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ANALYSIS OF ACTUARIAL PRICING STUDIES THROUGH BIBLIOMETRIC ANALYSIS

ABSTRACT

Actuarial pricing is a critical area underlying risk assessment and premium calculation processes in the insurance and finance sectors. It involves the application of mathematical and statistical models to determine the cost of insurance policies and predict potential future losses. Insurance companies place significant importance on actuarial pricing to provide their customers with affordable and sustainable policies. In this context, actuarial pricing studies are crucial for risk management and financial sustainability. Therefore, understanding and evaluating this vast and dynamic literature on actuarial pricing is essential for professionals and researchers in the sector. This study aims to examine the actuarial pricing literature using bibliometric analysis. Bibliometric analysis is a method that reveals the structure of the literature, development trends, and key research areas through the numerical and statistical analysis of publications in a specific field. This analysis is a powerful tool for identifying the historical development of actuarial pricing studies, the most influential researchers and their work, commonly used methodologies, and future research trends. This study demonstrates that the actuarial pricing literature has developed rapidly over the years, with changes in the global risk environment, particularly in the last two decades, stimulating research in this area. Analyses by author, country, publication type, and subject matter reveal the interdisciplinary nature of the field, the decisive role of central researchers and journals, and the importance of international collaborations in the development of the literature. The findings demonstrate that actuarial pricing is not only critical for the insurance sector but also vital for ensuring financial stability, developing risk management strategies, and designing sustainable policies. Therefore, deepening actuarial pricing studies and strengthening international collaborations through the integration of modern analytical methods, artificial intelligence, and machine learning in both academia and industry stands out as a strategic imperative for future success.

Keywords: Actuarial Pricing, Bibliometric Analysis, Visual Mapping

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1. INTRODUCTION

Insurance companies attach great importance to actuarial pricing in order to offer affordable and sustainable policies to their customers. In this context, the scope and methods of actuarial pricing studies have developed significantly over time. These developments show diversity in terms of the methodologies used in the studies in the literature, their areas of application, and theoretical approaches. Understanding and evaluating this broad and dynamic body of literature on actuarial pricing is critically important for professionals and researchers in the sector. A method that can be used to analyze the literature in question, bibliometric analysis, is the statistical analysis of books, articles, or other publications. It provides a quantitative measure that is generally used to evaluate the impact of researchers, institutions, or specific works (Pritchard, A. 1969). According to Broadus, R. N. (1987), this analysis, which involves the application of mathematical and statistical methods to books and other means of communication, is also extremely useful for understanding the structure and dynamics of scientific research. With this study conducted using the bibliometric analysis method, it is aimed to produce a comprehensive map of the literature in the actuarial pricing literature. This map is expected to have the potential to guide future research by providing researchers and professionals in the sector with the opportunity to see the general trends and gaps of existing studies. In addition, the systematic evaluation of the body of knowledge on actuarial pricing may contribute to the development of innovative approaches and practical applications in this field. However, despite the growing number of studies, the actuarial pricing literature still shows several methodological limitations. Many works remain focused on traditional statistical pricing techniques, while the integration of behavioral, macroeconomic, or AI-driven approaches is still limited. Moreover, comparative cross-country analyses are rare, leaving gaps in understanding how market maturity and regulation affect pricing models. Addressing these gaps would not only enrich the theoretical basis of actuarial pricing but also support the design of more adaptive and resilient pricing systems.In this context, the main purpose of the study is to reveal the overall structure, main themes, and developmental trends of the literature by conducting a bibliometric analysis of the actuarial pricing literature. With this analysis, it is expected that compiling important information that will contribute to the development of a deeper and more comprehensive understanding in the actuarial pricing literature will be a significant output of the study.

2. METHOD

Bibliometric analysis is a method that allows analysis based on the quantitative characteristics of scientific works (Dikme et al., 2024). This analysis is generally carried out by examining information contained in a specific dataset such as

academic publications. This method is used to understand research trends in a field, influential researchers and institutions, and the impact and development of publications. Conceptual maps, citation analysis, and co-citation analysis used in bibliometric analysis are among the common tools (Daim & Suntharasaj, 2009: 47). The first step in bibliometric analysis is the collection of suitable data for the analysis. These data typically consist of academic publications such as scientific articles, books, and theses. The inclusion criteria were limited to peer-reviewed journal articles and conference papers indexed in the Web of Science Core Collection between 1986 and 2024 that explicitly focused on actuarial pricing, insurance pricing, or risk-based premium modeling. Exclusion criteria included papers not written in English, works unrelated to pricing (e.g., purely regulatory or accounting topics), and duplicate records. Although the dataset provides comprehensive coverage of the field, it may not fully represent regional or non-English publications, which is a methodological limitation.They are usually selected according to criteria such as topic, time period, geographical region (Aksnes, 2006), adequacy of publications in the relevant field, publication quality, and the indexes in which the journals are listed. (Köse et al., 2017). The analysis of the collected data constitutes the basis of bibliometric analysis. At this stage, the data are analyzed using statistical and quantitative methods. Among these analyses are techniques such as publication counts, citation analyses, the construction of collaboration networks, and content analyses (Bornmann, L., 2014). The results of the analyzed data are generally presented in the form of visual graphs or tables. These results are extremely important as they provide researchers with the opportunity to understand and evaluate scientific developments and trends in a particular field (Moed, H. F. 2005). Finally, the results obtained are interpreted and recommendations are made to guide future research. This stage is another strength of bibliometric analysis, ensuring that it provides a roadmap for future research rather than merely being a tool of determination based on past data (Noyons, E. C., 2007).

3. FINDINGS

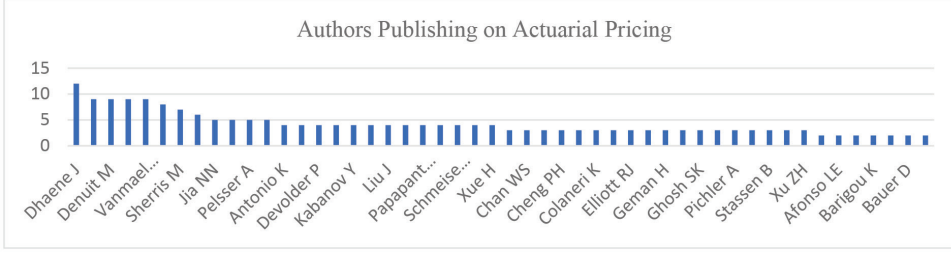
In this section, first, the performance analysis findings related to the publications obtained from the Webofscience database are explained. The performance analysis findings share results on the authors who publish on actuarial pricing, the countries in which publications are made, the dates of the publications, co-authorship analysis, author citation analysis, source citation analysis, keyword analysis, and bibliographic coupling analysis. The visual mapping findings were obtained through the VOSviewer software package.

3.1. Performance Analysis Findings

3.1.1. Authors Publishing on Actuarial Pricing

When examining the authors who have published the most on actuarial pricing, it is seen that certain names stand out. This indicates the presence of researchers who have made significant contributions to the development of the field. In first place, with 12 publications, is Dhaene, J. Standing out as the author with the most publications on actuarial pricing and risk management, Dhaene, J. has focused on the pricing of insurance products and the accurate assessment of risks.In second place, with 9 publications each, are Deelstra, G., Denuit, M., Siu, T.K., and Vanmaele, M. These authors have conducted important studies in the actuarial pricing literature, particularly focusing on risk modeling, insurance mathematics, and financial risks.Linders, D. ranks third with 8 publications, and his research focuses on insurance mathematics and actuarial modeling. Notably, Sherris, M. stands out with his studies on pension insurance and life insurance mathematics and ranks fourth with 7 publications related to actuarial pricing. Finally, the authors who rank last with 2 publications each are: Aase, K.K., Afonso, L.E., Alai, D.H., Barigou, K., Barry, L., Bauer, D., and Biagini, F. These authors have contributed to the actuarial pricing literature through their research conducted on various subtopics within the field.

Figure 1. Authors Publishing on Actuarial Pricing

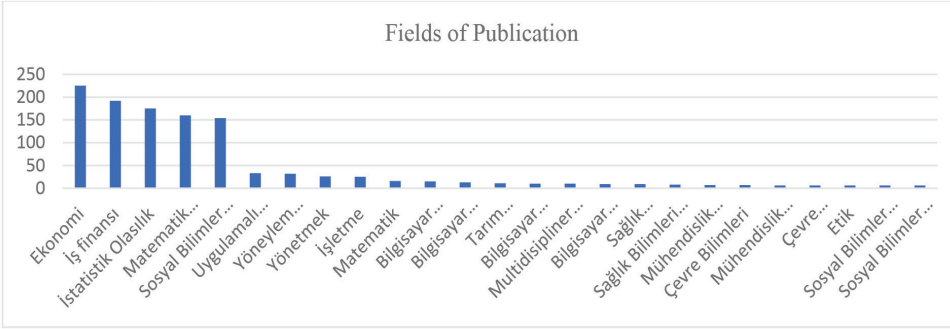


3.1.2. Fields of Publication on Actuarial Pricing

The concentration of studies on actuarial pricing in certain fields reflects the broad and multidimensional nature of this discipline. These fields encompass a diversity of knowledge that blends the theoretical and practical applications of actuarial pricing. Among these fields, the first place is taken by "Economics" with 225 publications. Studies in the field of economics cover the macroeconomic and microeconomic impacts of actuarial pricing, the functioning of insurance markets, and risk management. These publications focus on economic models and theories

used in the pricing of insurance and - field of Mathematics, 160 publications have been produced, and it is observed that these studies focus on actuarial calculations, optimization techniques, and mathematical modeling. The field of Mathematical Methods in Social Sciences has 154 publications. Mathematical methods in the social sciences are used to understand the societal impacts of insurance products and individuals' perceptions of risk. These publications cover the applications of actuarial pricing in the social sciences as well as mathematical modeling within this domain. These 906 publications, gathered under these five main headings, constitute a significant portion of the total 1,268 studies, demonstrating how broad the research spectrum on actuarial pricing is. Highlightsreveals that actuarial pricing requires an interdisciplinary approach and shows that studies conducted in different fields come together to provide a more holistic and comprehensive understanding.

Figure 2. Fields of Publication on Actuarial Pricing

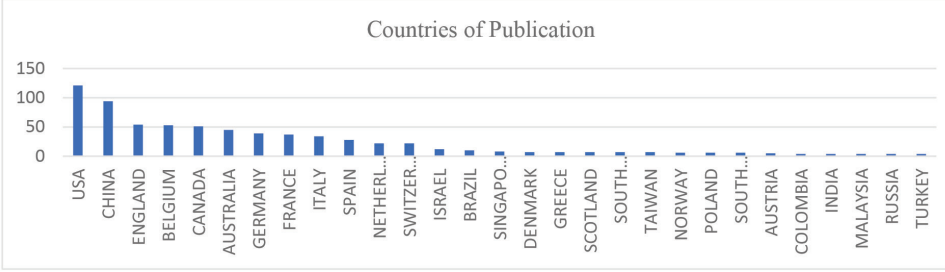


3.1.3. Countries Publishing on Actuarial Pricing

When the publications on actuarial pricing are examined, it is observed that some countries possess significant knowledge accumulation in this field. Considering the number of publications among the top 30 countries, Turkey ranks 30th with only 4 publications, which is noteworthy (Aydın & Koç, 2021; Özdemir & Yıldız, 2020). In this ranking, the United States takes first place with 121 publications, making it the leader in the field, followed by China with 94 publications. The United Kingdom (54 publications) and Canada (53 publications) come after China. These statistics highlight several important points listed below. The United States and China stand out as the countries producing the highest number of publications on actuarial pricing. This situation demonstrates the importance given to the field of actuarial sciences by universities, research institutions, and the insurance sector in these countries. The high number of publications in the USA and China shows that extensive research activities are being carried out in these

countries and that actuarial pricing is recognized as an important academic and practical field. The United Kingdom and Canada also have significant publications on actuarial pricing. This situation indicates that both countries have a strong background in the insurance sector and conduct intensive research activities in this area. In particular, the UK has a long-established tradition in the fields of insurance and actuarial science. Turkey's ranking at 30th with only 4 publications shows that actuarial pricing research in the country is limited. This situation indicates the need for more research in the field of actuarial sciences in Turkey and highlights the importance of increasing academic and sectoral collaborations in this area. To enhance Turkey's potential in this field, it is of great importance to strengthen the collaboration between universities, insurance companies, and research institutions. Most of the top 30 countries consist of developed nations. This shows that actuarial pricing is more frequently studied as a research topic in developed economies. In developing countries, however, research activities in this area remain limited. This reveals the need to build greater capacity in the fields of actuarial sciences and the insurance sector in developing countries. In conclusion, the distribution of publications on actuarial pricing by country shows that research activities in this field are closely related to geographic and economic factors. For Turkey to make further progress in this area, it is crucial to increase academic and sectoral collaborations and conduct more research in the field of actuarial sciences. In this way, Turkey can enhance its knowledge base in this field and achieve a competitive position at the international level.

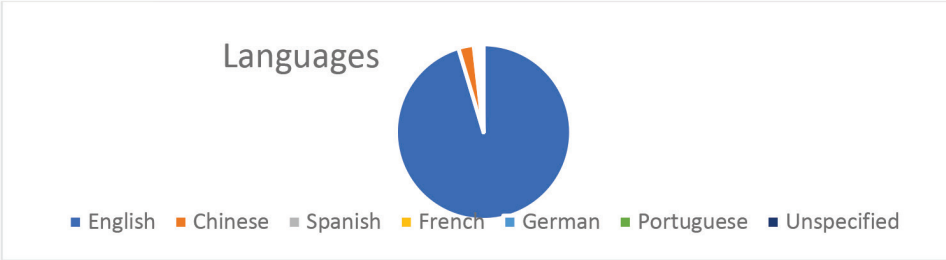
Figure 3. Countries of Publication on Actuarial Pricing



3.1.4. Language of Publications on Actuarial Pricing

Although China ranks second among the countries where publications are made, the presence of the United States, the United Kingdom, and Canada among the top five countries with the highest number of publications, and the fact that English has become the accepted academic language, show that 95% of the publications on "Actuarial Pricing" are in English.

Figure 4. Languages of Publications on Actuarial Pricing



3.1.5. Publication Dates of Studies on Actuarial Pricing

It is observed that the 1986–2000 period was a time when the number of publications on actuarial pricing was relatively low. In 1986, there was only one publication on actuarial pricing, and during the 1990s, the number of publications remained low (between 1 and 5). Until the year 2000, it can be considered a period when the topic of actuarial pricing had just begun to find a place in the scientific literature and the foundations were being laid. It is expected that the studies conducted during this period largely contributed to establishing the theoretical foundations related to the subject.

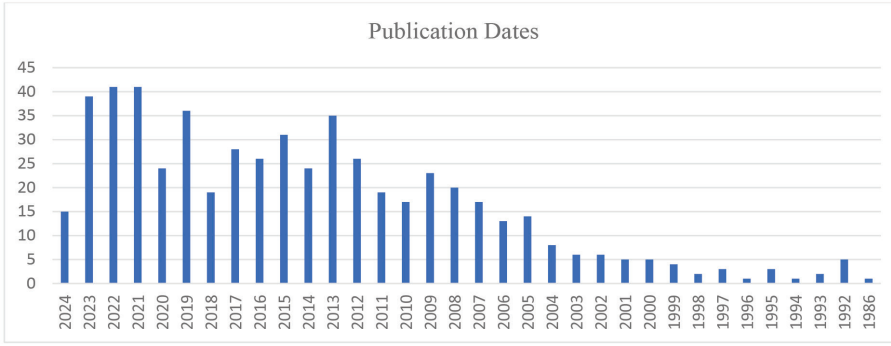
When the 2000–2010 period is evaluated, it is observed that starting from the year 2000, there was an increase in the number of publications on actuarial pricing. Between 2000 and 2005, the number of publications ranged between 5 and 14. This increase indicates that the topic began to attract more attention within academic circles. During the years 2006–2010, there were fluctuations in the number of publications, but the overall trend remained upward. In 2010, the number of publications was recorded as 17.

Between 2010 and 2020, a remarkable increase was observed in the number of publications on actuarial pricing. During this period, the number of publications generally ranged between 17 and 36. It is noteworthy that the number of publications in the years 2013 and 2019 was higher compared to other years, with 35 publications in 2013 and 36 publications in 2019. These years can be considered as times when intensive research was conducted on the subject of actuarial pricing. The year 2015 also stands out, with 31 publications, marking a high figure. This increase may indicate a period when new methodologies and approaches in actuarial pricing were being developed and shared.

When the period of 2020 and beyond is evaluated, there were 24 publications in 2020, while this number rose to 41 in both 2021 and 2022. In 2023, there were 39 publications. This increase during this period may be explained by the growing interest in actuarial sciences and risk management during the pandemic period.

The pandemic may have led to more research being conducted on risk calculations and pricing within the insurance and financial sectors. The fact that as of 2024, there have already been 15 publications shows that research activities in this field are ongoing.

Figure 5. Publication Dates of Studies on Actuarial Pricing

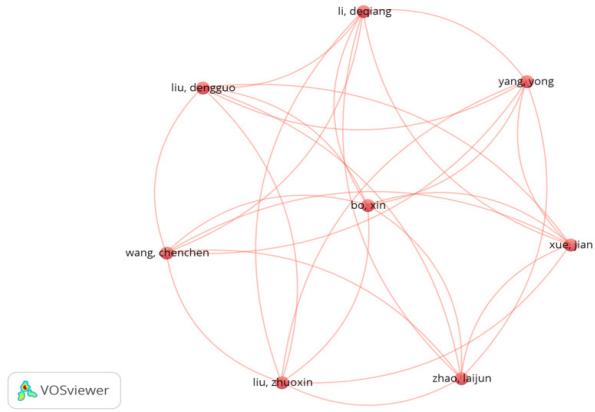


3.2. Visual Mapping Findings

3.2.1. Co-Authorship Analysis

The network map related to the co-authorship analysis presented below visualizes the collaborative relationships among authors conducting research in the actuarial pricing literature. In this network, created using the VOSviewer software, each circle represents an author; the size of the circles indicates the number of publications by that author, while the connections between the circles represent the joint studies conducted together.

Figure 6. Co-Author Analysis on Actuarial Pricing



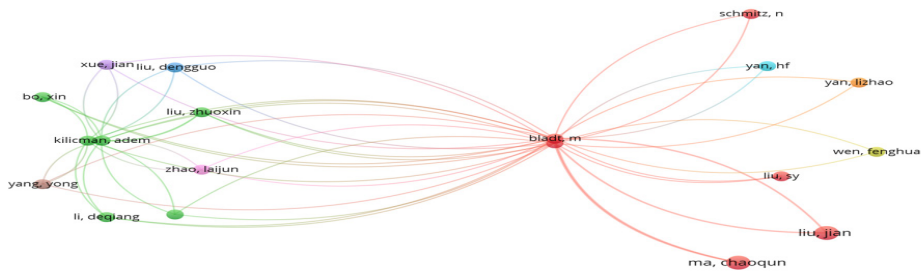
Bo, Xin occupies a central position and stands out as an important researcher forming the core of the collaboration network, with numerous joint studies conducted with many authors. Researchers such as Li, Deqiang, Wang, Chenchen, and Yang, Yong also have a high number of connections within the network and are among the authors who are in intensive collaboration with other researchers. Similarly, authors such as Xue, Jian and Zhao, Laijun contribute to collective studies in the literature by establishing multiple connections. The dense network structure observed in the map indicates that multi-authored and collaborative studies are common in the actuarial pricing literature. The fact that the network structure is circular and tightly connected suggests that specific research groups have been formed in this field and that these groups act together in producing literature.

Highlightsreveals that collective academic production plays an important role in the actuarial pricing literature and that there is a strong collaboration network among researchers. Furthermore, it can be said that such collaborations, which are influential in the development of the literature, not only improve research quality but also accelerate the dissemination of knowledge.

3.2.2. Author Citation Analysis

The second network map below shows that the collaborative relationships among authors in the actuarial pricing literature are considered on a broader and more global scale. Compared to the previous visual, this map includes different research clusters and a larger number of authors. This visualization more clearly reveals the global collaborations and clustering patterns present in the literature.

Figure 7. Co-Author Network in Actuarial Pricing Literature



Bladt, M. occupies a central position and becomes the focal point of the network structure in the literature by establishing direct collaborations with many authors from different clusters. Among the authors associated with Bladt, M. are Liu, Jian, Ma, Chaoqun, Schmitz, N., Yan, H.F., and Wen, Fenghua, which indicates the existence of a strong academic collaboration.

In the map, the sub-clusters shown in different colors represent specific research groups:

- The green cluster, which also appeared in the previous visual, includes authors such as Bo, Xin, Li, Deqiang, Yang, Yong, and Kılıçman, Adem, and it is observed that the internal connections within this group are highly intense.
- The red cluster has been formed particularly under the leadership of Bladt, M. and is based on collaborations with Chinese researchers.
- The yellow and purple clusters represent smaller but independent collaboration groups. These clusters generally reflect regional or topic-based specialized collaborations.

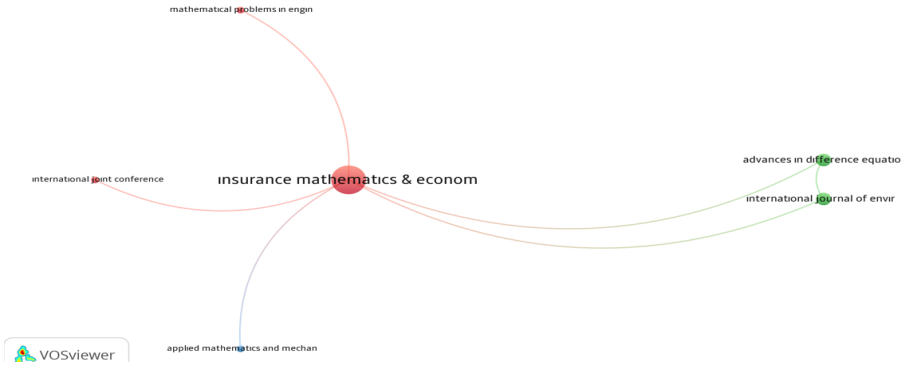
The presence of Kılıçman, Adem as a Turkish researcher within the network indicates that there are also contributions from Turkey to this field. At the same time, the connections that this author has established with Chinese and European researchers demonstrate the importance of international collaborations.

Overall, the network structure shows that there are both regional concentrations and global collaborations in the actuarial pricing literature. The structures clustered around central figures reveal that these individuals play guiding and connecting roles in the literature.

3.2.3. Source Citation Analysis

The network map below shows the relationships between the frequently cited academic sources in the actuarial pricing literature. This visualization, created using the VOSviewer software, reveals the interaction levels and central positions of the cited sources.

Figure 8. Source Citation Network in Actuarial Pricing Literature

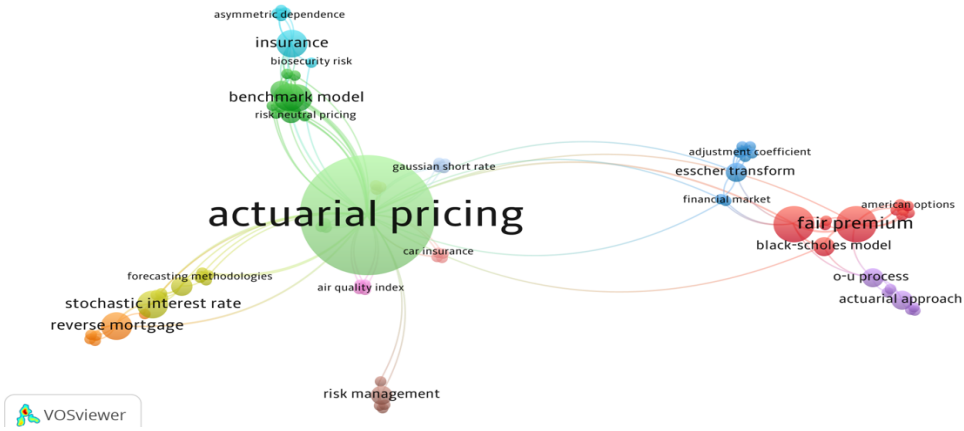


This source citation network reveals the interdisciplinary nature of actuarial pricing research and shows that it has developed through various academic journals. "Insurance: Mathematics & Economics" stands out as the primary reference journal in this field and plays a determinative role in shaping the direction of the literature through its intensive connections with other sources.

The structure in the visual demonstrates which publications researchers cite the most, thereby indicating both the existing knowledge foundations and which publications can serve as references for future studies. This analysis not only provides information about the key publications in the literature but also has the potential to guide researchers in making the right source selections.

3.2.4. Keyword Analysis

Figure 9. Keyword Analysis on Actuarial Pricing



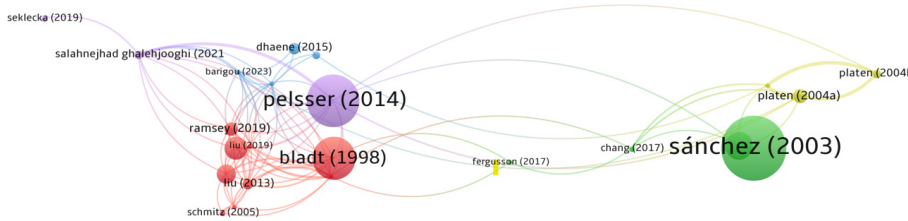
According to this keyword analysis, the actuarial pricing literature is not limited only to insurance mathematics but also brings to the forefront topics such as financial mathematics, environmental risks, statistical modeling, stochastic processes, and pricing models based on artificial intelligence and machine learning (Wüthrich & Merz, 2019; Richman & Wüthrich, 2021; Henckaerts, Antonio, Clijsters, & Verbelen, 2022).

The keyword clusters indicate that some of the studies in the literature focus on theoretical models and mathematical foundations, while others aim to develop practical solutions for applied insurance problems. This situation reveals that the actuarial pricing literature has an interdisciplinary structure and is continuously nourished by evolving application areas.

3.2.5. Bibliographic Coupling Analysis of Documents

The network map below visualizes the relationship between publications in the actuarial pricing literature that cite similar sources. Bibliographic coupling establishes a connection between two publications when they both cite the same third sources. In this context, this analysis in which studies based on the same literature foundations converge allows for an understanding of the thematic clusters and academic orientations within the literature.

Figure 10. Bibliographic Coupling Analysis on Actuarial Pricing



The studies by Pelsser (2014), Bladt (1998), and Sánchez (2003), which are located at the center of the network, are the publications with the widest connection networks. These three works are considered core reference sources in the literature and have become common reference points for numerous studies.

The study by Pelsser (2014), in particular, has strong relationships with the literature related to actuarial modeling, interest rate processes, and option pricing. Other studies connected to the same cluster (Dhaene, 2015; Salahnejhad Ghalehjooghi, 2021; Ramsey, 2019) stand out due to the reference infrastructure they draw upon from this work.

Bladt (1998), on the other hand, is a prominent reference study, especially in the fields of stochastic processes and mathematical modeling. The dense connections seen on the map (Liu, 2013; Schmitz, 2005; Ramsey, 2019) indicate that this work remains influential in both older and more recent literature.

Sánchez (2003) is positioned on the right side of the map and, together with the studies of Platen (2004a, 2004b), forms a cluster of publications focused on financial modeling and insurance mathematics. This cluster is primarily referenced in the literature regarding theoretical finance and pricing models.

The colored clusters represent studies concentrated on specific topics:

● Pelsser-focused cluster: Interest rate models and option pricing.
● Bladt-focused cluster: Stochastic processes and insurance applications.
● Sánchez and Platen cluster: Publications based on financial mathematics and modeling.
● and ● clusters represent smaller-scale publication groups that share sources within themselves.

This analysis reveals the core academic foundations of the publications in the actuarial pricing literature and shows which studies serve as central references in the literature.

4. CONCLUSION

This study, by utilizing bibliometric analysis methods to comprehensively evaluate the actuarial pricing literature, has made the direction, structure, and development dynamics of academic production in this field visible.

The findings reveal that actuarial pricing has evolved into a multidisciplinary scientific field intersecting not only with the insurance discipline but also with financial mathematics, statistics, engineering, and economics (Antonio & Beirlant, 2007; Kaas, Goovaerts, Dhaene, & Denuit, 2008).

Time series analyses indicate that publications in the actuarial pricing literature have shown a significant increase particularly in the last twenty years, and the rapid rise after 2020 reflects the growing need for risk modeling studies in a globally uncertain environment. This increase points to the rising necessity for risk management and accurate pricing not only in the insurance and financial sectors but also within public policies.

Author-based analyses demonstrate the emergence of a core group of authors shaping the field and show that this group has increased its influence by receiving a high number of citations in the literature. It is observed that European academics mainly contribute to theoretical models, while Asian researchers enrich the literature with applied studies. This indicates that the development of actuarial pricing is shaped by different areas of expertise across geographical regions.

The keyword cluster analysis shows that the dominant themes in the literature are not limited to classical premium calculation methods; instead, AI-based modeling, risk-neutral pricing techniques, and models that take environmental risk factors into account are also coming to the forefront. This demonstrates that actuarial science now responds not only to historical data but also to the need for proactive, forward-looking modeling.

Country-based analyses reveal that scientific production is largely concentrated in developed economies. Countries such as the USA, China, the UK, and Canada produce a significant portion of the publications in this field, feeding sectoral applications with academic output. In contrast, Turkey's limited representation in this field indicates that it remains an area open to development, both in terms of the number of academic publications and their impact value.

On the other hand, the fact that 95% of the publications are in English shows that research in this field is produced in a way that is accessible globally and that English continues to be the dominant language for academic impact. This situation requires strategic planning for researchers working in local contexts regarding translation, publishing in international indexes, and establishing collaborations.

Bibliographic coupling and source citation analyses show that certain publications have become attraction centers in the literature and that the studies clustered around these centers form thematic cores. These core publications are milestones that shape the evolution of the field, not only in terms of citation intensity but also through their methodological innovations.

In this context, actuarial pricing research not only produces new data but also transforms the structure of knowledge itself. In other words, the field demonstrates both quantitative growth and qualitative depth.

Consequently, it is evident that the actuarial pricing literature is becoming an increasingly strategic area in both the academic world and the insurance sector. By producing a bibliometric map of the field, this study has revealed the strengths and weaknesses of the current state of research.

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ANALIZA AKTUARSKIH STUDIJA ODREĐIVANJA CIJENA PUTEM BIBLIOMETRIJSKE ANALIZE

SAŽETAK

Aktuarsko određivanje cijena ključno je područje koje leži u osnovi procesa procjene rizika i izračuna premija u sektorima osiguranja i financija. Uključuje primjenu matematičkih i statističkih modela za određivanje troškova polica osiguranja i predviđanje potencijalnih budućih gubitaka. Osiguravajuća društva pridaju značajnu važnost aktuarskom određivanju cijena kako bi svojim klijentima pružila pristupačne i održive police. U tom kontekstu, studije aktuarskog određivanja cijena ključne su za upravljanje rizicima i financijsku održivost. Stoga je razumijevanje i vrednovanje ove opsežne i dinamične literature o aktuarskom određivanju cijena ključno za stručnjake i istraživače u sektoru. Cilj ove studije je ispitati literaturu o aktuarskom određivanju cijena korištenjem bibliometrijske analize. Bibliometrijska analiza je metoda koja otkriva strukturu literature, trendove razvoja i ključna istraživačka područja putem numeričke i statističke analize publikacija u određenom području. Ova analiza je moćan alat za identificiranje historijskog razvoja studija aktuarskog određivanja cijena, najutjecajnijih istraživača i njihovog rada, uobičajeno korištenih metodologija i budućih istraživačkih trendova. Ova studija pokazuje da se literatura o aktuarskom određivanju cijena brzo razvijala tokom godina, s promjenama u globalnom okruženju rizika, posebno u posljednja dva desetljeća, što potiče istraživanja u ovom području. Analize prema autoru, zemlji, vrsti publikacije i temi otkrivaju interdisciplinarnu prirodu područja, odlučujuću ulogu središnjih istraživača i časopisa te važnost međunarodne saradnje u razvoju literature. Nalazi pokazuju da aktuarsko određivanje cijena nije samo ključno za sektor osiguranja, već je i ključno za osiguranje financijske stabilnosti, razvoj strategija upravljanja rizicima i oblikovanje održivih politika. Stoga se produbljivanje studija aktuarskog određivanja cijena i jačanje međunarodne saradnje integracijom modernih analitičkih metoda, umjetne inteligencije i mašinskog učenja u akademskoj zajednici i industriji ističe kao strateški imperativ za budući uspjeh.

Ključne riječi: *Aktuarsko određivanje cijena, bibliometrijska analiza, vizualno mapiranje.*

JEL: G22,C61