

## **Evolution and trends of real options under incomplete markets: a bibliometric study**

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### **Abstract**

**Results and contributions:** This study contributes to the theory of real options under incomplete markets by identifying the journals that demonstrate the transition of the study of real options from finance to management, across four thematic nodes, three articles whose impact makes them pillars, and three lines of evolution that enable the identification of emerging categories for new research.

**Purpose:** This paper aims to analyze how research and the use of real options under incomplete markets have evolved. We analyze journals where new knowledge on the subject is being disseminated, the articles with the highest impact and their focus, as well as the most promising lines for future research.

**Gap:** So far, bibliometric studies of real options have focused on the application to specific fields such as natural resources, commodities and medicine. Despite the relevance of the problem of completeness, most articles have addressed the problem through reviews of the literature, hence there are no bibliometric studies that focus on methodological aspects. According to the research carried out, this is the first article that addresses real options under incomplete market phenomena through a bibliometric approach.

**Relevance:** The evidence suggests there has been further evolution of real options in incomplete markets, offering a path towards a better understanding and adoption of advanced techniques of prospective and decision analysis.

**Impact:** This study contributes significantly to the area of finance and financial management by showing the evolutionary process of real options in incomplete markets as well as by identifying the scientific network that has supported their evolution.

**Methodology:** As bibliometric studies are increasingly the focus of literature reviews in economics, management and finance, a bibliometric approach was applied to a series of articles studying the valuation of real options in incomplete markets. Using information from Scopus and WOS, 121 articles were collected and analyzed.

**Keywords:** Real options, Strategy decision, Incomplete markets, Bibliometrics.

## Introduction

Real options have been widely addressed by the literature, although their use still lags behind among managers and decision-makers. Their pragmatic value compared to the dominant NPV paradigm consists in a strategic look at maximizing firm value, beyond a static now or never decision (Jiang et al., 2019).

One of the main problems in its application is due to the violation of the assumption of market completeness. Henderson (2007) noted the difficulty to evaluate real options due to the inability to replicate the cash flows of a non-tradable asset when markets are incomplete. In line with the above, Miao & Wang (2007) highlight that real options are limited by incomplete markets, mainly due to information asymmetries and incentives that fail to be fully described by tradable assets, inducing unintuitive behavior by risk-averse investors or direct investors, clouding the analytical logic of real options in a complete market.

The problem of market completeness lies in this obstacle, since if a classification such as the MSCI framework is analyzed, it is possible to establish that only 25 countries worldwide have an advanced level of cost efficiency and price formation for each asset (MSCI, 2022). This means that neither emerging nor frontier countries would be appropriate scenarios for replicating real asset portfolios.

The completeness problem has been addressed by multiple authors; some propose the solution through stochastic elements, assuming continuity in the price of the underlying asset in line with the solutions proposed by Henderson (2007), Miao and Wang (2007), and Chen et al. (2010). Some others use methods that depend on the availability of information and the assumptions to

be modeled, such as price discontinuity and discreteness of variables (Borison, 2005), applying solutions based on binomial models, Brownian motion and various mechanisms to deal with probabilities in exogenous and endogenous risks.

Lambrecht (2017) and Armerin and Song (2018) point out that although there is a relevant theoretical deployment, from a practical point of view the adoption of real options still does not overcome the fixed NPV paradigm, while highlighting the importance of understanding incomplete markets in the interest of strengthening decision-making and taking advantage of the underlying strategic richness of real options.

Consequently, this paper aims to delve into the evolution of real options in incomplete markets, seeking to identify the theoretical lines that can identify a path towards greater understanding and adoption. Using bibliometric tools, an attempt has been made to compile the various academic products that have studied real options and incomplete markets, avoiding possible selection biases (Khan et al., 2021).

This study contributes to the theory of real options under incomplete markets by identifying the journals whose focus demonstrates the transition of the study of real options from finance to management. There are four thematic nodes, three articles whose impact makes them pillars, and three lines of evolution that allow the identification of promising emerging categories for new research.

## Methodology

The methodology involves the application of bibliometric tools (Pritchard, 1969), using the Bibliometrix and Biblioshiny libraries in Rstudio (Aria & Cuccurullo, 2017), as well as VOS viewer.

Scientific articles from the Web Of Science databases were used for its construction, selecting exclusively those that belonged to the core collection, as well as articles in Scopus. Subsequently, each of the titles and abstracts was reviewed. The search equations used were:

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SCOPUS ( TITLE-ABS-KEY ( "REAL OPTION*" ) AND TITLE-ABS-KEY ( ( "COMPLETE
MARKET*" OR "INCOMPLETE MARKETS" OR "EMERGING*
MARKET*" ) ) ) AND PUBYEAR > 1999
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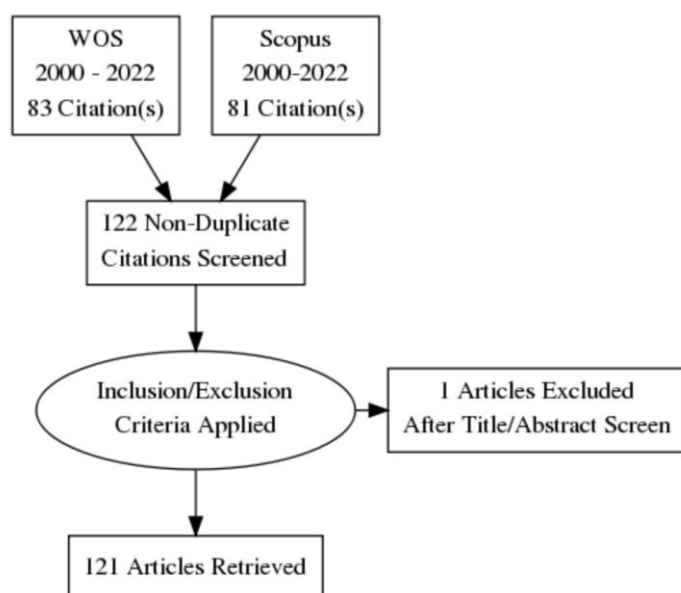
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(ALL=("real option*" AND ("complete market*" OR "incomplete Markets" OR
"emerging* market*")))
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BETWEEN 2000 AND 23/09/2021
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The search result is summarized in the Prism diagram (Figure 1) which presents the search results from the Scopus and WOS sources, after which duplicates were eliminated and a manual review of the titles and abstracts was performed to establish which ones matched the delimitation of the study, resulting in a total of 121 articles for the sample.

**Figure 1**

*Selection of retrieved articles from the Prism model*



Additionally, some keywords such as "frontier markets" and "stand alone markets" were incorporated because they may implicitly contain the problem of incompleteness; however, no results were found with these variations. Using the equations, the following products were incorporated into the study: scientific articles, books, book chapters and conference papers. Conference reviews were excluded, as well as articles whose subject was not related to the use of real options and problems of completeness.

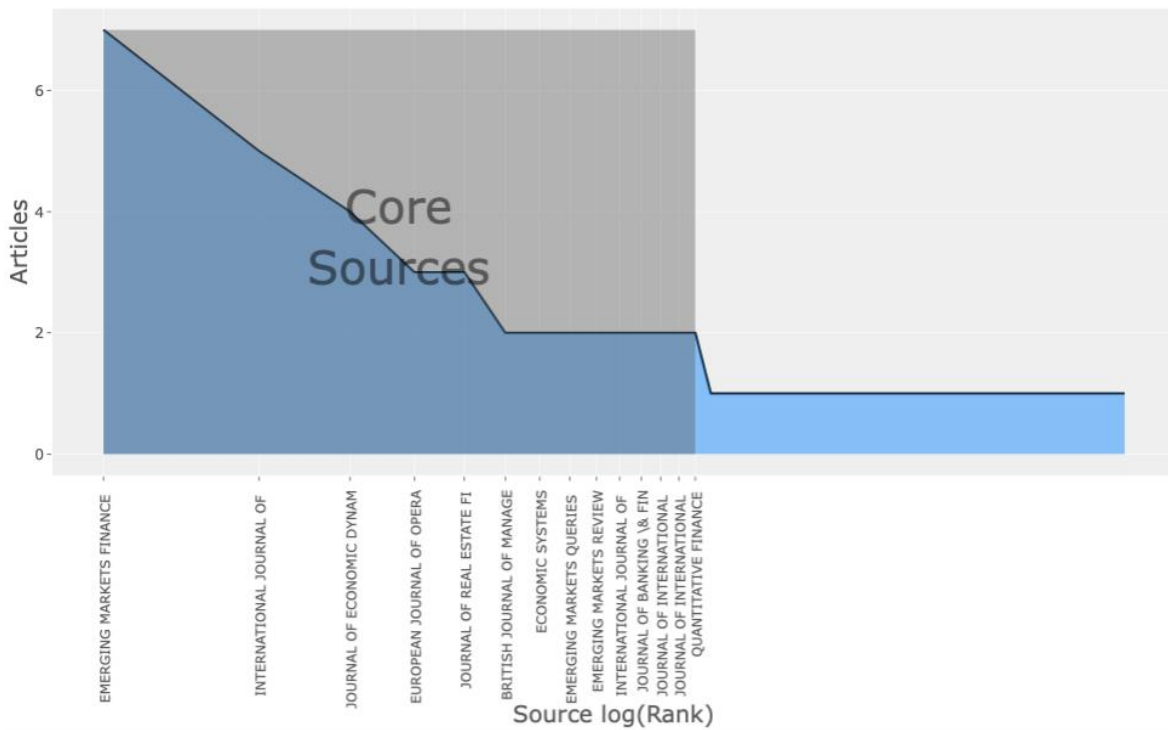
### **Analysis of results**

With the aim of mapping the concentration of the scientific production of real options in incomplete markets, Bradford's law was used to identify the journals with the highest citation and productivity in the area, which are mainly in Zone 1 that represents the core knowledge for this specific problem.

The evidence shows that relevant publications are not limited to the financial field, but that management and business publications are arising in Zone 1. Emerging Market Finance and Trade, the International Journal of Theoretical and Applied Finance, and the Journal of Economic Dynamics and Control have the highest concentration by topic, focusing on the study of emerging markets as well as applied finance and management (Ipsmiller, Brouthers, & Dikova, 2019).

**Figure 2**

*Bradford's Law*



Although it can be established that there is a strong dispersion in the publications, given that only 6% are concentrated in a single journal, it can be observed in Table 1 that at least 3 publications group together about 13% of the scientific products collected for the analysis. Table 1 shows that at least three publications account for 13% of the scientific products collected for the analysis.

**Table 1***Publications by source*

Source	Rank	Freq	Zone
EMERGING MARKETS FINANCE AND TRADE	1	7	Zone 1
INTERNATIONAL JOURNAL OF THEORETICAL AND APPLIED FINANCE	2	5	Zone 1
JOURNAL OF ECONOMIC DYNAMICS & CONTROL	3	4	Zone 1
EUROPEAN JOURNAL OF OPERATIONAL RESEARCH	4	3	Zone 1
JOURNAL OF REAL ESTATE FINANCE AND ECONOMICS	5	3	Zone 1
BRITISH JOURNAL OF MANAGEMENT	6	2	Zone 1
ECONOMIC SYSTEMS	7	2	Zone 1
EMERGING MARKETS QUERIES IN FINANCE AND BUSINESS (EMQ 2013)	8	2	Zone 1
EMERGING MARKETS REVIEW	9	2	Zone 1
INTERNATIONAL JOURNAL OF EMERGING MARKETS	10	2	Zone 1
JOURNAL OF BANKING & FINANCE	11	2	Zone 1
JOURNAL OF INTERNATIONAL BUSINESS STUDIES	12	2	Zone 1
JOURNAL OF INTERNATIONAL MANAGEMENT	13	2	Zone 1
QUANTITATIVE FINANCE	14	2	Zone 1

Figure 3 shows the most cited articles in the area of real options with concerns about completeness, which highlights the works (Henderson & Hobson, 2002) cementing the quantitative tools that have the greatest impact on the topic (Henderson, 2007), where a clear link with the strategy and decision-making area is evident. As well as Miao & Wang (2007), those who incorporate the vision of an entrepreneur in the joint decisions of business investments, consumption, savings and portfolio selection also foster the link between financial decisions, management and the structure of incomplete markets and real options.

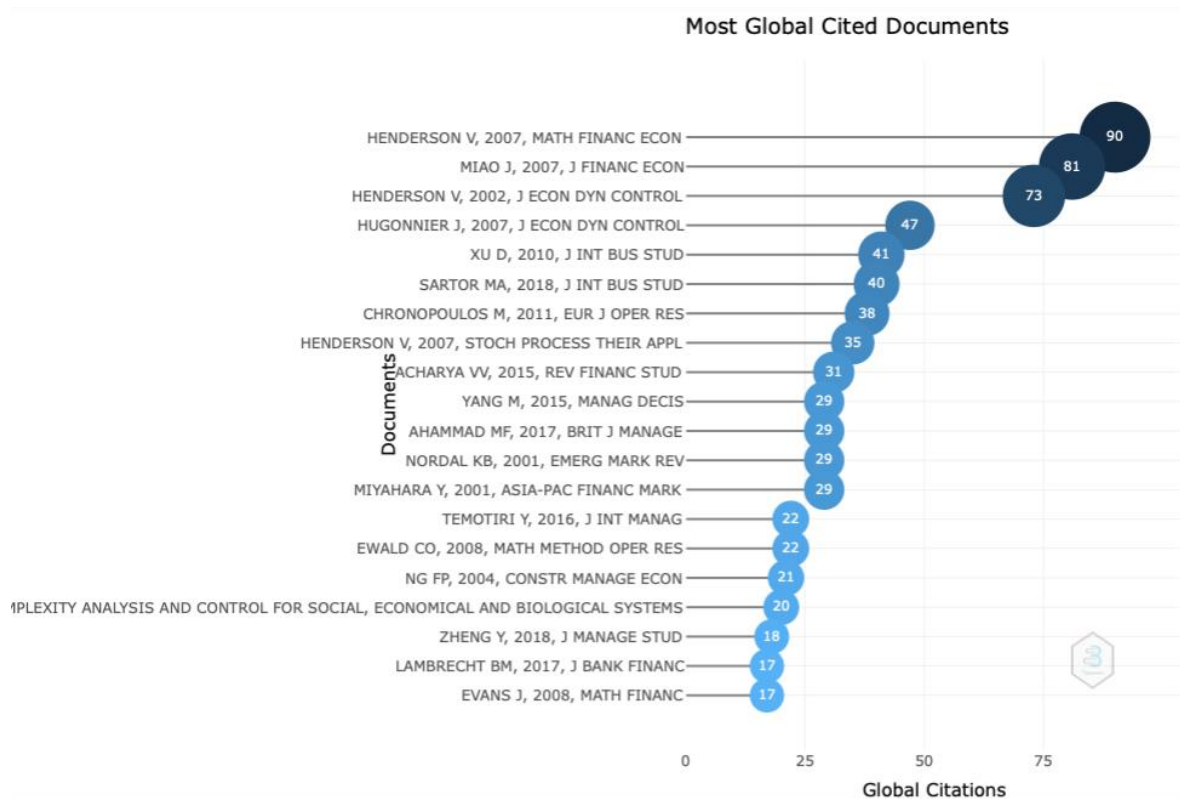
Likewise, some more recent works arise that structure emerging subjects such as Sartor and Beamish (2018), which focuses on international business expansions, as well as Ahammad et al. (2017), which is framed in terms of international mergers and acquisitions. In addition,



management journals emerge showing the evolutionary link between strategy, administration and finance (Figure 4) as well as the use of real options in incomplete markets.

Figure 3

*Most global cited documents*



**Thematic structure**

Following the methodology proposed by Cobo et al. (2011), a thematic map is developed based on the concurrence of key words that allow us to establish the density of the categories and their centrality. This shows the theoretical relevance and the development in the number of publications for each observed category.

Figure 4 shows the thematic development where the fields of management performance and the most prominent companies are the articulating node between real options and the fields where the approach is evolving; investment uncertainty and valuation are outlined as the articulating axis.

Areas are identified that are booming in real options for markets with completeness problems, which agree with the evolution shown in Figure 5, focused on strategy, trade, administration, foreign direct investment and decision sciences.

The areas with the greatest potential for the development of the field of knowledge are uncertainty, performance and management, since they have reached a relevant weight in the field of knowledge, but their density is still low in relative terms (Trigeorgis & Tsekrekos, 2018). Emerging markets and decision-making present a transitional condition from a niche segment with high density and intermediate centrality.

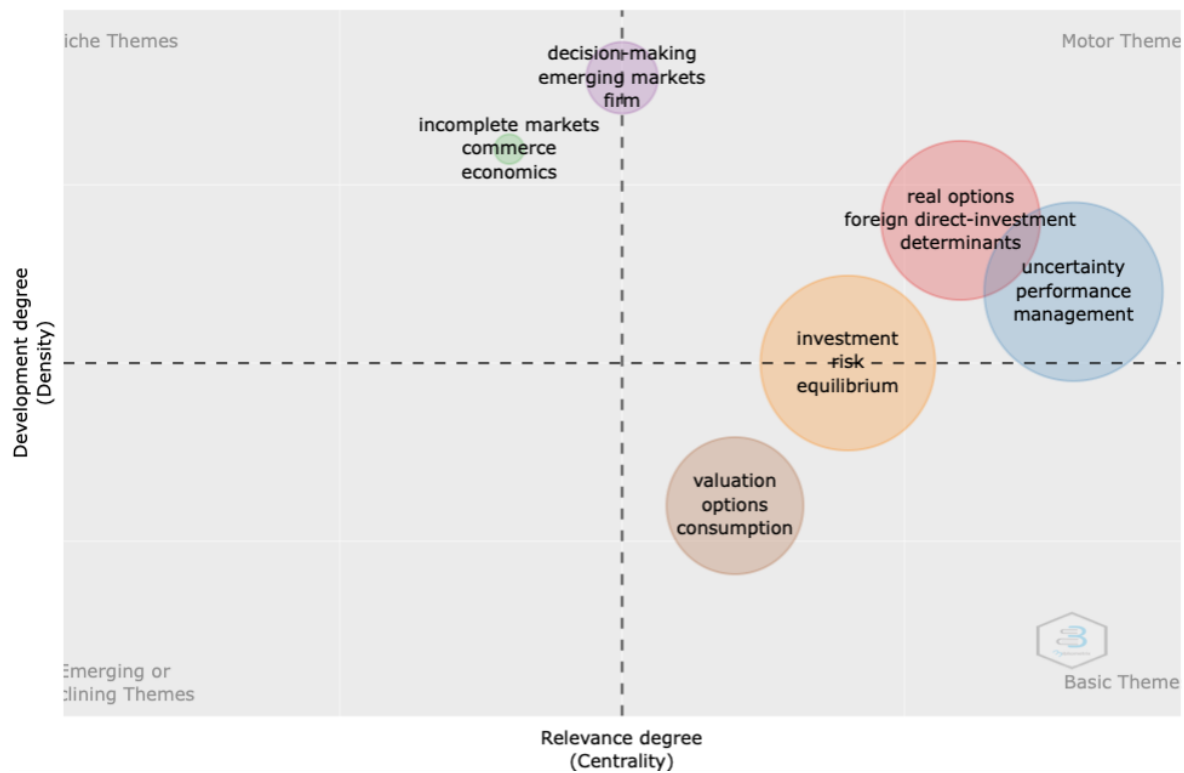
**Figure 4***Thematic map*

Table 2 presents results in which, by omitting the categories of real options and incomplete markets, uncertainty and decision-making are presented as relevant axes. The former in terms of centrality and the latter in terms of density, uncertainty being the node with the greatest potential for development along with the investment node. According to the Callon Centrality Measure, the most relevant theme is uncertainty (37.43), followed by investment (23.7) and valuation (17.55).

**Table 2***Categories by centrality and density*

Cluster	Callon Centrality	Callon Density	Rank Centrality	Rank Density
Uncertainty	37.43	347.22	9	6
Decision-making	16.88	731.06	5	9
Investment	23.70	336.58	7	5
Valuation	17.55	263.37	6	3

Both knowledge categories are in transition from the lower right quadrant, which marks them as thematic axes with room for knowledge advancement.

### **Trending topics**

Following the methodology proposed by Cobo et al. (2011), a longitudinal study is developed based on the concurrence of keywords that allow us to establish the stability of the categories, as well as to identify emerging or potential nodes for the development of knowledge.

Figure 5 shows the forceful strengthening of the lines of choice, performance and management in accordance with what was observed by Trigeorgis and Tsekrekos (2018) regarding the applications of real options in decision and strategy sciences. Investment evolves to feed into lines such as emerging markets and choice, consistent with the contributions of Tsekrekos and Wojakowski (2004), as well as Weeds (2002).

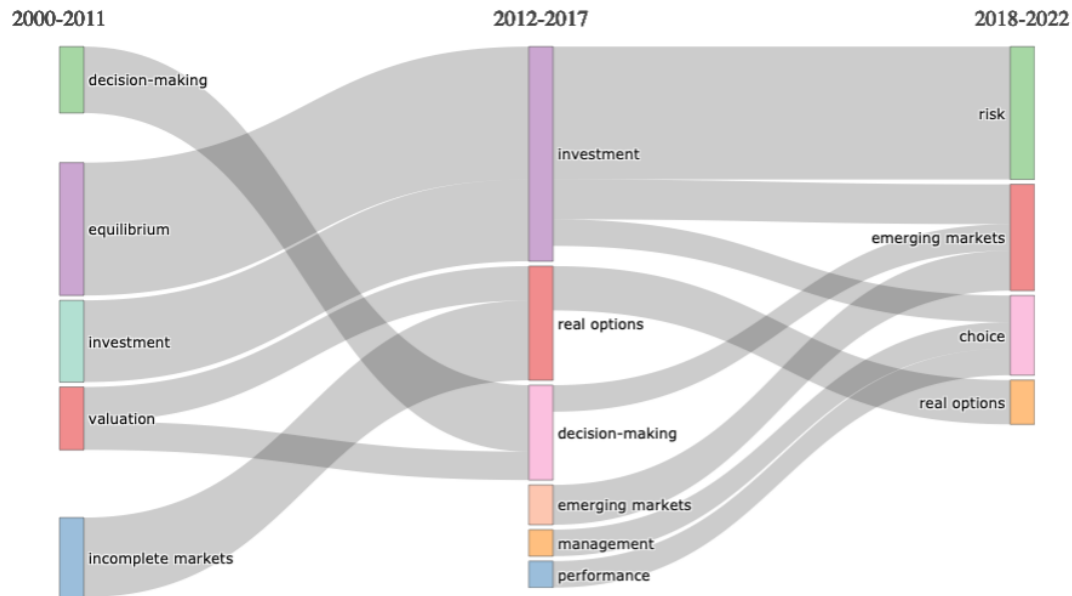
**Figure 5***Thematic evolution*

Table 3 allows us to evaluate the concurrence of keywords in a longitudinal study and to corroborate through the inclusion criterion (as well as the relative stability from one period to another) the emergence of three fields of knowledge: *performance*, *management* and *emerging markets*, which in turn nourish the most recent topics such as *choice* (with a weighted inclusion index above 0.50) and *emerging markets* for the last period observed (0.33).

**Table 3***Thematic evolution*

From	To	Words	Weighted Inclusion Index	Inclusion Index	Occurrences	Stability Index
Equilibrium--2000-2011	Uncertainty--2012-2017	Equilibrium	1.00	1.00	3	0.08
Incomplete markets--2000-2011	Uncertainty--2012-2017	Incomplete markets	0.60	0.50	3	0.07
Investments--2000-2011	Decision-making--2012-2017	Decision-making	0.22	0.33	2	0.14
Investments--2000-2011	Investments--2012-2017	Investments	1.00	1.00	5	0.33
Valuation--2000-2011	Decision-making--2012-2017	Valuation	0.21	0.20	5	0.06
Valuation--2000-2011	Uncertainty--2012-2017	Consumption;investment;risk-aversion;prices;uncertainty	0.34	0.08	3	0.04
Decision-making--2012-2017	Emerging markets--2018-2022	Decision-making	0.22	0.25	4	0.13
Emerging markets--2012-2017	Emerging markets--2018-2022	Emerging markets	0.33	0.25	4	0.11
Investments--2012-2017	Emerging markets--2018-2022	Investments	1.00	1.00	2	0.25
Management--2012-2017	Firms--2018-2022	Firms	0.33	0.33	2	0.11
Performance--2012-2017	Choice--2018-2022	Choice	0.50	0.50	2	0.10
Performance--2012-2017	Real options--2018-2022	Foreign direct-investment	0.10	0.14	2	0.07
Real options--2012-2017	Real options--2018-2022	Real options	0.47	0.50	13	0.13
Uncertainty--2012-2017	Firms--2018-2022	Portfolio	0.33	0.33	2	0.07
Uncertainty--2012-2017	Risk--2018-2022	Risk	1.00	1.00	4	0.08

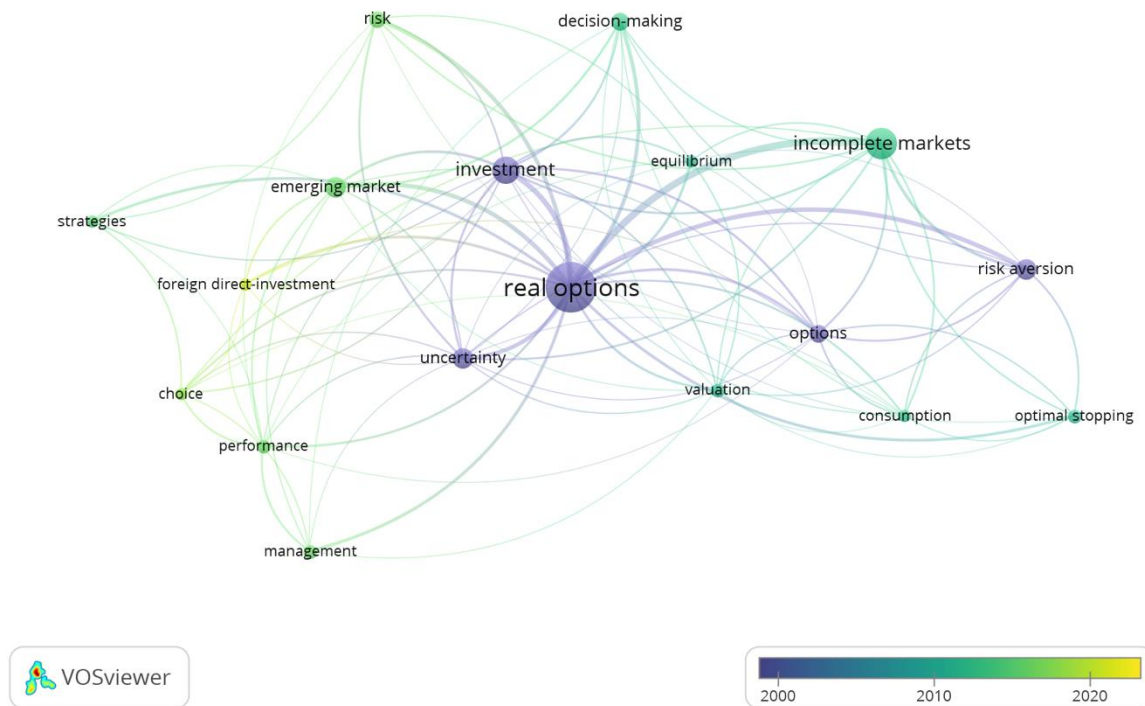
When analyzing the inclusion index in the 2000-2011 to 2012-2017 transitions, the main categories that stand out are investment and equilibrium for the 2012-2017 to 2018-2022 transition period; for the recent 2018-2022 period, the index is 1.

An alternative view consists of constructing a network according to criteria of centrality, density and the size of nodes by frequency (see Figure 6). One can observe the trend areas that begin to be located in the periphery, in particular foreign direct investment, choice and strategies.

Barbopoulos et al. (2019) highlight approaches to development and implementation of real options as emerging areas,

**Figure 6**

*Keywords concurrence map by year*



In general, links and centrality of the theme of real options are observed as an articulating axis between the problems of incompleteness and investment with emerging subjects. This allows us to outline, on the one hand, gaps in the connection between the problem of incompleteness and, on the other hand, the empirical application of the problem of real options to the issues that are strengthened from 2020, such as choice, risk and foreign direct Investment.

## **Conclusion**

The current structure of the field of knowledge of real options in markets with incompleteness problems shows concentration and development from authors and journals in the financial area. However, the increase of authors and publications in the business area that become relevant in the analysis is evident, showing at least a theoretical adoption of management and decision sciences.

Leading authors in the field also show the diffusion of applied finance, as categories such as entrepreneurship and optimal decision emerge when evaluating real options in incomplete markets.

Since the year 2000, it has been possible to quantify the relevant evolutionary changes in the field of real options in incomplete markets, where longitudinal evolutionary analyses demonstrate how some key categories such as investment and equilibrium have transcended categories such as choice and risk typical of business and applied finance.

At the same time, new categories such as performance, strategy and management have emerged as new trends in the field of study. The category of incomplete markets has moved into the real options field, and it is notable that this evolutionary path has focused on practical applications when the market under study has completeness problems.



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