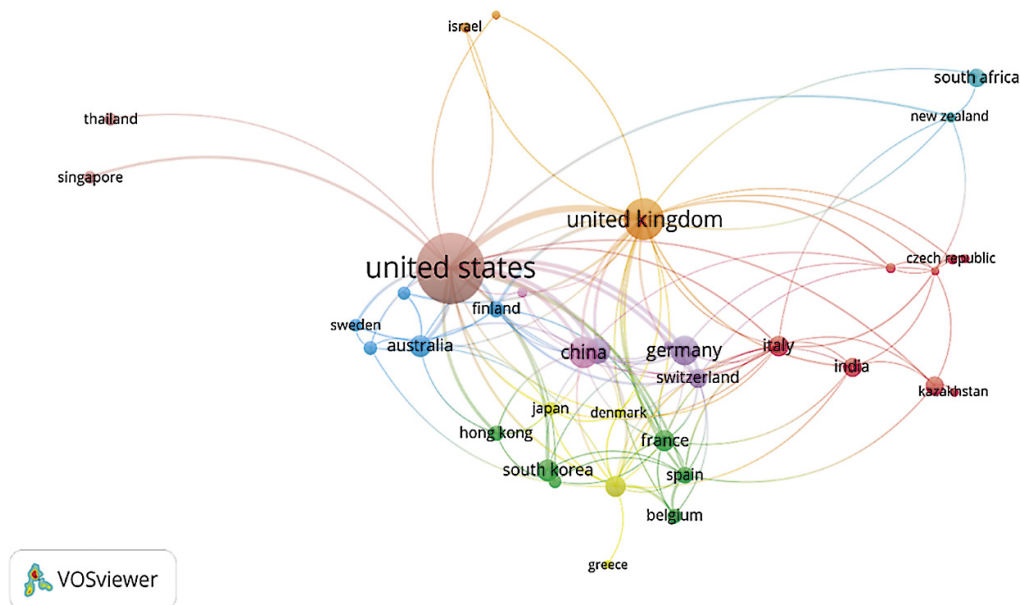


Figure 8. **VOSviewer map of collaboration of the most productive countries**

Source: Compiled by the authors based on SCOPUS data as of March 30, 2021

the main sources of funding. Then there are five agencies from the US, two from Canada, and one from the UK.

The most common *language of publications* indexed in the Scopus database is English (97.07%), followed by Russian (0.89%), German (0.57%), Chinese (0.49%), French (0.33%) and Spanish (0.33%). Meanwhile, in the analysis of the type of document, original articles accounted for 66.42% of the identified records, conference papers represented 13.33%, book chapters were 9.02% out of the

total, and reviews the 6.42%. Analysis of *subject areas* shows that 46.26% of the documents fitted in "Business, Management and Accounting" area (569 documents), 25.85% in "Economics, Econometrics and Finance" (318 documents), 23.09% in "Social Sciences" (284 documents) and 17.56% in "Engineering" (216 documents) (Table 8).

The maps presented in Figure 9 show the *frequency of appearance of the keywords* provided by the documents themselves and those derived from the title and abstract of the

Table 7

Main funding Agencies

Funding Agencies	Records	%
European Commission	18	1.46
National Natural Science Foundation of China	14	1.14
National Science Foundation	11	0.89
U.S. Department of Health and Human Services	11	0.89
National Institutes of Health	10	0.81
Ewing Marion Kauffman Foundation	8	0.65
U.S. Department of Defense	8	0.65
Government of Canada	7	0.57
Social Sciences and Humanities Research Council of Canada	6	0.49
UK Research and Innovation	6	0.49

Table 8

Distribution of the documents according to the main research areas

Research Areas	Documents	%
Business, Management and Accounting	569	46.26
Economics, Econometrics and Finance	318	25.85
Social Sciences	284	23.09
Engineering	216	17.56
Computer Science	86	6.99
Environmental Science	82	6.67
Energy	73	5.93
Decision Sciences	64	5.20
Earth and Planetary Sciences	63	5.12
Medicine	62	5.04
Arts and Humanities	40	3.25
Biochemistry, Genetics and Molecular Biology	39	3.17
Physics and Astronomy	35	2.85
Agricultural and Biological Sciences	31	2.52
Materials Science	27	2.20

same, respectively. *Figure 9A* shows the bibliometric map with the selected keywords. Cluster analysis based on term co-occurrence identified five major clusters (green, red, purple, blue, and yellow), being the main term (*investments*) situated in the green cluster, highly connected with terms from the other clusters (*venture capital*, *innovation*, or *economics*). Conversely, in

the keywords of the title and abstract of the documents (*Figure 9B*), the terms *investments*, *human*, and *United States* appeared as the central clusters.

As you can see in *Figure 9A* and *Figure 9B*, when we compiling the co-occurrence author keywords map and the co-occurrence term map of title and abstract words, several terms

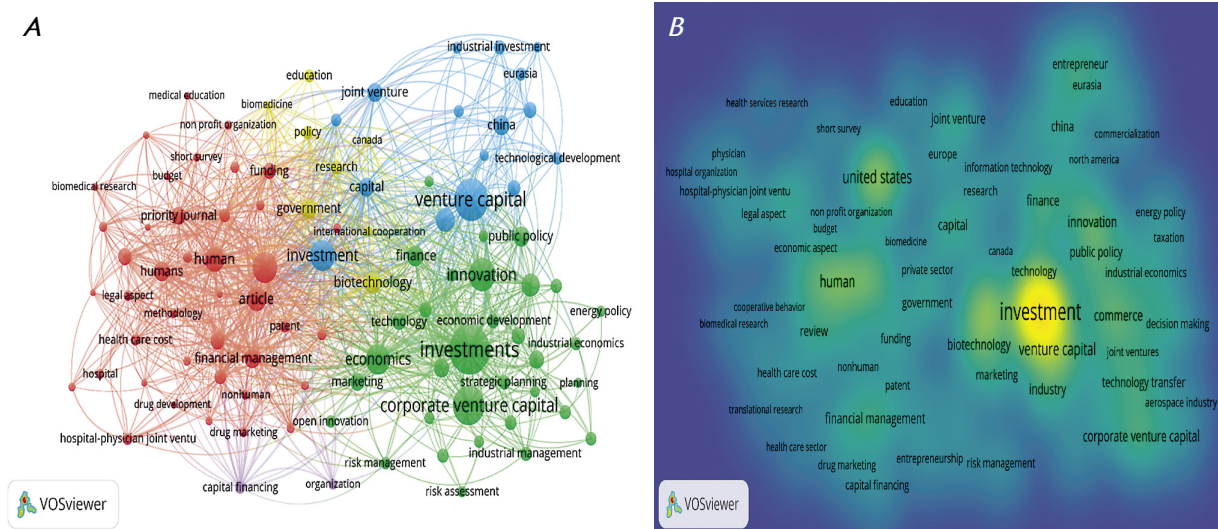


Figure 9. **VOSviewer co-occurrence author keywords map (A), and VOSviewer co-occurrence term map of title and abstract words (B)**
 Source: Compiled by the authors based on SCOPUS data as of March 30, 2021

appear in the figures not included in the main descriptors. Firstly, these are words that characterize the analyzed area and expand the used terminology in the field of venture capital, for example, joint venture, entrepreneur, technology transfer, capital financing. Secondly, we see sectors of the economy that most use corporate venture capital in their development, such as biotechnology, health care sector, aerospace industry. Third, the maps clearly show the countries and regions most involved in the venture capital industry (USA, Europe, China, Canada). And, finally, the maps display some terms, criteria, approaches, etc., which may not be obvious when setting the search problem, but the pool of scientific publications reflects their high importance in studying government incentives for the venture capital industry.

Finally, *Figure 10* shows the strategic diagrams of the *keywords clusters*, comparing two time periods; the first, which covers from 1978 to 2010 (*Figure 10A*, 535 documents), and the second, between 2011 and 2020 (*Figure 10B*, 695 documents). These diagrams constitute a space according to the values of centrality and the range of density along the *x*

and *y* axes: The topics of the upper right quadrant are well developed and are important for the structuring of the research field, whereas the topics in the upper left quadrant have well-developed internal ties, but not relevant external ties, so they only have marginal importance (highly specialized and peripheral issues). On the one hand, the themes in the lower left quadrant are weak and marginal (emerging or disappearing themes); on the other hand, the topics in the lower right quadrant are important to a research field but are not developed (cross-cutting and general topics). The most relevant cluster-topics in this area have evolved from *corporate venture capital* and *financial management*, in the first period, to *commerce* and *medical research* today. *Figure 11* shows the evolution map of the cluster-keywords between both periods. The solid lines mean that the keywords share the same theme, or that one keyword is part of the other. A dotted line means that the keywords have share elements or thematic nexuses. The thickness of the edges is proportional to the inclusion index, and the volume of the spheres is proportional to the number of published documents associated with each theme [44].

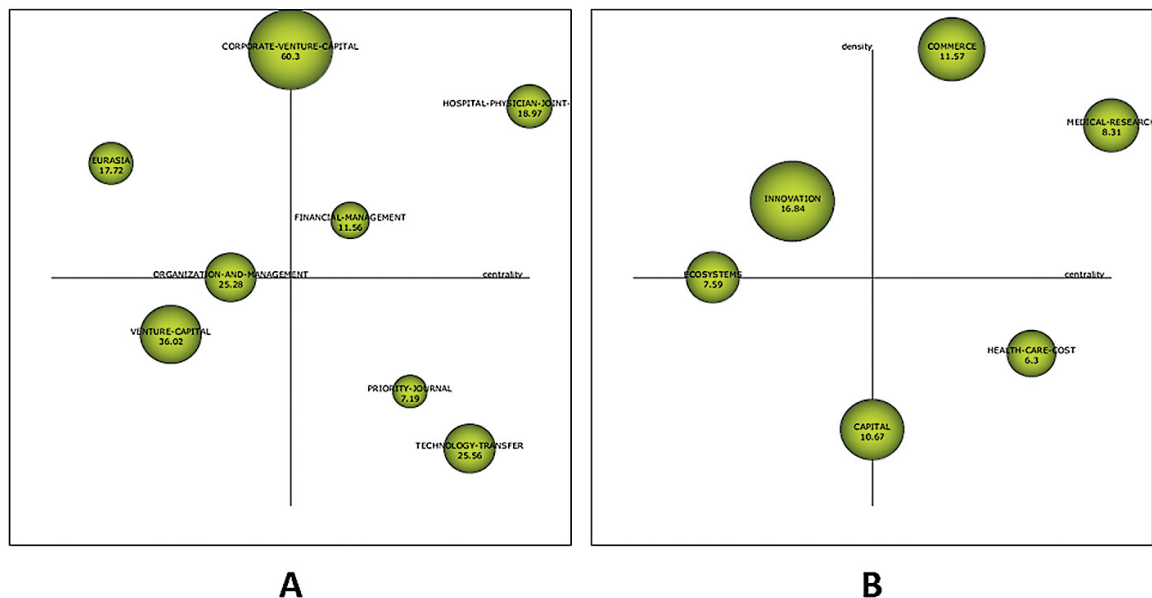


Figure 10. Strategic diagrams (average citation) for the periods 1978-2010 (A) and 2011-2020 (B) (mapping using Scimat)

Source: Compiled by the authors based on SCOPUS data as of March 30, 2021

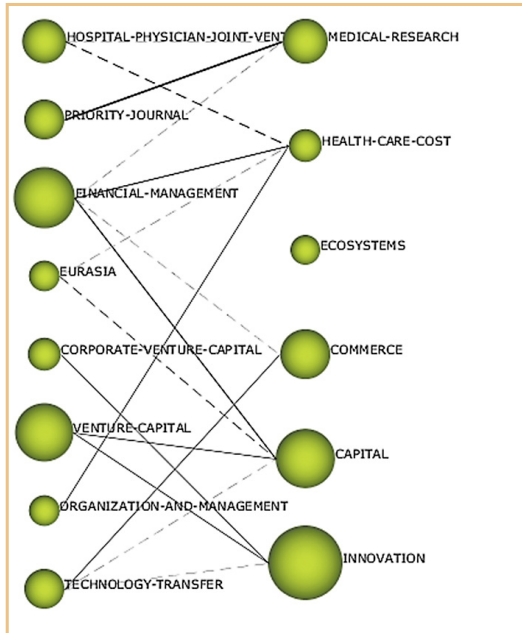


Figure 11. **Keyword evolution map (mapping using Scimat)**

Source: Compiled by the authors based on SCOPUS data as of March 30, 2021

DISCUSSION

In this article, we aimed to assess the publication patterns and trends on venture capital-related research worldwide, looking at several indicators such as, among others, the growth rate of publications, potential collaborations between authors and institutions kept over time. The findings obtained point towards an increase in the amount of publications related to venture capital, although its evolution in terms of scientific literature is better suited to a linear adjustment rather than an exponential increase, contradicting the Price Law and suggesting that publication growth on VC has not yet reached the saturation point postulated by this theory [45]. However, these results might be counterintuitive taking into account that, from the 1,230 documents identified through our search from 1978 to 2020, about 70% of the records seem to belong to the time period from 2008 until 2020 concentrated, additionally showing a greater concentration of published papers during the last three years. The difference in the amount of records identified through different time periods is in line with the results found by a recent review on financing

research [46], pointing towards a larger amount of literature from 2004 and onwards compared with the time period included between 1980 and 2003. The authors also concluded that there were differences not only on the amount of works but also on the evidence assessed, referring during the early ages to the initial definition of venture capital itself and the different types and switching to a deeper analysis of those financing types and some additional ones in case of the latest years.

Moreover, the high concentration of documents during such timeframe is consistent with the growth rate of venture capital across some OECD countries that have already been mentioned in the Introduction, with most of the countries reporting rates above 100%. Actually, Korea, as an Asian country, shows the highest venture capital growth rate (nearly 600% along 10 years), followed by Estonia (slightly above 500%), United States (400%), and Canada (300%). It would not be surprising, then, that the latter two, according to our results, are the countries establishing most of the collaborations between different institutions regarding venture capital. However, the dominance of some countries in terms of venture capital growth and research-related production might be subject to change, given the increasing importance that VC is gaining in emerging economies, where strategic networks and changing institutional environments are rapidly increasing [47].

Actually, an existing review on international VC aspects concluded that most of the existing evidence might have had the wrong focus as most of the reviewed literature concentrated on cross-country comparisons, rather than on the influence of institutional contexts, especially on social networks and cultures, which, according to the authors, might play a more important role when dealing with the crossing of country borders by VC firms [48]. Additionally, Drover et al. [46] found in their review an increasing internationalization of VC investment activity, with both formal and informal institutional environments influencing the VC activities [46, 49], particularly in developing contexts and emerging economies. Furthermore, some authors have already concluded that different institutional contexts may require different types of investors and investor

behaviors [50], entailing potential opportunities to identify alternative configurations for risk capital markets depending on those various contexts.

Another aspect of interest with respect to the scientific production that we have analyzed is its quality. The IF of journals used in disseminating works is very high, leading us to emphasize the quality of the publications in which these articles have been distributed. As detailed in the Results section, although there seems to be no concentration of published articles on a set of specialized journals, the first and second journals, which concentrate the highest number of records identified through our search, are journals specialized on VC. Those two journals are *Journal of Business Venturing* and *Venture Capital*, which have an Impact Factor of 7.59 and 1.844 (data from 2019 according to JCR) and are placed within the first quartile of the category "Business" and the second quartile of the category "Business, Finance," respectively. Although they represent only 5% of the total production, the fact that the two main sources of published evidence are on specialized journals seems to point towards a growing interest in this matter. Another remarkable result is that the country of origin of most of the journals included in the top 10 listed in *Table 6* is the United States, underlying the relevance of such country not only in terms of venture capital itself but also regarding the related evidence generated. The same subjective assessment of the quality of publications could be inferred when reviewing the most productive institutions and authors on this topic.

The study did not reveal any particular attention of researchers to state regulation of the venture capital industry. Some keywords directly and indirectly related to this problem are found in the terminological map of headings and abstract words (government, budget, public policy, funding) but do not represent a stable cluster.

Based on the results found in the current review, we feel that the scientific interest in venture capital remains remarkable, even though some documents (research paper, activity, statistics, and so on) related to VC might have been ignored through our search since these are not published at scientific journals. We do find strong differences between countries, which might be

related to the intensity of economic activity financed by VC and the entrepreneurial behaviour of those countries. However, a replicate search as the one performed might identify different geographical patterns, given the increasing relevance that venture capital is acquiring in some emerging economies, such as East Asia.

Limitations

Bibliometry has become a fundamental tool for evaluating the results of scientific activity [51]. However, previous bibliometric studies have addressed the limitations of this sociometric approach [52]. This study had some limitations. It is evident that the articles included in the analyzed repertoire only constitute a partial sample of the international scientific production on venture capital research, but the limits introduced by the bibliographic databases determine the subsequent analysis. For example, if the authors do not specify the terms included in our search strategy, these documents would not appear in our database. Moreover, most of the papers included in the present study were published in the English language, which is generally regarded as the predominant language in current medical research. However, it should be noted that this may produce a bias toward English-speaking countries when interpreting the results by geographical area. It should also be noted that in the field of venture capital, a pool of documents that are not related to scientific works plays an important role. Examples of such sources are analytical and statistical agencies materials, official documents of authorities, research papers not indexed in bibliometric databases, and other materials used for decision-making in the real world.

On the other hand, articles were identified and categorized according to the first author's country using data submitted to the literature. It is possible that considering only the primary author's institution missed the contribution of other countries in a global research network, particularly when the senior author is from another country. Unfortunately, when multiple authors are assigned to an article, it is difficult to decide about the relative contribution of each author. As in almost all cases, the first author will have played a key role in the research and article submission process

[53]. Using the primary author's country of affiliation is probably the most reliable indicator for comparing the research contribution of different countries and institutes.

However, the well-known reputation of the journals included in the database used and its wide coverage makes for a representative sample of the international research on venture capital.

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