

The Analysis of Hot Topics and Frontiers of Financial Engineering Based on Visualization Analysis

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Abstract The paper did a visualization analysis of co-citation data records regarding to financial engineering which were retrieved from Web of Knowledge by making use of CiteSpaceII software. Through establishing the knowledge map of financial engineering fields, this analysis reflects important figures, articles, knowledge structures, evolution rules of financial engineering industry. Confirms and the research edge and trend of international research on Financial Engineering by detecting subject headings whose word frequency fluctuation are significant.

Keywords Financial engineering · Knowledge map · CiteSpace · Visualization analysis

1 Introduction

Financial engineering has general and special concepts. In this paper we adopt the generalized concept, which refers to the use of engineering means everything to solve the financial problems of technological development. Meanwhile, financial engineering also includes not only the design of financial products, the financial product pricing, trading strategy design and financial risk management, et al. By the late 1980s, with the rapid development of commercial banking, investment banking and securities investment business, John Finnerty proposed the definition of financial engineering, thoughts that financial engineering is a creative solution to the problems of finance including design, development and application of innovative financial tools and financial instruments. The essence of financial engineering is the innovation and practice of financial services, which contains design,

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development and implementation of innovative financial tools and financial instruments. It provides a new way of thinking and financial innovations and become the main driving force of modern financial development in last 20 years, and represents the direction of financial development. In recent years, the rapid changes of corporate finance, commercial bank and investment bank led to the birth of a new discipline, people called it as financial engineering. In China, Conducted the research on financial engineering and built the awareness on financial engineering has important practical significance and broad prospects.

Information visualization is an interactive visual representation for abstract data using computer technics to enhance people's cognition on these abstract information. Information Visualization helps people quickly observe, cognitive processing-related information through the visual channel, facilitates to analyze the data, find that the laws and make decisions [1]. Information visualization can also reveal the relationship between information and the information hidden in nature rule. Citation analysis visualization is an important branch of information visualization, it first deal with massive citation data, then use the technology of information visualization to make it easier to observe and understand the information for people, and finally find the hidden rules and patterns in the data. Knowledge Mapping is the theory and methods combined with applied mathematics, graphics, information visualization technology, information science and other disciplines, and metrology citation analysis, co-occurrence analysis and other methods, showing the core structure subjects and develop history, frontier research and the overall framework of multi-disciplinary knowledge integration [2].

This paper is intended to quantitative investigate and visualization analysis for research the field of financial engineering authors, the art and cutting-edge research issue for study, draw a map to show the research frontier in the field of financial engineering, as well as hot field, breaking traditional methods of analysis, makes the majority of scholars to be more intuitive understanding of financial engineering research area.

2 Data and Research Methods

2.1 Data Retrieval

This paper downloads papers in field of financial engineering from the Web of Knowledge database which belongs to SCI by keyword retrieval, our search expression is: Topics = ("financial engineering"). The retrieval time is the May 3, 2012. Select the theme includes all disciplines, library update time for all years, the search results only include journal articles, and the paper language is limited to English. Our search results are as follows: Totally published papers is 440 records

between 1993 and 2012. Each of record includes a data of authors, title, abstract, and literature citations, save as a pure formatted text.

2.2 Research Methods

Herein our visualization tool for citation analysis is CiteSpaceII, the version number is 3.0.R5.

This scientific literature analysis tool developed by Chen Chaomei team of Drexel University in US based on JAVA platform is a pluralistic, sharing time, dynamic network analysis of the new generation of information visualization techniques [3, 4]. CiteSpace is based on the concept of research front in information science and the time-variant duality concept between intellectual bases, and implemented the two complementary views: cluster views and time-zone views [5, 6]. We analyze a particular technology areas and disciplines, by co-occurrence analysis on keyword and co-citation analysis on document, drawing the scientific knowledge map in the field of science, which show the trends of a discipline or field of knowledge in a certain period of development, to form the historic evolution of several research frontiers. Here the CiteSpaceII software can free download at website <http://cluster.ischool.drexel.edu>.

2.3 Data Pre-processing

Before the data processing with formal, we need download the data from the Web of Knowledge database and transform text into format that can be run. That is to separate 440 records as 440 text files that contain only a record, see Fig. 1.

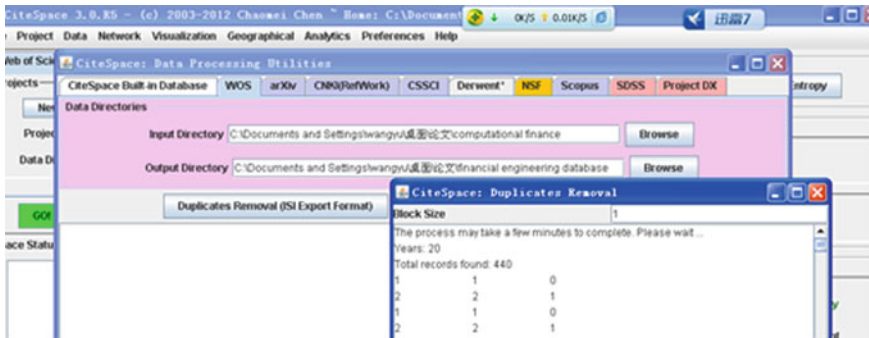


Fig. 1 The pretreatment data format conversion

3 Result Analysis

3.1 Analysis of Intellective Base of Research Frontier

Intellective Base of research frontier specified the cited files with term vocabulary. It reflects the situation on the absorption and utilization of advanced concepts in the scientific literature. In CiteSpaceII, it can cluster the co citation network by spectral clustering, the formation of knowledge base of the co citation map of network knowledge [7]. Now we precede visual analysis to the previous downloaded 440 text data using CiteSpaceII. Setting the time scaling value as 2, saying that divided 20 years into 10 periods for segmenting process. Here segmenting process to the data mainly consider the following two aspects: one factor is the CiteSpace software using the principle of “divide and conquer strategy” in the design and operation process; the second factor is easy to analyze the prominent point on evolution of subject and frontier of temporal pattern using of this form. Secondly, setting c , cc , ccv (where c is the literature citations; cc for a total of two literature citations; ccv for literature co-citation coefficient) thresholds are (3, 2, 20), (2, 3, 20), and (4, 3, 20), wherein the specific annual threshold partition is determined by linear interpolation. Finally, according to the different content of analysis, select the corresponding network nodes, such as the choice Cited Reference, Cited Author, Cited Journal, Keyword, Institute as an analysis object, set the threshold value of time slices as 30. Thus, CiteSpaceII can begin analyzing objects with co-citation analysis of the literature, the author co-citation analysis, journal co-citation analysis, keyword co-occurrence analysis, co-institutional analysis, and co-authors analysis and draw the appropriate scientific knowledge maps.

After running the CiteSpace, the result of co-citation network knowledge map on financial engineering literature is Fig. 2, in which includes 241 nodes, 1002 connection lines. In Fig. 2, each node represents a cited literature, extending outward without color circle described in the literature citation time series in different years, the number of citations and the thickness of the circle is proportional to the corresponding year. The node with purple circle represents the key nodes from a cluster transit to another cluster. Assume that a node with a circle of gray as the key node. Here the key nodes has relative the center of high degree and cited frequency, from the view point of knowledge, the key node literatures are classical literature which is generally proposed a new theory or of great theoretical innovation, these nodes may become the key point from one time period to another time transition network. Therefore, to determine the key nodes of research area is the phase of econometric analysis. Supposed that $\Psi\alpha$ and $\Psi\beta$ is main research frontier with paper laded α and β at t moment produced by the knowledge base of $\Omega\alpha = \Phi(\Psi\alpha)$ and $\Omega\beta = \Phi(\Psi\beta)$, then form 2 co-citation clustering with paper α and β , respectively. Connecting the paper $[p(i)]$ on the two clustering path, which describes the character transition from $\Psi\alpha$ to $\Psi\beta$, here $[p(i)]$ called key node. In Fig. 2, includes 7 key nodes of literature, the details is as Table 1.

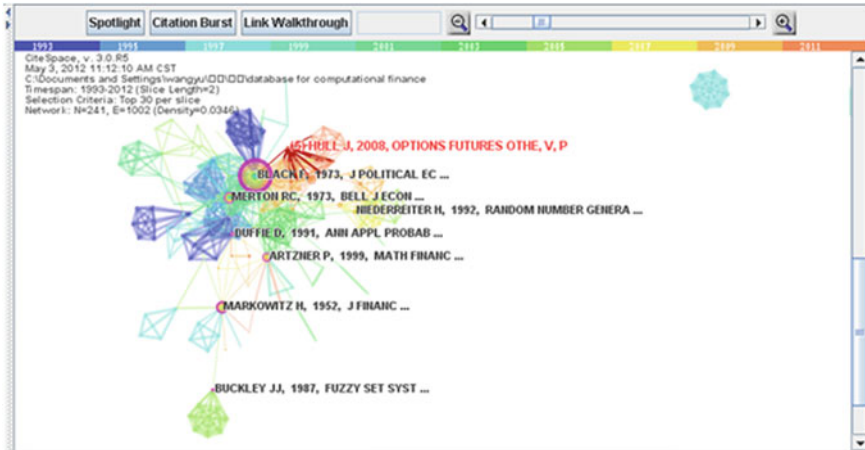


Fig. 2 Financial engineering literature co-citation network knowledge map

Table 1 Information of key nodes of co-citation network knowledge map

Node author	Public year	Paper publication	Co-citation frequency	Central degree
Black F.	1973	J Political Con	55	0.64
Merton R.C.	1973	Bell J Econ	24	0.11
Markonwitz H.	1952	J Financ	22	0.21
Artzner P.	1999	Math Financ	17	0.16
Duffie D.	1991	Ann Appl Robab	8	0.12
Niederreiter H.	1992	Random UMBER Genra	15	0.10
Buckley J.J.	1987	Fuzzy Set Syst	6	0.10

3.2 Analysis of Research Hotspot

From Figs. 2 and 3 can be seen, research and financial mathematics, financial engineering (Financial Mathematics) are inseparable. Financial mathematics is to use mathematical tools to research financial analysis, mathematical modeling, theoretical analysis, numerical calculation and quantitative finance, in order to find the inherent law and used to guide practice. Can be understood as the application of financial mathematics, modern mathematics and computer technology in the financial sector and therefore, mathematical finance is a new interdisciplinary subject, development is very rapid, is one of the frontiers of the discipline of the very active. Through analysis of two important research directions in the field of financial engineering is in Table 2.

From Figs. 2 and 3 we can be seen that research on financial engineering and financial mathematics are inseparable. Financial mathematics is to use mathematical

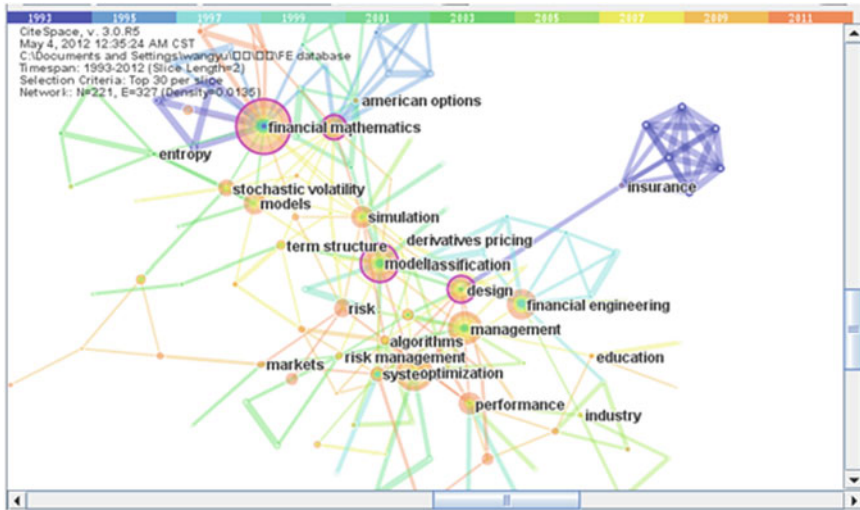


Fig. 3 High frequency keywords knowledge map in financial engineering

Table 2 Vocabulary of research hotspot in financial engineering

No.	Frequency	Keywords	No.	Frequency	Keywords
1	41	Financial mathematics	11	12	Risk management
2	32	Model	12	11	Innovation
3	30	Optimization	13	10	Uncertainty
5	25	Design	14	10	Algorithms
6	20	Simulation	16	9	Interest-rates
7	16	Stochastic volatility	17	6	Insurance
8	13	Valuation	18	6	Credit risk
9	13	Option pricing			

tools to research finance, then proceeds financial analysis, mathematical modeling, theoretical analysis, numerical calculation and quantitative analysis so as to find the inherent regular and used to guide practice. Financial mathematics can be understood as the application of modern mathematics and computer technology in the financial area. Therefore, financial mathematic is a new interdisciplinary subject, development with rapidly, is one of the very active discipline of the frontiers. Table 2 draws the two important research directions in the field of financial engineering.

1. Concept of financial engineering and research scope: Innovation, Design, Optimization, Risk management, et al. can expand the concept and research in the field of financial engineering of the three main aspects. American finance professor John Finnerty divide the scope of the study of financial engineering

into three aspects: The first one is the design and development of new financial instruments, which is a major area of research in the current financial engineering, from the exchange, Options, note issuance facilities, interest rates protocol to index futures, covered warrants, securities depository receipts, zero coupon bonds, convertible bonds, synthetic stock all belongs to this column. The second one is design to reduce the transaction costs of new financial instruments, this part contents includes the optimization of inner operations in financial institutions, the exploration and exploit of arbitrage opportunities in financial markets, and innovation of transaction settlement system. The purpose is to fully mining the profit potential to reduce regulatory costs. The third one is to provide creative solutions for a complete system to solve some financial problems, including various types of risk management, the development and application of technology, innovative cash management strategy, the creation of company's financing structure, the design of corporate mergers and acquisitions program, the implementation of asset securitization and other program contents.

2. Key research object in financial engineering: (a) Option pricing, it is important basis in whole discipline of financial engineering. Option is the acquired option which allowed buyer to buy or sell a certain number of commodities in the future after paid a certain fee options. (b) Stochastic Volatility (SV) model, it is the most active model of income volatility, was first proposed by Clark in the description of joint distribution of stock returns and trading volume, then introduced in econometrics by Harvey et al. (c) Uncertainty trends, the price of investment vehicle is uncertainty in financial markets brings the volatility of returns. The phenomena always are the core issue in the financial field. While research on the volatility of return rate is the basis of analysis such as formation mechanism in capital asset price, financial risk management, financial derivatives pricing, portfolio and so on.

3.3 Research Frontier and Trends Analysis

Research in any field always forward evolution constantly, with the research frontier constant substitute and time lapse, the original research frontier is gradually maturity. It forms the knowledge base of discipline development, in the same time a new research frontier is birth out. The progressive relationship in literature citation expresses the changes in number of words or phrases in research frontier. So, we can detection frequency change to determine the frontier research fields and development trend. Provided by CiteSpaceII of frequency detection technology, we first analysis the previous retrieval data, then set the value of burst term [8], inspect time distribution on term frequency, detect the high rate of frequency change from large subject term. According to the change trend of frequency which is not only the high frequency, we determine the frontier and the development trend in field of financial engineering, as shown in Fig. 4.

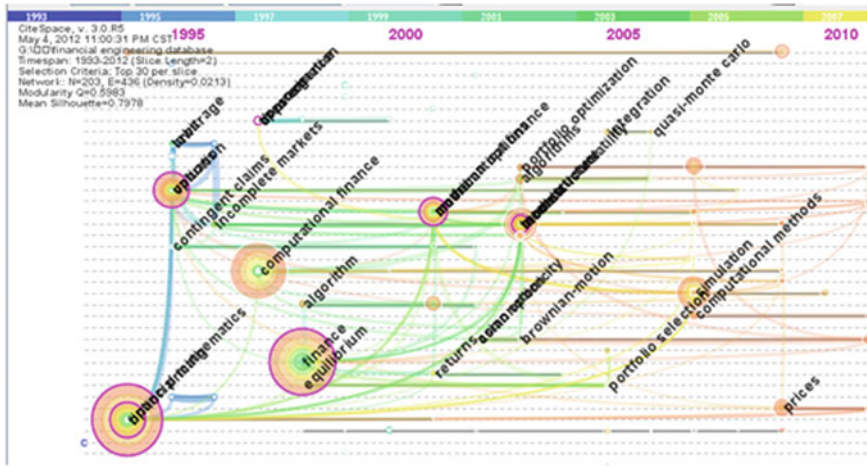


Fig. 4 Knowledge map of research frontier in financial engineering

By setting the appropriate threshold to detect including portfolio selection, multivariate integration, quasi-monte carlo methods, stochastic volatility, portfolio optimization et al. 5 emergence word, we can see the portfolio selection is the biggest change frequency, while quasi-monte carlo methods and portfolio optimization less than the forth. In the following we simply analyze the three important emergence words, then can be detected that the emergence words have good effect on the forward direction.

Portfolio selection is to study how to put the wealth distribution to different assets at a given level of risk to achieve the maximum benefits, or in the case of income to minimize the risks. The balance of risks and benefits always be in the process of investment activity, it is one of the basic problems of investment decision and management. In recent years, with the development of computing technology and information technology, the method of stochastic programming has become a hotspot and frontier of financial engineering in the field of research and practice of dynamic portfolio choice, and achieved certain results. Montecarlo's method is based on the theory of probability and mathematical statistics. The method and the two fork tree, finite difference methods are all belong to numerical pricing methods. Its essence is the average return of asset price path by simulating the target prediction option and option price estimate. Pricing analysis of Montecarlo method and Mengteerte method has been widely used in financial securities, and obtain the good estimate effect. In recent years, the Montecarlo method and imitate Montecarlo method are applied more and more widely in financial derivative securities pricing. Base on this theory, the enterprise investment decision analysis method of real option has increasingly become the focus of attention to various people. Portfolio optimization original from the investors always want to get the biggest income at the level of the minimum risk. According to the operation

research of multi-objective programming theory, we can constraint an object on a certain level to transform the multi-objective optimization problem into a single objective optimization problem. After that, the optimal solution is the efficient solution in multi-objective programming. In recent years, more and more investors pay attention to measurement of investment risk, the portfolio optimization problem is sustained attention by them.

4 Conclusions

As we known the knowledge map can help analyze focus on the evolution of the research hotspot in the research area. This paper uses the CiteSpaceII software to draw the knowledge map of the research area of financial engineering, reveals that our research focus mainly concentrated in the innovation and development, option pricing, risk management, etc. By detecting the change trend of term frequency, it can deduce that in next few years the research frontier mainly focused on portfolio selection, stochastic volatility model, portfolio selection, Montecarlo methods etc. The results of this study and research methods and data sources have certain practical significance. But in overall, this study belongs to exploratory research. There are still many shortcomings. For instance, the data retrieval process is too rough to fine, which may affect the amount of literature in scale, causes the results of analysis is not comprehensive. Meanwhile, for threshold to determine, it is largely based on the experience to carry out the selection of threshold with a certain degree of subjectivity to some extent. In the future research, we will further study the other aspects in this field.

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