

BLACK-SCHOLES OPTION PRICING MODEL (BSOPM) & BINOMIAL OPTION PRICING MODEL (BOPM): A BIBLIOMETRIC ANALYSIS

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Abstract

Option pricing has recently attracted much interest from investors and financial institutions. This paper analysed the broad research trends on option pricing models. The core objective of this study is to evaluate the application of BSOPM and BOPM for option pricing. The present study accomplishes this objective by using a scientific method of mapping. The researcher extracted the relevant data using R studio, which was obtained from the Scopus database over a period of 45 years (1977-2022). The data in the present study are analysed using descriptive statistics. The study covers 651 publications from the areas of economics, business management, accounting, finance, and econometrics. According to factors like total publications, citations, or h-index, this study emphasises the most significant authors, illustrious journals, and producing countries. Additionally, the study examines co-citations, co-authorship, and keyword co-occurrence in option pricing research. This paper will also benefit academicians, practitioners, future researchers, and other stakeholders by offering new views for future research efforts. Results of the current study revealed that most of the research is done in the USA, and Cox JC's work is the most-cited article internationally and locally. Additionally, it has been discovered that the "Black-Scholes Option Pricing Model (BSOPM)" is more active than the "Binomial Option Pricing Model (BOPM)." Graphic and tabular analysis of the relevant data exhibits that extensive research has been done on option pricing. As the concept of option pricing first evolved in developed countries, the maximum number of research was concentrated in developed countries like the USA, UK, and Japan. However, the option pricing concept is relatively new in emerging countries, so a negligible amount of research was done in emerging economies, giving space for further research.

Keywords: Bibliometric Analysis, Option Pricing, Black-Scholes, Binomial, Scientific Mapping

1. Introduction

Option pricing theory has drawn much attention since Black and Scholes' revolutionary article, which presented a model for valuing European options, was published in 1972 (Black et al., 1972). Option pricing models use math to figure out how much an option will be worth in the future. According to all the relevant inputs, an option's value may be estimated by looking at its theoretical value. We receive the option's fair value from the models. Financial professionals might adjust their trading

strategies and investment portfolios if they understand the option's estimated fair value. The "Black-Scholes Option Pricing Model (BSOPM)" and "Binomial Option Pricing Model (BOPM)" are the subjects of our data collection for bibliometric analysis.

The "Black-Scholes Option Pricing Model (BSOPM)" was proposed by Black and Scholes in 1973 and has become one of the essential concepts in current finance theory for European stock option pricing. "This mathematical equation calculates the theoretical value of derivatives and other investment instruments while accounting for time and other risk variables" (Black & Scholes, 1973). In addition, the model makes several assumptions about how stock prices are distributed and the economy's condition. Another well-liked method for pricing stock options was developed in 1979 and is known as "The Binomial Option Pricing Model (BOPM)" (Cox et al., 1979). The idea that markets function effectively is the foundation for this approach. This presumption states that the model can determine the option's price at any given time.

"Bibliometrics" is formed from the words "biblion," which means "book," and "metrics," which means "measurement." (Groos & Pritchard, 1969) described bibliometrics as "a new research in which research methodologies were employed to analyze the research information exchange by measuring and evaluating relevant aspects of written documents." "Bibliometrics should be used to analyze relevant information. It is used to assess human communication records by identifying patterns in the authorship of publications, the citations used for a topic, etc., over time, providing insight into the dynamics of a relevant area of study" (Rushiji Mathankar, 2018). "Bibliometrics" has evolved into a standard scientific policy and research management instrument. Every significant scientific indicator collection depends on publication data, citation information, and other bibliometric approaches. Bibliometrics is a study of authors and publishing trends using mathematical and statistical analysis.

2. Research Methodology

Researchers have gathered information from the Scopus database to achieve the objectives. In recent years, "Scopus" and "Web of Science" (WoS) have emerged as databases for researchers. "Bibliometric analyses have determined that the Scopus database has only compiled scientific publications since 1966" (Paule-Vianez et al., 2020). The bibliometric analysis of this research was extended by network data analyzed in R studio.

"The bibliometric analysis focuses largely on making use of three different knowledge structures:

1. The conceptual structure, which identifies relevant topics and trends;
2. The social structure, which explains interactions between authors, universities, and countries;
3. And the intellectual structure, which explains how the work of one author inspires the work of other authors" (Aria & Cuccurullo, 2017).

As previously mentioned, R studio was used to do the network analysis. R studio makes it easy to understand even the most complex bibliometric maps. The study looked at three levels how often the exact keywords were used together and how sources and authors were linked in the bibliography. Results are described in three sections: publication and citation structure, a literature study of important articles, and an analysis of top authors, institutions, and countries.

2.1 Database, Keywords, and Inclusion Criteria

Scopus database is sourced for collection of complete data. Scopus is a collection tool connected to a vast database that includes published articles and quotations and a handy tool for bibliometric

analysis and comprises articles published in high-impact journals. The data spanning the years 1977 to 2022 were analyzed in this study. Option prices in the derivatives market are calculated using the BSOPM and BOPM models. The search criteria include the phrases "option pricing," or "black-Scholes" or "binomial" or "option pricing model" which may appear in the article's title, abstract, or keywords. The current study limited to specialize disciplined like as economics, business management, accounting, finance, and econometrics and restricted to papers published in English language. Only the final stage of publication was taken into consideration. Some publications were taken from relevant abstracts, and some full-length papers were retrieved to verify relevancy. The papers focused on option pricing in the derivatives market to ensure that relevant articles were included. The final document result provided 651 results as a result of this search. The documented effect was found using a step-by-step methodology on the Scopus database. The systematic process for obtaining a document result is shown in Table 1.

Table 1: Steps for obtaining data

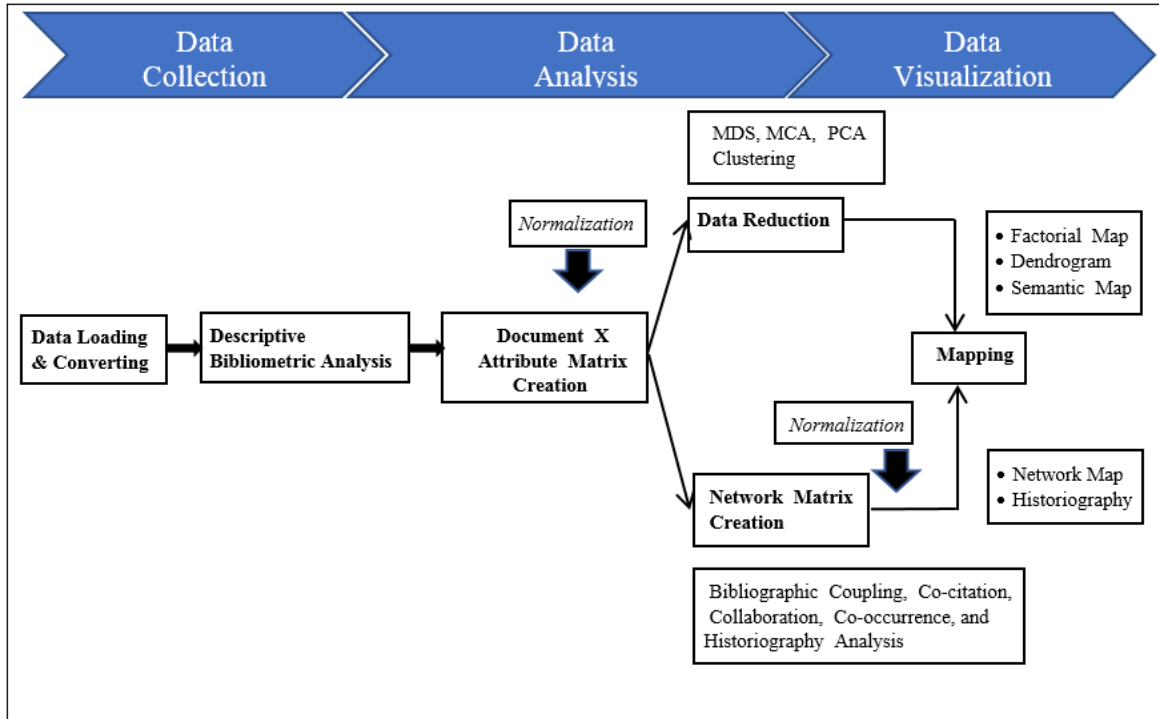
Steps	Restricted Limit to	Document Result
1	Title, Abstract, Keywords	1797
2	Subject Area	781
3	Final	781
4	Article	664
5	English	651

2.2 Bibliometrics Analysis

The bibliometric analysis uses a bibliometric approach using the data from the R studio and Scopus research articles. This data includes the names of authors and co-authors, keywords, titles, journals, publishers, universities, summaries, and the complete list of domestic and international citations (Groos & Pritchard, 1969) and (Broadus, 1987). "Studies that were innovative served as the basis for the development of the concept and methodology of bibliometric analysis.". After that, (Heck & Bremser, 1986) presented "the analysis based on the author and university-related analyses." Recent years have observed an increase in the number of researchers using bibliometric analysis within sociology. Since option pricing is still a controversial topic in academia and with the extensive literature review, it came to know that there is no single study could be traced on option pricing model. no one has studied it before, (Rey-Martí et al., 2016) used " bibliometric citation analysis and networking analysis with the intention of obtaining more understanding into the research that has been conducted in this area."

The research starts with a review of bibliometric data and then examines two different techniques. "The first method is called performance analysis, and it utilizes bibliographical indexes to conduct evaluations of various characteristics such as author's publications, universities affiliations, countries, and others. These analyses are based on data related to citations and authors" (Narin & Hamilton, 1996). Second, it discusses scientific mapping analysis, often known as SMA, which is a method that compiles data from network mappings of the social and cognitive structures of different research areas. This study examines the relationships between existing macro and micro researchers to explore the option pricing model and identify future research opportunities. "The science mapping workflow described by (Aria & Cuccurullo, 2017) & (Firdaus et al., 2019) was used by the authors in their article".

Figure 1. Main methodology's phases - Bibliometrics and the recommended science mapping workflow



Source: Authors' keywords elaboration using Biblioshiny

According to (Seuring & Müller, 2008), "the data analysis for an inductive study is divided into two parts bibliometric analysis and network mapping." The R studio package combines bibliometric & graphical analysis with Biblioshiny data visualization tools. "When empirical research is continuously focused and generates a significant amount of newer research streams, science mapping is useful" (Aria & Cuccurullo, 2017). R studio is simple to understand and implement because it is a free and open-source package. The Biblioshiny bibliometrics package may be installed using R studio for bibliometric analysis. As a result, this study processes using Biblioshiny using R studio.

3. Objectives of Bibliometrics analysis

The primary goals of this study are to identify the new trends in the Option Pricing model and to discover the answers to specific significant questions about the following major topics raised in related articles:

- **Q1.** Analyzing the contribution of top authors, articles, countries, and universities?
- **Q2.** Which are the burning themes of research and studies on option pricing model?
- **Q3.** Which research topic and gaps in the option pricing model should be explored in the future?
- **Q4.** Which is the most famous trending option pricing model for researchers from Black-Scholes or Binomial in recent years?

The bibliometric analysis would assist in the study of the above research questions with great importance in the existing literature in the area of bibliometric analysis and assist in the analysis of the study's existing gaps.

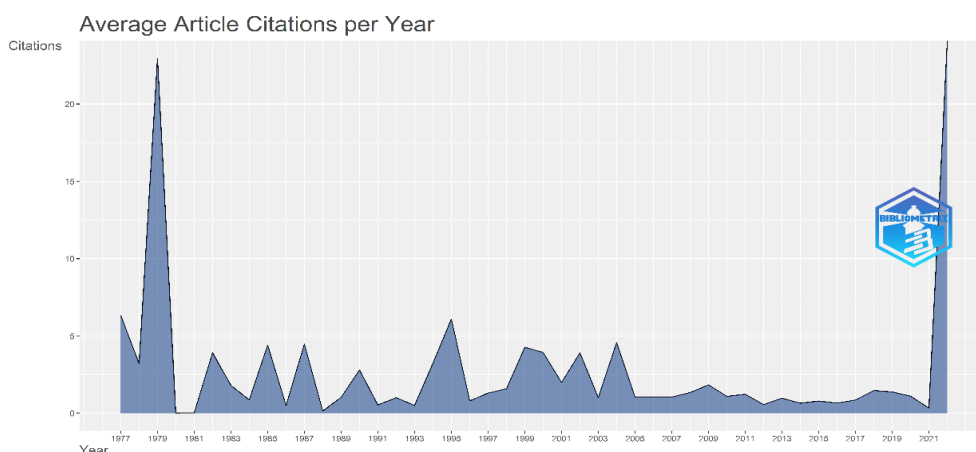
4. Statistical analysis and its results

The study of the bibliometric data starts with a summary of the essential bibliometric statistics. After that, the authors, indications, information, and research countries are explored more closely. The methods were used to conduct in-depth research and analysis of each category. Many different types of information are shown, including annual publication trends, author's citation, university information, leading sources, a subject Dendrogram, a country collaboration graphical map, etc. The presently available subsections provide a detailed examination of each section in sequence.

4.1 Details of annual publishing of papers on option pricing

In Figure 2, we see how the count of articles on option pricing published in Scopus over four decades (from 1977 to 2022) has changed. From one article in 1977 to 40 in 2013, the number of articles has risen steadily since 2002.

Figure 2. Scopus publication trend per year from 1977-2022



Source: Authors' keywords elaboration using Biblioshiny

Table 2 shows all relevant published articles, option pricing information, and data collected from the Scopus database. As mentioned before, 651 research publications were used in the study. These papers give a complete overview of option pricing research from 185 journals in economics and business, assuring performance. These studies employed 307 different keywords, and the author used 1,496. The term "keyword plus" (ID) refers to the various keywords related to the paper in the Scopus database. The literature review covers 44 years (1977-2022) and averages 30.3 citations per document. 1,176 different authors wrote these articles, and only 153 of the 651 articles were written by a single author. The number of author appearances represents the total number of authors from all documents. On average, there were 1.8 authors involved in creating one document. Out of a total of 1,176 authors, there are a total of 140 individual authors who have published articles on their own, while 1036 authors have published jointly. As a result, the authors decided to focus their subsequent study on data related to the authors and their citations.

Table 2: Main keys & information of published articles

Description	Results
1. Time-span	1977:2022
2. Sources (Journals, Books, etc.)	185
3. Documents	651
3.1 Average years from publication	13.9
3.2 Average citations per document	30.3
3.3 Average citations per year per doc	1.411
4. References	16844
5. Document Types	
5.1 Article	651
6. Document Contents	
6.1 Keywords Plus (ID)	307
6.2 Author's Keywords (DE)	1496
7. Authors	
7.1 Authors	1176
7.2 Author Appearances	1428
7.3 Authors of single-authored documents	140
7.4 Authors of multi-authored documents	1036
8. Authors Collaboration	
8.1 Single-authored documents	153
8.2 Documents per Author	0.554
8.3 Authors per Document	1.8
8.4 Co-Authors per Documents	2.19
8.5 Collaboration Index	2.08

Source: Authors' keywords elaboration using Biblioshiny

4.2 Epistemological Perspective

"Researchers attempted to define the study's objective in previous works, which led to the division of the study into theoretical, prescriptive, or descriptive orientations" (Barley et al., 1988). The research uses this theory to find an answer to the issue of determining the epistemological orientation. The research analyses selected articles by looking at the abstracts. After reviewing the abstracts, 6.3% of the articles were categorized as conceptual research studies since they analyzed previous studies without significant research or analysis. In comparison, 24% of the researchers were analytical, making up facts or perspectives.

4.3 Sources of publications:

Table 3 lists the top 10 option pricing journals contributing 37.33% of the total publications. 'Journal of Quantitative Finance' has 48 articles, whereas 'International Journal of Theoretical and Applied Finance' has 34. Option pricing is a popular way to get money, which is why it should be looked at in these journals. The list of the option pricing area has also been applied to all journals, demonstrating the market's dominant ranking in high-quality management journals.

Table 3: Top 10 most relevant source publishing on the financial derivative of option pricing

Source	h_index	g_index	m_index	TC	NP	Rank
Quantitative Finance	13	26	0.590909091	734	48	1
International Journal of Theoretical And Applied Finance	9	13	0.45	223	34	2
Journal of Futures Markets	9	11	0.391304348	164	25	3
Journal of Derivatives	10	21	0.384615385	476	24	4
Mathematical Finance	15	24	0.46875	1408	24	5
Applied Mathematical Finance	9	21	0.310344828	494	23	6
Journal of Banking and Finance	13	19	0.333333333	542	19	7
Asia-pacific Financial Markets	6	13	0.25	176	16	8
The Journal of Finance	15	16	0.340909091	2354	16	9
Journal of Financial and Quantitative Analysis	11	14	0.275	1297	14	10

Source: Authors' keywords elaboration using Biblioshiny

(TC =Total citations, NP = Nos. of publications)

4.4 Analysis related to Authors, affiliated universities, and countries

The most famous authors are ranked in Table 4, which lists their total review of relevant articles. First and second on the list are Fabozzi FJ and Zhu SP, each with 06 publications; next comes Huang HH, with 05 papers, and then Boyle PP, with 04 publications. “The highest number of citations was achieved by Duan JC (668)”. Fabozzi FJ and Zhu SP are experts on option pricing. They have written extensively about the option pricing model, hedging, stochastic volatility, and implied volatility. The h-index is a quantitative expression of an author's work growth in their subject. When the researcher's h-index is 6, they have generated at least 6 articles, and each of those papers has received 6 citations.

An author's G index is calculated by how often other authors have cited their work. According to the acquired citations, mostly the G-index has at least a G2 citation, which is based on the total publication count. The G index for Zhu SP is 6, meaning that the author has produced at least 6 articles cited by other works 59 times.

Table 4: Top 10 academic authors are listed.

Author	h_index	g_index	m_index	TC	NP	PY_start
Fabozzi FJ	2	5	0.222	30	6	2014
Zhu SP	6	6	0.5	59	6	2011
Huang HH	3	5	0.167	72	5	2005
Boyle PP	3	4	0.091	319	4	1990
Duan JC	3	4	0.097	668	4	1992
French DW	3	4	0.077	56	4	1984
Jarrow RA	4	4	0.118	51	4	1989
Kim YS	3	4	0.333	42	4	2014
Lee J	4	4	0.444	50	4	2014
Ahmadian D	3	3	0.3	37	3	2013

Source: Authors' keywords elaboration using Biblioshiny

TC =Total citations, NP = Nos. of publications

Table 5 shows the top 10 option pricing publishing institutes. The most well-known University is National Taiwan University, which has published 12 publications, followed by Cornell University, which has published 10 articles.

Table 5: Top Institutions publishing in option pricing

Top Institutions	Articles
National Taiwan University	12
Cornell University	10
Monash University	9
University of California	9
Columbia University	8
New York University	8
University of Melbourne	8
Chinese University of Hong Kong	7
Edhec Business School	6
Hankuk University of Foreign Studies	6

Source: Authors' keywords elaboration using Biblioshiny

According to Table 6, the top three countries for articles on the subject of option pricing are the United States (134), China (52 papers), and the United Kingdom (37 papers). This demonstrates that option pricing research is mostly concentrated in Western countries. It shows that the majority of study has been undertaken in these three countries, and further studies in other countries worldwide are required. The rich countries have understood the value of option pricing and are gradually winning over emerging countries.

Table 6: Top Countries publishing in option pricing

Country	Articles	Freq	SCP	MCP	MCP_Ratio
USA	134	0.25969	111	23	0.172
China	52	0.10078	44	8	0.154
United Kingdom	37	0.07171	24	13	0.351
Australia	33	0.06395	26	7	0.212
Canada	29	0.0562	17	12	0.414
Korea	25	0.04845	20	5	0.2
Germany	21	0.0407	15	6	0.286
Italy	17	0.03295	10	7	0.412
Hong Kong	15	0.02907	10	5	0.333
India	15	0.02907	15	0	0

Source: Authors' keywords elaboration using Biblioshiny

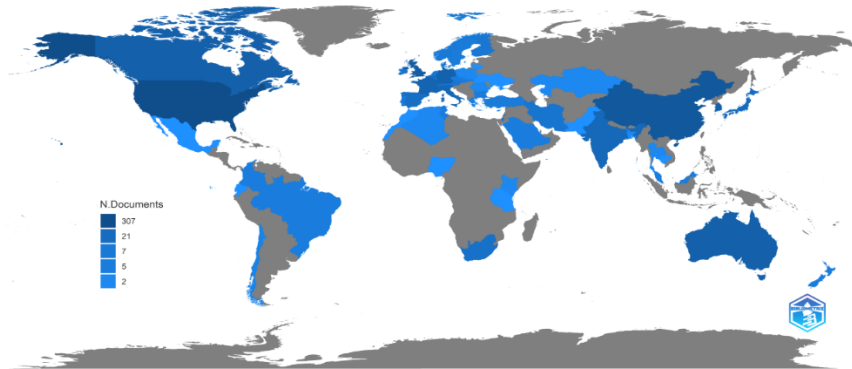
(All SCP writers come from the same country, but MCP authors come from different countries. MCP ratio = Multi-country published articles/total articles).

It is also possible to verify these outcomes by referring to Figure 3, which is provided below. The United States American society has welcomed the inflow of option pricing since it was developed. As a result, studies in option pricing have been conducted on hedging, stochastic volatility, and implied volatility. The USA, China, and the United Kingdom have published the most option pricing articles, followed by Australia. China and India have conducted studies on option pricing in the BRICS countries. It has been

found through analysis that emerging economic countries are not actively participating in the research of option pricing.

Figure 3: Country-wise Scientific Production

Country Scientific Production



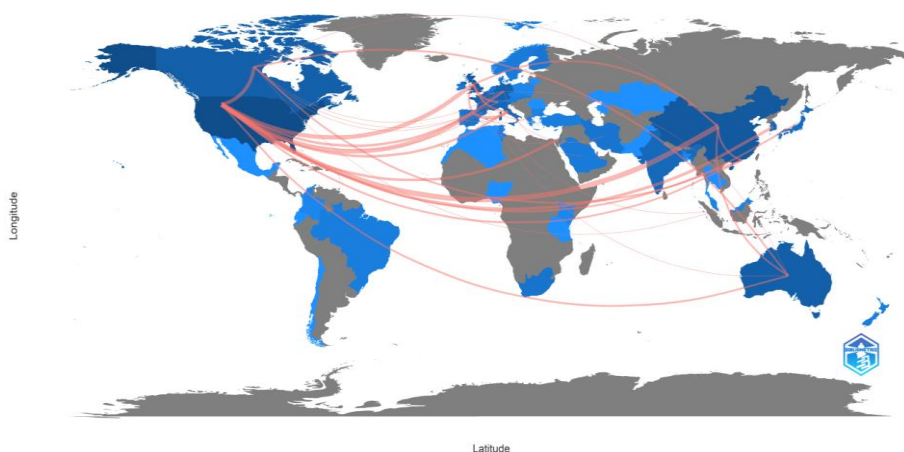
Source: Authors' keywords elaboration using Biblioshiny

Country-to-Country Cooperation Map

The international connections are shown in Figure 4. The map's blue color signifies international cooperation in scientific research, while the map's pink boundary between countries shows the authors' level of international collaboration. Countries with the most option pricing publications are active. The USA and UK work with China and Germany but can't agree on a topic because of their distance differences. On the other hand, the collaboration between countries may be of assistance when it comes to exchanging policies and coordinating efforts in the market.

Figure 4: Country-Collaboration Diagram

Country Collaboration Map



Source: Authors' keywords elaboration using Biblioshiny

Analyzing References

The citations received by a piece of writing throughout time are quantified by looking at how many times they have been referenced. Generally, a paper with a high number of citations is superior to one with fewer sources. A citation analysis process may best assess the quality of a research paper. A cited article in option pricing is considered significant. Option pricing has drawn attention from various areas, as demonstrated by the gap in local and international citations. Table 7 lists the authors of local and international option pricing from 1977 to 2022. According to the areas of study and topics covered in all databases, international citations calculate the regularity with which a paper is cited internationally. Local citations show how frequently an article is cited in the publication network. Cox JC (1979) has the most local citations (70) and the most international citations (3032), followed by Kou SG (2002), which has 25 local citations and 983 international citations. Cox JC (1979) has the most influential articles in the area of option pricing, as well as relevant research gaps for future research. It provides analytical and quantitative information on the influence that option pricing has on a company's profitability.

Table 7: Top 10 local and international citations with sources

Authors' Citation	Local Citations	International Citations
Cox JC, 1979, J Financ Econ	70	3032
Kou SG, 2002, Manage Sci	25	983
Hillegeist SA, 2004, Rev Account Stud	4	569
Scott LO, 1987, J Financ Quant Anal	34	550
Duan JC, 1995, Math Finance	47	545
Geske R, 1979, J Financ Econ	31	528
Garman MB, 1983, J Int Money Finance	18	435
Hutchinson JM, 1994, J Finance	17	364
Rubinstein M, 1985, J Finance	36	343
Carr P, 2004, J Financ Econ	9	313

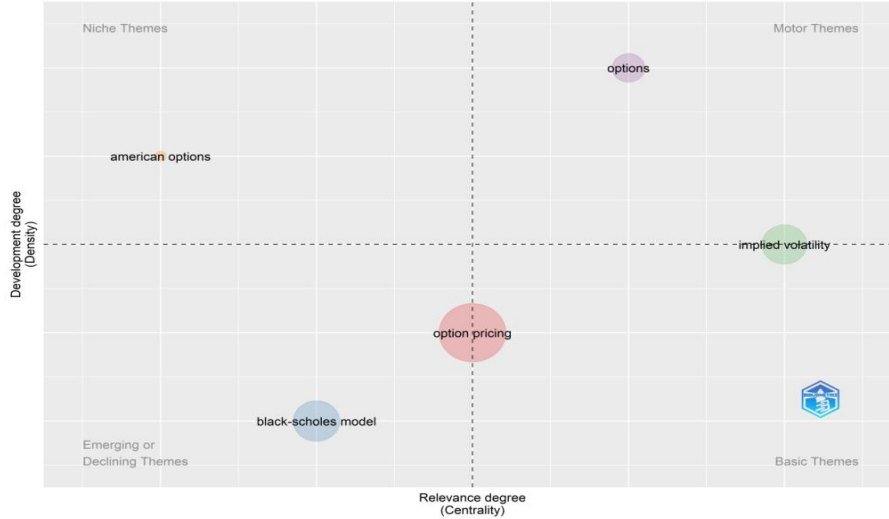
Source: Authors' keywords elaboration using Biblioshiny

Keyword Research

Thematic-Map:

(Cobo et al., 2011) "Examine several methods that may be used to estimate and visualize the topic of a specific study area." A thematic map is a diagram that looks simple at first glance. It has four categories of information ranked by how important they are, and it has two dimensions degrees that relevance on the x-axis and development on the y-axis. This map is further separated into four different themes, including declining or emerging (lower left section), fundamental (lower right section), niche (upper left section), and motorized (upper right section). The fundamental theme demonstrates the study carried out, the niche theme reflects the development in isolation, and the final theme demonstrates the development. The declining or emerging themes may fall out of the research or be established by the researchers. It can be seen from the map in Figure 5 that there have been many studies carried out on the subject of "option pricing" and "implied volatility." The figure demonstrates the need for more study in the areas of "option pricing" and "implied volatility," both of which are subjects that make constant development in the main topic as well as "emerging or declining" themes, respectively. Examine the research on "option pricing" and "implied volatility" sensitivity in both developed and developing countries.

Figure 5: Thematic Map

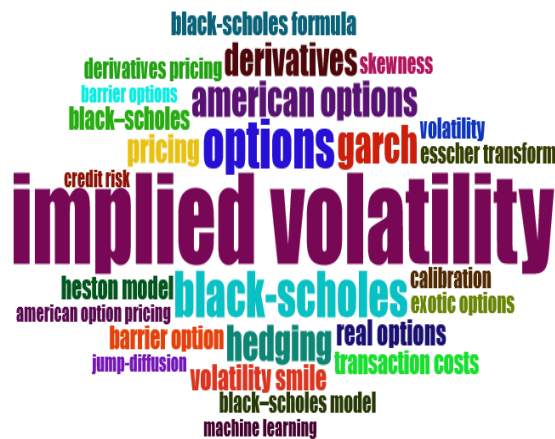


Source: Authors' keywords elaboration using Biblioshiny

Word Cloud:

Figure 6 is an expression of a thumbnail picture organized using keywords and is known as a word cloud. Based on these numbers, it's clear that the field of option pricing literature focused on implied volatility has been the most productive and active in generating new data. Terms such as "Black-Scholes," "option," "garch," "American option pricing," "hedging," and "derivatives" are frequently used. The most popular approach investor's use in option pricing for risk management is hedging. When determining the value of an option, investors often use the Black-Scholes model.

Figure 6: Word Cloud of Option Pricing Studies

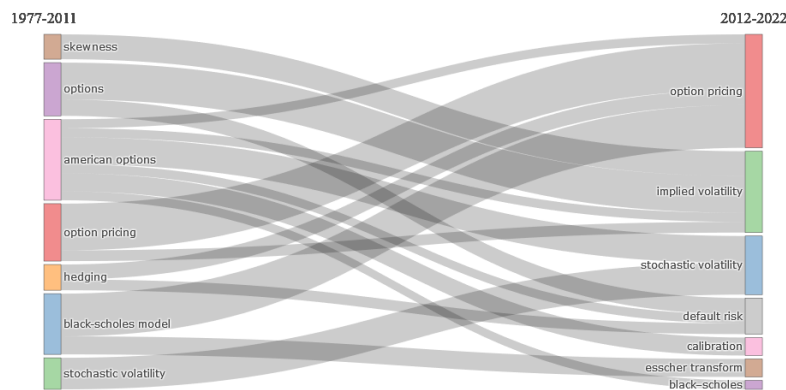


Source: Authors' keywords elaboration using Biblioshiny

Thematic Evolution Map:

In Figure 7, from 1977–2022, various research was undertaken on the interaction between option pricing, American options, implied volatility, stochastic volatility, the Black-Scholes model, hedging, default risk, etc., which led to studies in relevant areas. A thematic evolution map divides the time period into 1977–2011 and 2012–2022. The research that was done on the word relationships between the two-time spans is explored in the study. The results show that option pricing has the strongest relationship, followed by the Black-Scholes model, implied volatility, and stochastic volatility. The figure shows the findings of the most systematic research studies in the above subject areas of option pricing. According to the research done, the term "option price" is the word that spans both time periods. This analysis revealed that the phrases assessed had their origins in the titles of publications in the option pricing area.

Figure 6: Thematic Evolution Map

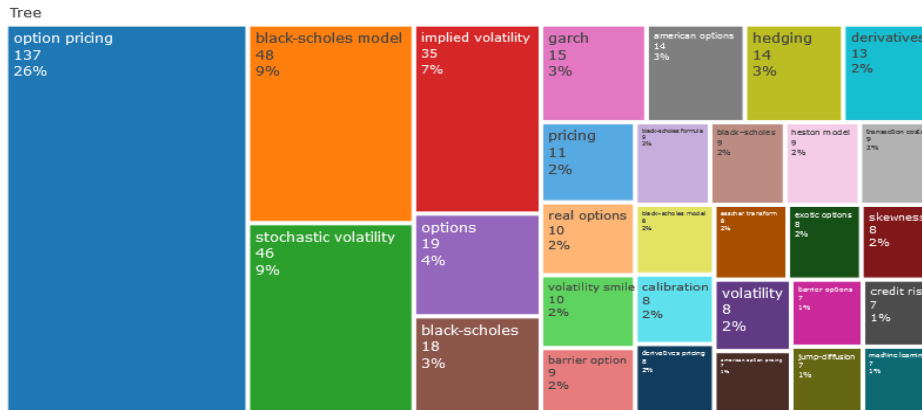


Source: Authors' keywords elaboration using Biblioshiny

Word Tree Map:

A word tree map is a structured analysis highlighting popular subjects by different shaped & colored rectangles of sub-groups. Figure 8 shows the word tree map for the highest trending research topic with total publications and percentage of relevant studies. It displays various keyword combinations for option pricing, the Black-Scholes model, stochastic volatility, implied volatility, garch, American options, hedging, etc. The figure shows that option pricing-related publications have 26% of the biggest rectangle, followed by Black-Scholes model (9%), stochastic volatility (9%), implied volatility (7%), and so on.

Figure 8: Word Tree Map

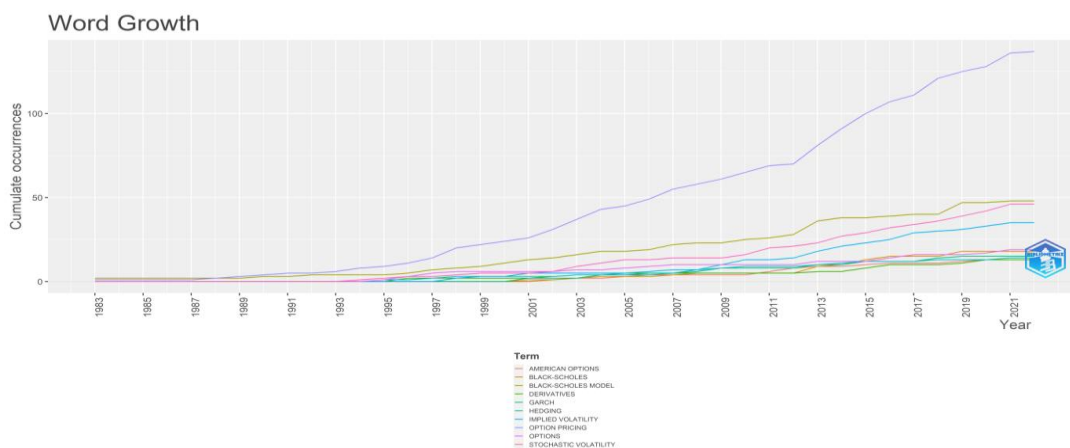


Source: Authors' keywords elaboration using Biblioshiny

Word Growth:

The word growth graph shows how specific words in the research articles will likely change over time. The researchers will benefit from this kind of study, which will help them better understand the progression over time. Figure 9 shows the annual cumulative occurrences data of the words used in articles about option pricing and related topics from 1977 to 2022. It was noticed that the number of studies went up quickly and kept going up after 2009. "The graph displays the outcome of the Loess regression, and the variables included in the Loess regression were the number of times the word was used and the publication time" (Jacoby, 2000). Hedging, American options, stochastic volatility, the Black-Scholes model, and option pricing have all shown an upward pattern.

Figure 9: Word Growth

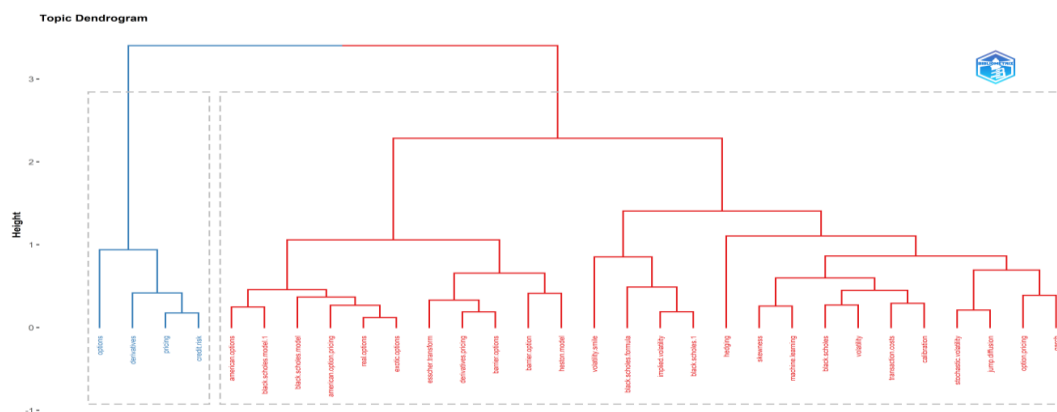


Source: Authors' keywords elaboration using Biblioshiny

Dendrogram:

Dendrograms are unique tree diagrams illustrating the hierarchical clustering connections between related data sets by connecting each group to two or more conceptually comparable groups. It is trusted that the tree-like structure of the layered groups would provide a helpful categorization system. "Dendrograms show a strong correlation between the different clusters that create, and its primary purpose is to assess the total number of clusters so that researchers may single out the most important factors across studies" (Andrews, 2003). Dendrogram analysis (see Figure 10) allows us to see how various topics related to option pricing might be grouped based on keyword analysis. This study identifies two clusters, the first of which reflects an option pricing-based research theme and the second of which correlates to the Black-Scholes model and the Heston model. The second keyword analysis also shows interconnected themes and keywords change due to option pricing's use of many factors. The second major theme of the study identifies the various option pricing possibilities as real, exotic, and barrier. These options indicate extra implied, stochastic, and garch volatility in the market. Option pricing risk and return is the third Dendrogram subject. In the options market of derivatives, risk and return are controlled by hedging. One last primary theme focus of option pricing studies is the role of several factors in determining option prices. This theory accounts for stock price variation by establishing a risk-reward relationship between share values and a company's specific characteristics.

Figure 10: Dendrogram



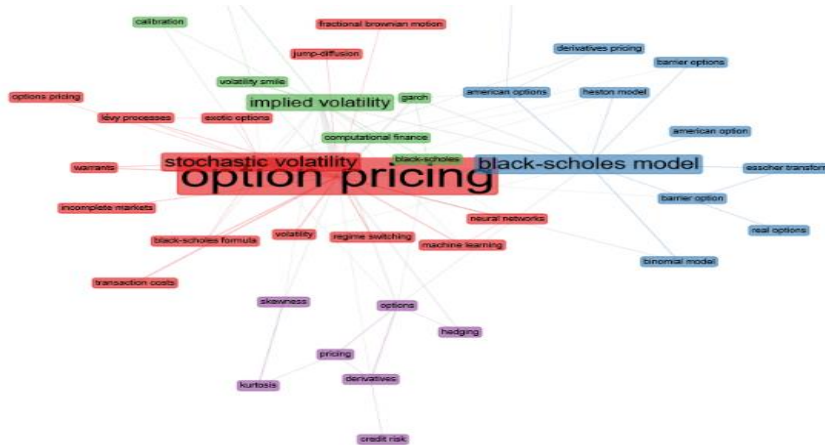
Source: Authors' keywords elaboration using Biblioshiny

Co-occurrence networks for keywords:

A keyword co-occurrence network is a one-dimensional, time-invariant representation of a domain that fails to account for evolutions in the terminology used. All journal papers will generally have a set of keywords added below the abstract. These keywords will indicate essential aspects of the study presented in that particular publication. A few primary keywords are utilized extensively and often throughout the articles. Repeating the same terms together, referred to as keyword co-occurrence, communicates several essential meanings to the readers.

A study of the co-occurrence of keywords is carried out in order, which combinations of terms are most often utilized in research. This coincidence sheds light on several related subfields of study with the same theoretical foundation. Therefore, this kind of study reveals the interconnectedness of several research areas. The most frequently used and related terms in option pricing studies are shown in Figure 11.

Figure 11: Co-occurrence map of keywords

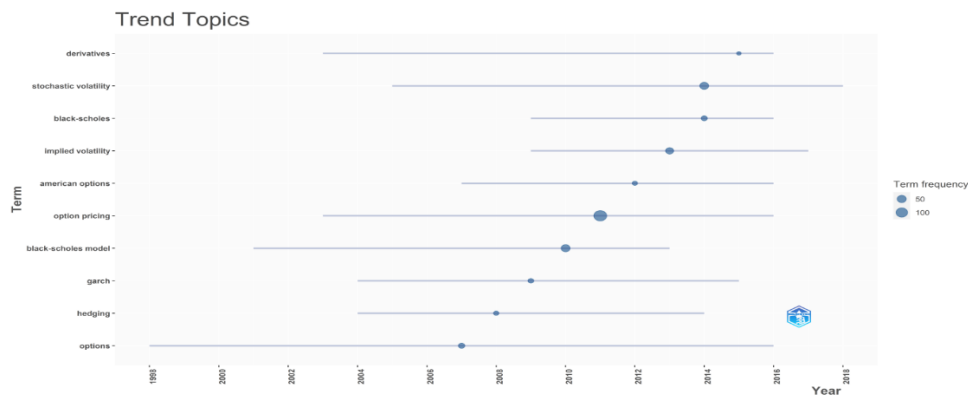


Source: Authors' keywords elaboration using Biblioshiny

Prominent subjects during the years

"Trend topic" refers to phrases, sentences, or topics often discussed on social media. These subjects become popular quickly, either unexpectedly, via user effort, or because of a circumstance. The Black-Scholes Model, which derives option prices from implied and stochastic volatility, was the subject of many 2011 academic surveys. In recent years, research has shown which themes have been most popular. As the area developed, research evaluating the connection between models, options, and option pricing volatilities was carried out, as shown in Figure 12. From 2007-2015, researchers focused on the following subjects, finding that option pricing, the Black-Scholes model, implied volatility, stochastic volatility, and the American option were the most popular.

Figure 12: Trend Topics



Source: Authors' keywords elaboration using Biblioshiny

Analytical Study of Co-Citations

The published papers works create a new research article. This method is used in bibliometric analysis to identify relevant content and make sense of the intellectual structure of journals, articles, and other publications.

4.7.1 Clustering: Thematic Classification a category is said to be thematic if it contains at least two different types of objects linked together by a particular connection. Categorizing the connections that make up a graph image into various subsets is possible. Each article within the same group has a characteristic that differentiates it from others. Clustering might be helpful when analyzing the themes in a co-citation network.

4.7.2 Analysis of Contents: Content analysis is a technique used in research to determine whether specific keywords, themes, or concepts appear in the collected qualitative data and to conclude the data's significance. The frequency of a set of keywords, themes, or concepts appearing in a text and their importance and relationships may be discovered using content analysis. The content analysis comes after the co-citation analysis of all 651 research publications divided into four clusters. A common thread emerged from the data after an in-depth analysis of the three different clusters.

4.7.3 Clustering of Data: Data clustering is discovering relationships between datasets by grouping them into subsets with high similarity but low similarity to other subsets. The most relevant groups of content (or clusters) may be obtained using data clustering. The four clusters that come from our technique of the data clustering approach to determine the critical areas of the option pricing theory study are shown in Table 8, along with their related areas of study.

Table 9 provides specific information on the quantity of articles categorized under each cluster. Because the number of papers in each cluster is more significant than 75, we will only look at the top 10 articles in each cluster to make the analysis procedure workable. Page rank analysis is used to identify the top publications on a cluster-by-cluster basis; hence, ten articles are kept in each cluster. After that, the contents of the papers, as well as the topics of study that lie behind them, are analyzed for each cluster, and the research emphasis is broken down cluster by cluster as follows:

Table 8: Top local citation-scored articles in each cluster

Cluster 1	Cluster 2	Cluster 3	Cluster 4
Cox JC, 1979	Geske R, 1979	Hillegeist SA, 2004	Ball CA, 1994
Kou SG, 2002	Benaroch M, 1999	Hutchinson JM, 1994	Frey R, 1997
Scott LO, 1987	Chernov M, 2000	Avellaneda M, 1995	Corrado CJ, 1997
Duan JC, 1995	Whaley RE, 1982	Ingersoll JR. JE, 1977	Lehar A, 2002
Garman MB, 1983	Benaroch M, 2000	Millo Y, 2009	Guidolin M, 2003
Rubinstein M, 1985	Klein P, 1996	Garcia R, 2000	Frey R, 1999
Carr P, 2004	Chesney M, 1989	Wu Y, 2010	Andersen L, 2013
Kou SG, 2004	Bollen NPB, 1998	Lauterbach B, 1990	Alexander C, 2004
Chiras DP, 1978	Miltersen KR, 1998	Cook TJ, 1984	Garcia R, 1998
Defusco RA, 1990	Carmona R, 2008	Platen E, 1998	Bensoussan A, 1994

Source: Authors' keywords elaboration using Biblioshiny

Table 9: Total articles published in each cluster

Cluster	No. of articles
Cluster 1	224
Cluster 2	219
Cluster 3	131
Cluster 4	76

Source: Authors' keywords elaboration using Biblioshiny

Clusters 1 & 2 configure the same structure with different subareas dimensions by Black-Scholes Model, Stochastic volatility, and implied volatility of option pricing and study the “Black-Scholes Option Pricing Model” by diversification on other volatility techniques. These clusters describe the analysis of two different volatilities and their impact on option pricing by the “Black-Scholes Model.” The volatility is used in the “Black-Scholes Option Pricing Model” formula for calculating the option premium.

Cluster 3 configures related to the options by 50% and includes 27.8% part of the hedging techniques of the options. Many types of hedging techniques are studied in this cluster and describe how to manage the risk and return in option pricing by the Black-Scholes Model. We explored the risk-return relationship in this cluster to decrease risk-return by applying different hedging techniques in the options.

Cluster 4 revolves around volatility and option pricing research mentioned above in cluster 1 and cluster 2. As a movement of the stock prices, the option premium changes up/down by calculating through volatility, and the volatility also calculates the future option pricing. The articles explain how to change the option pricing by different volatility in different periods. This cluster also shows that the volatility smile configures the option pricing.

Cluster analyses of option pricing studies organize the whole of the study into several characteristics of the current field of study. On the other hand, these various subareas must observe one another. Clusters of related articles provide information on how option pricing research has changed over time and how different areas of the topic have been represented. Except for cluster 3, all configurations cover much the same ground regarding research. The Black-Scholes Model of option pricing is the central focus of all clusters, together with the volatility. Following that, it focuses on the methods of hedging used to control the options' risk-reward. It contends that the market is not information-efficient, and as a result, it cannot reach a condition of equilibrium on its own.

Conclusion, Research Limitations, and Suggestions for Future Studies

The idea of option pricing is an essential component of the current study of economics, business management, accounting, finance, and econometrics. There are several options trading, each of which uses a unique combination of methods and strategies in the option derivative market. The money that comes from option pricing is used in many different ways. This bibliometric research study provides the most summarized history of options pricing and its underlying volatility. This study would be helpful to academic researchers, options traders, and regulators in that it would evaluate the studies relevant research topics and provide information on the specifics of option pricing. Therefore, the purpose of this study is to follow the changes in option pricing and indicate different possibilities for further research. The study identifies and emphasizes the most influential authors, keywords, publications, and research clusters in option pricing theory based on a comprehensive research study and bibliometric analysis of 651 documents published over 45 years (1977–2022). Even though several authors have addressed a wide range of topics, such as option pricing, American options, stochastic volatility, the Black-Scholes model, and hedging, the topic is not yet fully developed. Most research has assumed a causal connection between volatility and the Black–Scholes model of pricing options. The authors have sought to identify gaps in option pricing literature. The present review will assist the authors in estimating important work in options pricing, affiliating countries, productive authors, keywords, productive publications, and interrelationships in the research. The USA and Canada are the two developed countries with the most research on option pricing, followed by the United Kingdom, Australia, and other European countries. Regarding studies on option pricing, there was a

noticeable lack of involvement from researchers in Asia. This trend is now becoming more popular in developing countries. Cox JC has received the most citations in this area, whereas Fabozzi FJ is a well-known researcher in the research area of option pricing. It was observed that authors from developed countries work in large numbers, but authors from developing countries have a lot of space to expand their collaborations in option pricing research. Many studies have looked at various aspects of option pricing, including its relationship to the Black-Scholes model, volatility, the American option, hedging, and risk. This shows very clearly that these studies are relevant. This basic study gets the most important information about option pricing, which has become more important for developing country growth.

Moreover, the multi-factor option pricing model, the sub-areas dimensional explanation of the volatility connection, American options, and other market frictions are criticized via keyword co-occurrence and page rank monitoring. The study of option pricing may be broken down into four distinct subfields, each representing an essential component of the theoretical perspective at the foundation of option pricing. The results show a universal gap in the option pricing literature from advanced to developing economies. Figure 12's conceptual model reveals that a significant amount of study has to be conducted on the employment impact of option pricing, sustainable options investors, and selecting the appropriate exit strategy for investors. This report should provide a wake-up message to policymakers and options investors alike. Connecting the many subareas described in this study may help them assess the quality of option pricing research and open up new possibilities for study. Pricing options have a significant impact on the growth of a country's economic position and have the potential to steer economies toward being more stable and competitive.

Despite its limitations, the current study shows some interesting findings about previous studies on option pricing. To begin with, the data for analysis comes only from the Scopus index. Although the authors have tried their best to ensure that the search criteria cover the area, some of the studies may be unavailable due to the absence of the related keywords. There is a possibility that the data obtained from various sources, such as the Web of Science (WoS), SSCI, SCI, ASCI, Google scholar, and a significant number of other places, may provide inconsistent findings (Zemigala, 2019). Second, since the period covered by the study spans from 1977 to 2022, it's possible that specific prior research won't apply to this analysis. Thirdly, the scope of the research is confined to scientific keywords and phrases. While we searched for relevant publications in the Scopus database by using the terms "option pricing," "option pricing volatility," and "option pricing American options," it is possible that we missed some studies that should have been included. The research concentrates not on a particular component but the overall picture of option pricing.

The study has several limitations, but one is most important: Binomial Option Pricing Model (BOPM) data is not a trending topic and found insufficient data for analysis. Hence, it has been concluded that the Black-Scholes Option Pricing Model (BSOPM) has been the most trending topic in frequent years, and the Binominal Option Pricing Model (BOPM) required more attraction from the researchers.

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