“Efficiency assessment and trends in the insurance industry: A bibliometric analysis of DEA application”

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EFFICIENCY ASSESSMENT AND TRENDS IN THE INSURANCE INDUSTRY: A BIBLIOMETRIC ANALYSIS OF DEA APPLICATION

Abstract

Data Envelopment Analysis is a crucial tool for evaluating the performance of insurance companies, considering its ability to handle multiple inputs and outputs. This study provides a comprehensive bibliometric analysis of Data Envelopment Analysis (DEA) application in the insurance industry from 2010 to 2023, examining 405 documents from 432 sources. Materials from academic databases (Web of Science and Scopus) were used for the analysis. The methodological flow included three stages. For analysis, two sets of keywords were identified: one set oriented toward DEA and the other tailored to the Insurance Industry domain. To analyze and visualize the data, VOSviewer software, version 1.6.19, and RSTUDIO were used. This paper highlights the evolution of DEA methodologies, incorporating advanced techniques like Artificial Intelligence and Machine Learning, and addresses emerging trends such as digital transformation, customer-centric assessments, and sustainability. The analysis reveals significant geographical and sectoral differences in efficiency assessments, with higher efficiency levels typically found in developed markets such as North America and Europe compared to emerging markets in Asia and Africa. It also notes the distinctive efficiency patterns between life and non-life insurance firms, influenced by product complexity and market competition. The findings indicate that DEA remains versatile and essential for performance evaluation in the insurance industry, adapting to challenges through methodological advancements.

Keywords data envelopment analysis, insurance efficiency, bibliometrics, DEA applications, performance benchmarking, research trends

JEL Classification C44, G22, O30

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INTRODUCTION

The efficiency of the insurance industry is crucial for its sustainability and competitive positioning in the global market. In recent years, the industry has faced numerous challenges, including economic volatility, regulatory changes, and the increasing complexity of risk management. These factors underscore the necessity for robust analytical tools that can help insurance companies assess and enhance their operational efficiency. One such tool, Data Envelopment Analysis (DEA), has gained prominence for its ability to evaluate the performance of decision-making units (DMUs) within the sector by considering multiple inputs and outputs simultaneously. DEA application in the insurance industry is particularly significant due to the sector's inherent complexity and the diverse nature of its operations. Unlike other industries where outputs are tangible and easily quantifiable, the outputs of insurance companies include financial security, risk management services, and customer satisfaction, which are more challenging to measure. DEA provides a comprehensive framework for benchmarking efficiency by creating an efficient frontier against which companies' performances are evaluated. This makes it an invaluable tool for insurers seeking to improve their operational practices and achieve a com-

petitive edge. The dynamic nature of the insurance market, influenced by technological advancements, shifting consumer expectations, and regulatory requirements, further amplifies the need for effective performance assessment methodologies. DEA offers a structured approach to identify best practices and areas for improvement, allowing insurance companies to optimize their resource allocation and strategic planning. The method's flexibility and adaptability make it suitable for various contexts within the industry, from evaluating the efficiency of insurance branches and products to assessing the overall performance of firms.

Understanding and enhancing efficiency through DEA is not just relevant but imperative. Recent trends in the insurance industry, such as the rise of digital insurance platforms and the increasing focus on sustainability and corporate governance, present both opportunities and challenges for efficiency improvement. DEA's role in this landscape is to provide actionable insights that can guide companies in navigating these changes effectively.

1. LITERATURE REVIEW

The application of Data Envelopment Analysis (DEA) in the insurance industry has grown significantly over the past decade. The literature reveals a growing interest in applying DEA to evaluate the efficiency of insurance companies. A notable trend is the shift from traditional efficiency assessments to more comprehensive models that incorporate advanced techniques such as Artificial Intelligence (AI). The post-pandemic worldwide has accelerated the use of AI (Gusti et al., 2024). The DEA method is one potential tool available that can measure a company's performance in a complex way represented by one indicator (Fenyves & Tarnóczi, 2020).

Cummins and Rubio-Misas (2006) identified the positive effects of deregulation on Spanish insurers' production efficiency (see see Appendix A, Table A1). Similarly, Micajkova (2015) explored the effectiveness of insurance companies in Macedonia, highlighting the potential for efficiency improvements through better resource allocation. It is worth noting that, Table A1 provides a comprehensive summary of the sources cited in the literature review. The table offers a consolidated view, making it easier for readers to reference specific studies and their contributions. This consolidation is crucial for understanding the breadth and depth of DEA application in the insurance industry.

A prominent theme in this literature is the impact of regulatory changes, with identifying deregulation's positive effects on Austrian insurers' production efficiency (Cummins & Xie, 2013). This insight highlights the significance of regulatory environments in shaping the efficiency landscape of insurance markets. Similarly, Micajkova (2015) explores the effectiveness of insurance companies in Macedonia, reflecting the worldwide trend of deregulation as insurance markets adapt to changing economic dynamics.

Efficiency analysis extends beyond deregulation to encompass broader dimensions of insurer performance (Ennsfellner et al., 2004). Research dives into efficiency's intricacies by examining operating and investment efficiency in general insurance companies (M. Garg & S. Garg, 2020). This dual focus offers a comprehensive perspective on how insurers manage their resources and investments to maximize efficiency (Medved & Kavčič, 2012). On the other hand, there will likely be an empirical study of efficiency in Croatia and Slovenia's insurance markets, potentially involving a comparative examination of features influencing the performance of insurers in these neighboring regions. This comparative approach sheds light on the diverse dynamics within regional insurance markets, emphasizing the importance of the context in efficiency evaluations.

Efficiency analysis extends its reach to specific markets and regions, providing insights into the performance of insurers in various geographical contexts. Al-Amri et al. (2012) investigate insurance efficiency in the Gulf Cooperation Council (GCC) countries, offering valuable insights into the performance of insurers in this region characterized by unique economic and regulatory dynamics. This regional focus allows a nuanced

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understanding of how regional factors influence efficiency. Additionally, Siddiqui's (2020) examination of the Indian life insurance sector goes beyond national boundaries, encompassing both public and private insurers, thereby contributing to the global perspective on insurance efficiency. This expansion of research scope to specific markets and regions enriches the literature by highlighting the contextual nuances that affect insurer performance.

The literature also delves into deregulation's influence and the most crucial conglomeration on insurer efficiency (Ennsfellner et al., 2004). Both discuss the influence of deregulation and its impact on insurance companies, emphasizing the potential benefits of regulatory changes for improving efficiency. This theme underscores the dynamic nature of the insurance industry, where regulatory shifts can have profound implications for insurer performance.

Berger et al. (1992) explored the effects of conglomeration and strategic focus in the insurance industry, shedding light on how organizational structures and strategies influence efficiency. Meanwhile, a study of the Spanish insurance industry by Cummins and Xie (2008) potentially reveals the intricate relationship between deregulation, consolidation, and efficiency. Understanding these relationships is vital for policymakers and industry stakeholders seeking to optimize the regulatory environment.

Mergers and acquisitions represent another dimension of insurance industry evolution (Cummins & Xie, 2013). Mergers and acquisitions impact the productivity and efficiency of companies in the property-liability insurance sector in the United States. These corporate strategies have practical consequences on insurance companies' operations, providing valuable insights for insurers contemplating such M&A activity.

Efficiency analysis in the insurance sector extends to the global stage, with comprehensive study providing a panoramic view of the association between efficiency and productivity (Eling & Schaper, 2017; Eling & Jia, 2018). The efficiency-profitability relationship is industry-dependent, with different dynamics for life and non-life insurers. This global perspective highlights the importance of considering industry-specific nuances in efficiency assessments.

Specific markets and regions remain fertile ground for research, generating insights into local efficiency dynamics (Ndlovu, 2021). Analyzing efficiency and understanding the impact of productivity returns (Alhassan & Biekpe, 2016; Cooper et al., 1999; Hu et al., 2020; Ndlovu, 2021) and the improvising factors of economies in South Africa's healthcare insurance market contribute to the understanding of the factors influencing efficiency in a specialized sector.

In the context of the insurance sector, the DEA uses methodologies and models based on several critical determinants of efficiency:

- Firm Size: Larger insurance firms generally exhibit higher efficiency scores. This can be attributed to economies of scale, which enable more effective resource management and operational efficiencies. For instance, larger firms can spread their fixed costs over a larger volume of business, resulting in lower average costs (Al-Amri et al., 2012).

- Market Conditions: Market conditions, including competition intensity and market saturation, significantly influence efficiency. Competitive markets force firms to optimize their operations to maintain profitability, leading to higher efficiency scores. Conversely, in less competitive markets, firms may not be as motivated to improve efficiency (Seog, 2009).

- Regulatory Environment: Regulatory frameworks play a pivotal role in shaping efficiency. Supportive regulations that encourage innovation and best practices contribute positively to efficiency outcomes. For example, regulations promoting transparency and consumer protection can drive firms to adopt more efficient processes to comply with standards (Eling & Schaper, 2017).

- Technological Adoption: Technological advancements have significantly impacted the efficiency of insurance firms. Innovations such as automated underwriting systems,

data analytics, and digital claims processing have streamlined operations, reduced costs, and improved customer service. Studies consistently show that firms adopting these technologies achieve better efficiency scores (Ashiagbor et al., 2023).

In summary, the systematic literature review on efficiency analysis in the insurance industry is rich and diverse, encompassing many themes, methodologies, and geographic contexts. These studies cooperatively contribute to a nuanced understanding of the factors that influence insurer performance, offering valuable insights for policymakers, industry stakeholders, and researchers seeking to optimize the efficiency and sustainability of insurance markets.

The purpose of this study is to provide a comprehensive bibliometric review of DEA applications in the insurance sector, analyzing trends from 2010 to 2023.

2. METHOD

The initial step involved an exhaustive search across prominent academic databases, with a predominant focus on Web of Science and supplemented by a limited number of papers from Scopus. Methodological flow includes three stages:

- Stage 1 (data base: scopes; keywords: SET 1 (DEA keywords), SET 2 (insurance related);
- Stage 2 (filter; subject area: insurance; document type: journal; period: 2010–2023; language: english);
- Stage 3 (screening all the papers and inclusion based on relevance of title and abstract; final dataset: 432 ariticles (for analysis).

To facilitate this process, two sets of keywords were identified and utilized: one set oriented towards Data Envelopment Analysis (DEA), Efficiency Analysis, Performance Measurement, DEA Models, Input-Output Analysis, Technical Efficiency, Scale Efficiency, Efficiency Benchmarking, Decision-Making Units (DMUs), Productivity Analysis (Wu et al., 2021; Zhu, 2022); the other set tailored to the domain of Insurance Industry, General Insurance, Property and Casualty Insurance, Insurance Coverage, Risk Management, Insurance Policies, Claims Processing, Underwriting, Insurance Premiums, and Insurance Regulation. Subsequently (Ghosh, 2013; Nektarios & Barros, 2010), this study embarked on an extensive research endeavor, sifting through the vast Web of Science corpus. The inclusion criteria necessitated that at least one keyword from both sets be present in the selected papers, ensuring a nuanced and relevant selection.

To analyze and visualize the data, VOSviewer software, version 1.6.19, and RSTUDIO were used. Also, several packages were installed such as bibliometric and shiny application. The metric analysis tool is usually used to present a visualized knowledge graph based on data obtained according to the principle of literature analysis.

3. RESULTS AND DISCUSSION

Table 1 lists the leading journals that have published extensively on Data Envelopment analysis in the insurance sector.

Leading the list is the European Journal of Operational Research, which boasts the highest h-index (16) and g-index (19), reflecting its significant impact and prolific output with 19 publications and over 3,000 citations since 1997. The Geneva Papers on Risk and Insurance follows with a strong focus on risk management and practical insurance issues, having an h-index of 10 and g-index of 17, and 17 publications starting from 2005. The Journal of Banking and Finance stands out in the financial domain with 8 papers and a substantial citation count of 723. Omega and the Journal of the Operational Research Society also contribute valuable insights into operational and strategic issues in insurance, with notable h-index and citation metrics. More recent contributions come from journals like the International Journal of Environmental Research and Public Health and Sustainability, both starting in 2020, highlighting the growing interdisciplinary interest in applying DEA to insurance. Each of these journals

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Table 1. Top journals that widely published on DEA application in the insurance sector

Source	h_index	g_index	m_index	NC	NP	PY_start
European Journal of Operational Research	16	19	0.571	3021	19	1997
Geneva Papers on Risk and Insurance: Issues and Practice	10	17	0.5	494	17	2005
Journal of Banking and Finance	8	8	0.381	723	8	2004
Omega (United Kingdom)	6	6	0.545	326	6	2014
European Journal of Operational Research Society	5	7	0.217	121	7	2002
Cost Effectiveness and Resource Allocation	4	4	0.4	93	4	2015
Global Business Review	4	5	0.286	59	5	2011
International Journal of Environmental Research and Public Health	4	6	0.8	45	6	2020
Sustainability (Switzerland)	4	4	0/8	91	4	2020
Annals of Operations Research	3	3	0.107	94	3	1997

plays a crucial role in advancing the understanding and application of DEA in the insurance industry, providing a rich repository of research that spans operational, financial, and sustainability perspectives.

Table 2 provides a comprehensive summary of the bibliometric data analyzed for studies on DEA in the insurance sector. Covering a timespan from 1994 to 2024, the data encompass 261 different sources, including journals and books. A total of 405 documents have been examined, showcasing an annual growth rate of 10.11%, indicating a robust and increasing interest in this research area over the years.

Table 2. Descriptive summary

Description	Results
Main Information About Data	
Timespan	2010:2023
Sources (Journals, Books, etc.)	432
Documents	405
Annual Growth Rate %	10.11
Document Average Age	8.42
Average citations per doc	24.83
References	0
Document Contents	
Keywords Plus (ID)	1,237

The average age of these documents is 8.42 years, suggesting a relatively young yet established body of literature. Each document, on average, has garnered 24.83 citations, reflecting their academic impact. Notably, the dataset does not include any references, but it does highlight 1,237 unique keywords, underlining the diverse topics and themes explored in this field.

Figure 1 shows the publication history of various authors from 1997 to 2023. Each circle represents the number of articles published by an author in a given year, with larger circles indicating more articles. The shade of each circle signifies the total citations per year, with darker shades representing higher citation counts. Authors such as Cummins

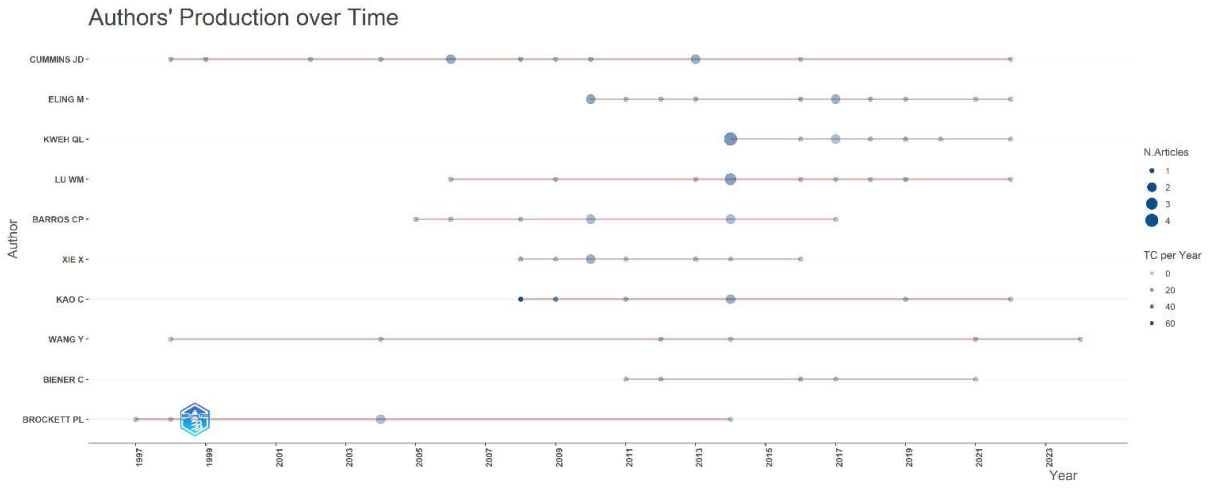

Figure 1. Author's production over time

J. D. and Brockett P. L exhibit extended periods of activity, with Cummins J. D. peaking around 2013 in both publications and citations. Eling M. shows significant publication activity around 2015, while Kweh Q. L., Lu W. M., and Barros C. P. have notable contributions in the mid-2010s. Xie X. maintains a consistent publication record with increased activity in recent years. Wang Y. and Biener C., though having fewer publications, show substantial impact in certain years. The chart effectively highlights prolific authors and significant years, illustrating trends in research output and influence over time.

The surge in publications during this period can be attributed to several factors, including increased academic interest, advancements in DEA methodologies, and a heightened focus on efficiency due to economic pressures and competitive market conditions. Moreover, the diversification of DEA models, such as Network DEA and Two-stage DEA, has allowed for more nuanced analysis, catering to the complex nature of insurance operations. The efficiency analysis in the insurance industry has yielded a wealth of knowledge, predominantly employing DEA as the primary methodology. Researchers have delved into various dimensions of insurer performance, shedding light on critical factors that influence efficiency outcomes. Notably, studies have uncovered the impact of regulatory changes, with evidence pointing towards the positive effects of deregulation on insurer efficiency. Comparative regional analyses have played a pivotal role in understanding the contextual nuances shaping efficiency, providing insights into the diversity of dynamics across different markets. However, as this literature matures, several noteworthy gaps and areas for further exploration emerge.

The mid-2010s, especially around 2013 and 2015, appear to be peak periods for several authors, indicating a significant surge in research output and influence during this time.

Table 3 shows prolific authors in the field of DEA in the insurance sector. Cummins J. D. tops the chart with 13 documents, followed by Eling M. with 12, and Kweh Q. L. and Lu W. M. each with 11 documents. The remaining authors, such as Barros C. P., Xie X., and others, have also made significant contributions, as indicated by their respective bubble sizes.

John D. Cummins is a leading figure in insurance research, particularly known for his work on efficiency and productivity analysis using DEA (Cummins & Xie, 2013). His studies often explore the financial performance and risk management practices in insurance companies. Cummins' prolific output has significantly advanced the understanding of how operational efficiencies impact the overall competitiveness and stability of insurance firms.

Martin Eling is another prominent scholar whose research primarily focuses on the efficiency and productivity of insurance companies using DEA (Eling & Schaper, 20175). His work often addresses performance measurement, risk assessment, and the regulatory impacts on the insurance sector. Eling's contributions have provided valuable insights into optimizing insurance operations and improving strategic decision-making.

Kweh Q. L. and Lu W. M. have both contributed extensively to the field of DEA in insurance (Chen et al., 2014; Lu et al., 2014). Their research typically revolves around assessing the operational efficiencies

Table 3. Authors-leaders of research in the field of DEA in insurance

Author	h_index	g_index	m_index	TC	NP	PY_start
Cummins J. D.	11	13	0.407	1408	13	1998
Eling M.	10	12	0.667	657	12	2010
Lu W. M.	10	11	0.526	469	11	2006
Kweh Q. L.	9	11	0.818	386	11	2014
Barros C.P.	8	8	0.4	273	8	2005
Xie X.	7	8	0.412	450	8	2008
Kao C.	6	7	0.353	1775	7	2008
Weiss M. A.	5	5	0.192	551	5	1999
Biener C.	4	5	0.286	178	5	2011
Brockett P. L.	4	5	0.143	218	5	1997

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and competitive dynamics of insurance firms. They have explored various methodological advancements in DEA to better evaluate and compare the performance of companies within the industry.

Carlos Pestana Barros is recognized for his extensive research on the application of DEA in assessing the performance of insurance companies. His work often intersects with topics such as benchmarking and performance improvement strategies. Barros' studies have been instrumental in highlighting the operational strengths and weaknesses in the insurance sector, guiding firms towards enhanced efficiency (Barros et al., 2005; Wanke & Barros, 2016).

Xie X. and Kao C. have also made notable contributions to the DEA literature in insurance. Their research often focuses on methodological innovations and practical applications of DEA to evaluate the efficiency and productivity of insurance operations. Their insights have helped in refining the analytical tools used to assess performance in this sector (Xie, 2010).

Figure 2 shows a visual representation of the key themes in journal publications. The most prominent keyword is "data envelopment analysis," which accounts for 11% of the focus, highlighting a strong interest in performance and efficiency evaluation. Other significant keywords include "insurance," "human," and "health insurance," indicating that research frequently addresses financial aspects and human factors. Additionally, terms such as "productivity," "organizational," and "decision making" reflect a focus on improving management practices and operational efficiency. The tree map also shows a diverse range of topics, including "economics," "public health," and "health care policy," underscoring the interdisciplinary nature of the work. In total, the image encompasses 54 distinct keywords.

Figure 3 illustrates the cumulative occurrences of key terms in the journal publications from 1994 to 2024. "Data envelopment analysis" shows a significant rise, indicating its growing importance in research. Other terms like "insurance," "efficiency," and "health insurance" also display in-

Figure 2. Tree map of keyword occurrence

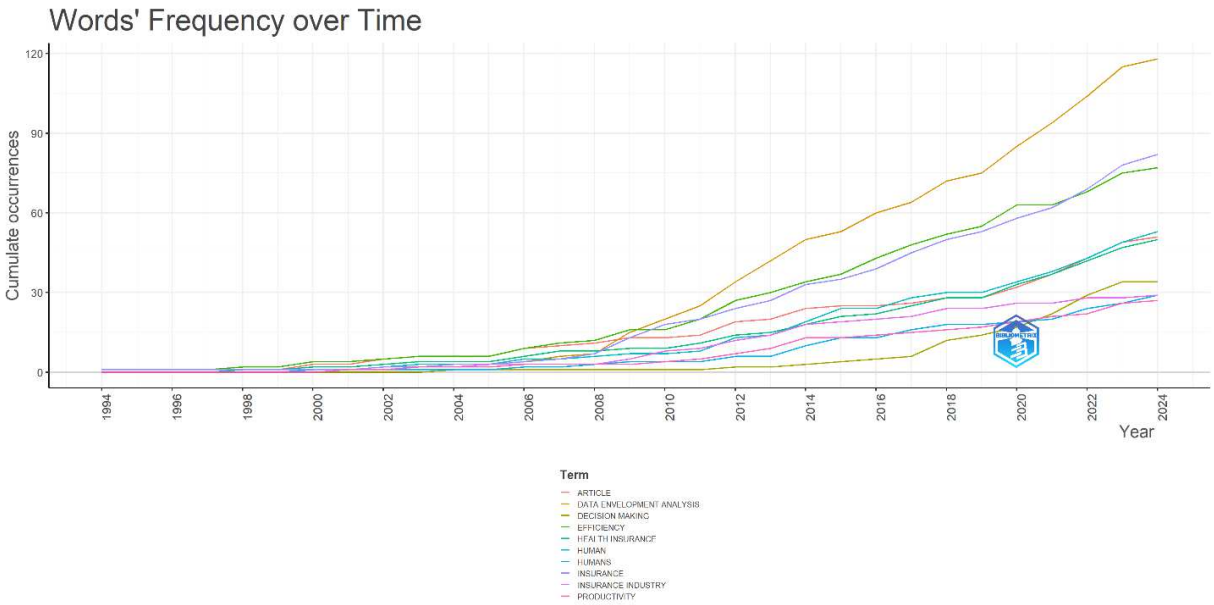

Figure 3. Word frequency over time

creasing trends, reflecting ongoing interest and research activity in these areas. The steady growth in the use of keywords such as "human," "decision making," and "productivity" suggests a broadening scope that includes human factors and operational efficiency. This temporal analysis highlights the evolving focus of research over the past three decades.

Within the framework of this study, key trends and topics in the literature were analyzed (Figure 4). The study highlights a significant shift towards healthcare and insurance sectors, with frequent terms like "health care planning," "health insurance," and "life insurance," indicating a growing focus in these areas. Regional studies on China and Taiwan have become prominent, reflecting increased geographical interest. The persistent appearance of terms such as "efficiency," "productivity," and "regression analysis" underscores the central themes of DEA. From 2016 onwards, there is a notable rise in publication volume, suggesting expanding research output. This analysis provides valuable insights into the evolving land-

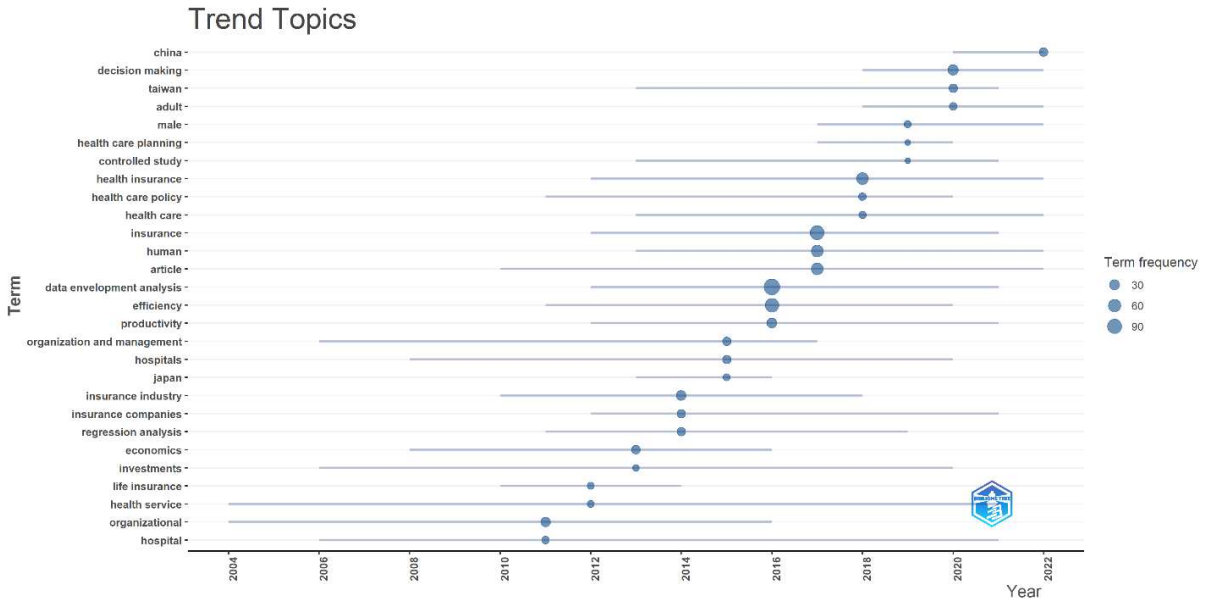

Figure 4. Trending topics

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Table 4. Description of clusters formed by co-author

Cluster	Color	Countries
1	Red	United States, China, Taiwan, Kenya, Ireland, South Africa, Indonesia, russia, Saudi Arabia, Malawi, Yemen, Mauritius, North Macedonia, Serbia
2	Green	Iran, Poland, Oman, Azerbaijan, Lithuania, Czechia, Slovakia, Ukraine
3	Blue	Germany, Italy, Norway, Finland, Spain, Austria, Greece, Jordan, Cyprus, Chile, Brazil, Sudan
4	Yellow	Slovenia, Croatia, Ghana, Namibia, Sierra Leone, Botswana

scape of DEA research, guiding future directions and emphasizing areas of significant impact. The most important thing to understand is that methodological diversification is a definite need.

In the context of this study, a robust international partnership between the United States, China, and European countries is being followed. Notable collaboration with countries in Asia, South America, and Africa also reflects DEA's global research network. This is evidence that cross-border collaboration is essential to advance DEA research and its application worldwide.

A comprehensive overview has been conducted of the clusters formed by co-authors based on their geographical collaborations in the field of DEA applications in the insurance industry. The analysis reveals four distinct clusters of countries, each characterized by unique research dynamics and contributions (Table 4). Cluster 1, dominated by the United States, China, and russia, reflects a diverse blend of developed and emerging markets, underscoring their pivotal roles in driving DEA research across vast and complex insurance ecosystems. This cluster illustrates significant engagement in developing and applying DEA methodologies to enhance efficiency in large-scale insurance operations. In contrast, Cluster 2, which includes countries like Iran, Poland, and Ukraine, primarily represents transitional and developing economies. Research efforts within this cluster often focus on adapting DEA techniques to suit the evolving regulatory and economic landscapes of these regions. Cluster 3, featuring countries such as Germany, Italy, and Spain, comprises predominantly European nations with well-established insurance sectors. The research here is inclined towards advanced DEA applications tailored to mature market conditions and sophisticated regulatory frameworks. Lastly, Cluster 4, encompassing nations like Slovenia, Croatia, and Namibia, highlights regions with smaller or nascent insurance markets. Studies in this cluster typically explore the optimization of resources and operational efficiencies in these less mature environments. These clusters collectively underscore the global nature of DEA research in the insurance industry and reveal how regional collaborations are influenced by the specific characteristics and needs of various markets (Figure 5). This diversity in collaboration points to the rich array of research focus and the adaptation of DEA methodologies to address different operational contexts within the global insurance landscape.

Geographical and sectoral differences in efficiency assessments are also evident. Studies

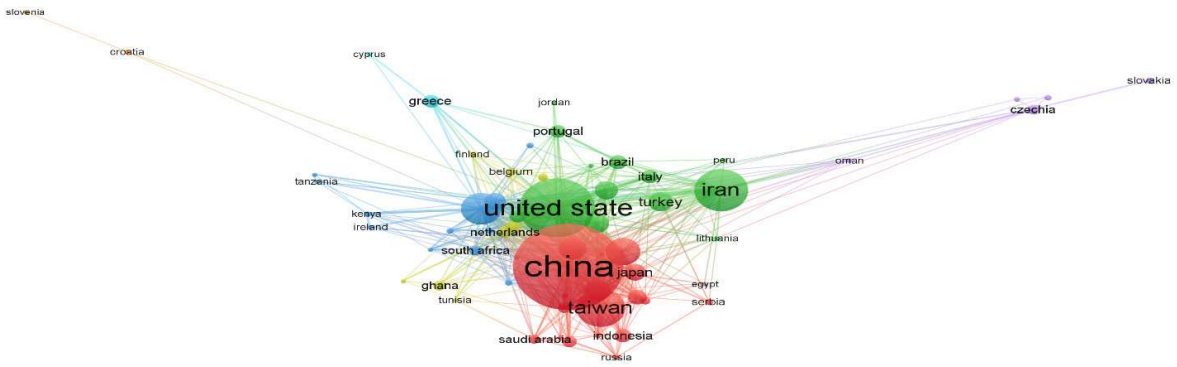

Figure 5. Co-authorship network

covering developed markets, such as North America and Europe, often report higher efficiency levels compared to those in emerging markets like Asia and Africa. Similarly, sectoral analyses reveal that life insurance firms exhibit different efficiency patterns compared to non-life insurers, driven by factors such as product complexity, market competition, and regulatory frameworks. These differences highlight the need for tailored strategies to enhance efficiency, considering the unique challenges and opportunities within each market segment.

The systematic review of 432 scholarly papers using DEA in the insurance sector reveals several critical insights into the efficiency trends and determinants within the industry.

The analysis indicates a notable focus on cost efficiency across the reviewed literature. Many studies have documented improvements in cost efficiency attributed to technological advancements and enhanced operational processes. For instance, several papers highlight the positive impact of digital transformation and process automation in reducing operational costs and improving service delivery.

Technical efficiency remains a key area of interest, with studies showing mixed results. While some insurance firms, particularly in developed markets, demonstrate high technical efficiency due to effective resource management and innovative practices, others, especially in emerging markets, face challenges in achieving similar levels of efficiency. This variability underscores the importance of contextual factors, such as market maturity and regulatory environment, in shaping technical efficiency outcomes.

The reviewed literature employs a variety of DEA models, including CCR, BCC, and hybrid approaches. The choice of model often reflects the specific research questions and data characteristics. For example, studies aiming to benchmark efficiency across different firms commonly use the CCR model, while those focusing on variable returns to scale prefer the BCC model. Hybrid models combining DEA with techniques like Stochastic Frontier Analysis (SFA) offer nuanced insights, capturing both efficiency and random error components.

There are significant geographical and sectoral differences in the efficiency assessments. Studies covering developed markets, such as North America and Europe, often report higher efficiency levels compared to those in emerging markets like Asia and Africa. Similarly, sectoral analyses reveal that life insurance firms exhibit different efficiency patterns compared to non-life insurers, driven by factors such as product complexity and market competition.

The study underscores the significant progress made in understanding and enhancing efficiency within the insurance industry through DEA applications. While notable advancements in cost efficiency are evident, the mixed results in technical efficiency and productivity changes highlight the need for continued research and tailored strategies to address regional and sectoral disparities. By focusing on the identified research gaps and leveraging innovative methodologies, future studies can further contribute to optimizing efficiency in the insurance sector. It is much more important to understand that longitudinal studies are extremely important and should be conducted; some actual data or research that tracks the performance of an insurance company over long periods of time. Regulations, economic cycles, and technological improvements constantly shape the insurance industry's landscape. The different changing trends in insurer efficiency can be captured by longitudinal research, which also offers insights into the trajectories of efficiency and the long-term effects of regulatory actions and technological advancements Additionally, taking a multifaceted approach to efficiency measurement is crucial. Strategic, environmental, social, human resources, customer satisfaction efficiency, and operational factors are all included in efficiency. Future research should include a wider range of efficiency indicators considering social impact, environmental responsibility, and strategic decision-making. Such an approach would align with the rising emphasis on corporate social responsibility and sustainability in today's business landscape.

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CONCLUSION

This bibliometric analysis of DEA applications in the insurance industry from 2010 to 2023 provides valuable insights into the evolution of efficiency assessment in this sector. The study reveals a notable increase in research activity, particularly post-2015, reflecting the rising recognition of DEA as a crucial tool for measuring and improving efficiency in insurance firms. Key themes identified in the literature include health insurance, insurance companies, efficiency, productivity, and organizational management, highlighting the primary areas of focus for researchers.

The country collaboration map underscores the significant contributions of the United States, China, and European countries to DEA research in the insurance sector. These regions not only produce a substantial volume of research but also engage in extensive international collaborations, fostering the exchange of ideas and methodologies. This global network of research collaboration is pivotal in advancing the application of DEA and addressing the diverse challenges faced by the insurance industry worldwide. The trend analysis indicates a shift towards more sophisticated and integrated methodologies, combining DEA with other quantitative techniques such as regression analysis. This evolution reflects the need for more robust models to tackle the complex and multifaceted nature of efficiency assessment in the insurance industry. Moreover, the increasing focus on specific segments within the insurance sector, such as health insurance and life insurance, suggests a deeper investigation into the unique operational dynamics and efficiency determinants pertinent to these areas.

In summary, this bibliometric review highlights the critical role of DEA in enhancing operational efficiency within the insurance industry. The increasing research activity, evolving methodologies, and extensive international collaborations underscore the dynamic and vibrant nature of this field. Future investigations should focus on the identified gaps, such as the impact of regulatory environments and the role of InsurTech in enhancing efficiency.

AUTHOR CONTRIBUTIONS

Conceptualization: K. S. Druva Kumar, J. P. Senthil Kumar.
Data curation: K. S. Druva Kumar, J. P. Senthil Kumar.
Formal analysis: K. S. Druva Kumar, J. P. Senthil Kumar.
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Methodology: K. S. Druva Kumar, J. P. Senthil Kumar.
Software: K. S. Druva Kumar, J. P. Senthil Kumar.
Supervision: J. P. Senthil Kumar.
Validation: K. S. Druva Kumar, J. P. Senthil Kumar.
Visualization: K. S. Druva Kumar, J. P. Senthil Kumar.
Writing – original draft: K. S. Druva Kumar, J. P. Senthil Kumar.
Writing – review & editing: K. S. Druva Kumar, J. P. Senthil Kumar.

REFERENCES

1. Akyüz, G. Ç. (2022). Evaluation of Topsis and Mabac Methods in Financial Performance Analysis of Non-Life Insurance Companies. *İzmir İktisat Dergisi*. https://doi.org/10.24988/IJE.1017854
2. Al-Amri, K., Gattoufi, S., & Al-Muharrami, S. (2012). Analyzing the technical efficiency of insurance companies in GCC. *Journal of Risk Finance, 13*(4), 362-380. https://doi.org/10.1108/15265941211254471
3. Albouy, F.-X., & Blagoutine, D. (2001). Insurance and Transition Economics: The Insurance Market in Russia. *Geneva Papers on Risk and Insurance-Issues and Practice, 26,* 467-479. https://doi.org/10.1111/1468-0440.00132
4. Alhassan, A., & Biekpe, N. (2016). *Competition and efficiency in the non-life insurance market in South Africa. Journal of Economic Studies, 436,* 882-909. https://doi.org/10.1108/JES-07-2015-0128

5. Almulhim, T. S. (2019). Analysis of Takaful vs. Conventional insurance firms' efficiency: Two-stage DEA of Saudi Arabia's insurance market. *Cogent Business & Management, 6*(1), 1633807. https://doi.org/10.1080/23311975.2019.1633807

6. Ashiagbor, A., Dziwornu, R. K., Gbade, A. V., Offei-Kwafo, kwasi, & Liticia, G. (2023). Measuring efficiency and productivity changes: A non-parametric analysis of Ghanaian life insurance industry. *Cogent Economics & Finance, 11*(1), 2210855. https://doi.org/10.1080/23322039.2023.2210855

7. Barros, C. P., Barroso, N., & Borges, M. R. (2005). Evaluating the efficiency and productivity of insurance companies with a malmquist index: A case study for Portugal. *Geneva Papers on Risk and Insurance: Issues and Practice, 30*(2), 244-267. https://doi.org/10.1057/PALGRAVE.GPP.2510029

8. Berger, A. N., Cummins, J., Weiss, M. A., & Zi, H. (2000). *Conglomeration Versus Strategic Focus: Evidence from the Insurance Industry* (Working Paper No. 99-29). https://doi.org/10.2139/SSRN.174810

9. Berger, L. A., Cummins, J. D., & Tennyson, S. (1992). Reinsurance and the liability insurance crisis. *Journal of Risk and Uncertainty, 5,* 253-272. https://doi.org/10.1007/BF00057882

10. Bhatia, A., & Mahendru, M. (2022). Revenue efficiency evaluation of life insurance companies in India: identification of leaders and laggards. *Benchmarking: An International Journal, 29*(10), 3133-3162. https://doi.org/10.1108/BIJ-01-2021-0051

11. Biener, C., & Eling, M. (2012). Organization and Efficiency in the International Insurance Industry: A Cross-frontier Analysis. *European Journal of Operational Research, 221*(2), 454-468. https://doi.org/10.1016/J.EJOR.2012.03.037

12. Brockett, P. L., Cooper, W. W., Golden, L. L., Rousseau, J. J., & Wang, Y. (2004). Evaluating solvency versus efficiency performance and different forms of organization and marketing in US property – Liability insurance companies. *European Journal of Operational Research, 154*(2), 492-514. https://doi.org/10.1016/S0377-2217(03)00184-X

13. Brockett, P. L., Cooper, W. W., Golden, L. L., Rousseau, J. J., & Wang, Y. (2005). Financial intermediary versus production approach to efficiency of marketing distribution systems and organizational structure of insurance companies. *Journal of Risk and Insurance, 72*(3), 393-412. https://doi.org/10.1111/J.1539-6975.2005.00130.X

14. Cansong, L., Lede, N., & Peng, J. (2016). Research on Operating Efficiency Spatial Evolution of Property Insurance Company and Influence Factors Thereof Based on Geographic Information System. *2016 International Conference on Robots & Intelligent System (ICRIS)*. https://doi.org/10.1109/ICRIS.2016.76

15. Chakraborty, K., & Harper, R. K. (2017). Dynamic Productivity Analysis of Insurance Firms-The Effect of Firm-Specific and Macroeconomic Characteristics. *International Journal of Applied Economics, 14*(2), 37-55.

16. Chen, F. C., Liu, Z. J., & Kweh, Q. L. (2014). Intellectual capital and productivity of Malaysian general insurers. *Economic Modelling, 36,* 413-420. https://doi.org/10.1016/J.ECONMOD.2013.10.008

17. Cooper, W. W., Seiford, L. M., & Tone, K. (1999). *Data Envelopment Analysis: A Comprehensive Text with Models, Applications, References and DEA-Solver Software*. Springer. Retrieved from https://link.springer.com/book/10.1007/978-0-387-45283-8

18. Cozad, M., & Wichmann, B. (2013). Efficiency of health care delivery systems: Effects of health insurance coverage. *Applied Economics, 45*(29), 4082-4094. https://doi.org/10.1080/00036846.2012.750420

19. Cummins, J. D., & Rubio-Misas, M. (2006). Deregulation, Consolidation, and Efficiency: Evidence from the Spanish Insurance Industry. *Journal of Money, Credit and Banking, 38*(2), 323-355. https://doi.org/10.1353/MCB.2006.0029

20. Cummins, J. D., & Xie, X. (2008). Mergers and acquisitions in the US property-liability insurance industry: Productivity and efficiency effects. *Journal of Banking and Finance, 32*(1), 30-55. https://doi.org/10.1016/J.JBANKFIN.2007.09.003

21. Cummins, J. D., & Xie, X. (2013). Efficiency, productivity, and scale economies in the U.S. property-liability insurance industry. *Journal of Productivity Analysis, 39,* 141-164. https://doi.org/10.1007/S11123-012-0302-2

22. Diacon, S., Starkey, K., & O'Brien, C. (2002). *Size and Efficiency in European Long–term Insurance Companies: An International Comparison*. *Geneva Papers on Risk and Insurance: Issues and Practice, 27*(3), 444-466. https://doi.org/10.1111/1468-0440.00184

23. Dutta, A. (2013). Impact of Privatization on Productivity: A Non-Parametric Analysis of Indian Insurance Sector. *Global Business Review, 14*(2), 297-314. https://doi.org/10.1177/0972150913477519

24. Eling, M., & Jia, R. (2018). Business failure, efficiency, and volatility: Evidence from the European insurance industry. *International Review of Financial Analysis, 59,* 58-76. https://doi.org/10.1016/J.IRFA.2018.07.007

25. Eling, M., & Schaper, P. (2017). Under Pressure – How the Environment Affects Productivity and Efficiency of European Life Insurance Companies. *European Journal of Operational Research, 258*(3), 1082-1094. https://doi.org/10.1016/j.ejor.2016.08.070

26. Ennsfellner, K. C., Lewis, D., & Anderson, R. I. (2004). Production Efficiency in the Austrian Insurance Industry: A Bayesian Examination. *Journal of Risk and Insurance, 71*(1), 135-159. https://doi.org/10.1111/J.0022-4367.2004.00082.X

27. Enz, R. (2000). The S-Curve Relation Between Per-Capita Income

http://dx.doi.org/10.21511/ins.15(1).2024.07

and Insurance Penetration. *Geneva Papers on Risk and Insurance-Issues and Practice, 25,* 396-406. https://doi.org/10.1111/1468-0440.00072

28. Fenn, P., Vencappa, D., Diacon, S., Klumpes, P. J. M., & O'Brien, C. (2008). Market structure and the efficiency of European insurance companies: A stochastic frontier analysis. *Journal of Banking and Finance, 32*(1), 86-100. https://doi.org/10.1016/J.JBANKFIN.2007.09.005

29. Fenyves V. and Tarnóczi T. (2020). Data envelopment analysis for measuring performance in a competitive market. *Problems and Perspectives in Management, 18*(1), 315-325. https://doi.org/10.21511/ppm.18(1).2020.27

30. Garg, M. C., & Garg, S. (2020). Efficiency Evaluation of Indian General Insurance Companies. *IUP Journal of Management Research.*, *19*(1), 7-26. Retrieved from https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3797535

31. Ghosh, A. (2013). Life Insurance in India: the Relationship between Reforms and Growth in Business. *Geneva Papers on Risk and Insurance-Issues and Practice, 38*, 88-112. https://doi.org/10.1057/GPP.2012.2

32. Gusti M. A., Alpon Satrianto, Candrianto, Egy Juniardi and Halkadri Fitra (2024). Artificial intelligence for employee engagement and productivity. *Problems and Perspectives in Management, 22*(3), 174-184. https://doi.org/10.21511/ppm.22(3).2024.14

33. Harrington, S., & Nelson, J. M. (1986). A Regression-Based Methodology for Solvency Surveillance in the Property-Liability Insurance Industry. *The Journal of Risk and Insurance, 53*(4), 583-605. https://doi.org/10.2307/252965

34. Hu, Y., Wu, Y., Zhou, W., Li, T., & Li, L. (2020). A three-stage DEA-based efficiency evaluation of social security expenditure in China. *PLoS ONE, 15*(2). https://doi.org/10.1371/JOURNAL.PONE.0226046

35. Ilyas, A. M., & Rajasekaran, S. (2019). Productivity of the Indian non-life insurance sector: New evidence employing Färe-Primont index approach. *International Journal of Productivity and Performance Management, 69*(4), 633-650. https://doi.org/10.1108/IJPPM-04-2019-0147

36. Jaloudi, M. M. (2019). The efficiency of Jordan insurance companies and its determinants using DEA, slacks, and logit models. *Journal of Asian Business and Economic Studies, 26*(1), 153-166. https://doi.org/10.1108/JABES-10-2018-0072

37. Kaigorodova, G. N., & Mustafina, A. A. (2014). The Influence of Forms of Insurance Coverage Organization on Population's Life Quality. *Mediterranean Journal of Social Sciences, 5*(24), 18. Retrieved from https://www.richtmann.org/journal/index.php/mjss/article/view/4948

38. Lee, H., Cheng, F., Har, W., Nassir, A., & Razak, N. (2019). Efficiency, firm-specific and corporate governance factors of the Takaful insurance. *International Journal of Islamic and Middle Eastern Finance and Management, 12*(3), 368-387. https://doi.org/10.1108/IMEFM-06-2018-0187

39. Li, Z., Li, Y., & Zhang, W. (2021). Configuration analysis of influencing factors of operating efficiency based on fsQCA: evidence from China's property insurance industry. *Chinese Management Studies, 15*(5), 1085-1103. https://doi.org/10.1108/CMS-04-2020-0151

40. Lim, Q. M., Lee, H. S., & Har, W. M. (2021). Efficiency, productivity and competitiveness of the Malaysian insurance sector: an analysis of risk-based capital regulation. *Geneva Papers on Risk and Insurance: Issues and Practice, 46*(1), 146-172. https://doi.org/10.1057/S41288-020-00173-8

41. Litvak, E., & Bisognano, M. (2011). Analysis & commentary: More patients, less payment: Increasing hospital efficiency in the aftermath of health reform. *Health Affairs, 30*(1), 76-80. https://doi.org/10.1377/HLTHAFF.2010.1114

42. Lu, W. M., Wang, W. K., & Kweh, Q. L. (2014). Intellectual capital and performance in the Chinese life insurance industry. *Omega (United Kingdom), 42*(1), 65-74. https://doi.org/10.1016/J.OMEGA.2013.03.002

43. Luhnen, M. (2009). *Determinants of Efficiency and Productivity in German Property-Liability Insurance: Evidence for 1995–2006. Geneva Papers on Risk and Insurance: Issues and Practice, 34,* 483-505. https://doi.org/10.1057/GPP.2009.10

44. Mahlberg, B., & Url, T. (2010). Single Market Effects on Productivity in the German Insurance Industry. *Journal of Banking and Finance, 34*(7), 1540-1548 https://doi.org/10.1016/j.jbankfin.2009.09.005

45. Medved, D., & Kavčič, S. (2012). An empirical study of efficiency in Croatia and Slovenia insurance markets. *Ekonomska Istrazivanja, 25*(1), 105-120. https://doi.org/10.1080/1331677X.2012.11517496

46. Micajkova, V. (2015). Efficiency of Macedonian Insurance Companies: A DEA Approach. *Journal of Investment and Management, 4*(2), 61-67. https://doi.org/10.11648/J.JIM.20150402.11

47. Ndlovu, T. (2021). Efficiency, productivity and returns to scale economies in South Africa's healthcare insurance market. *Studies in Economics and Econometrics, 45*(3), 164-183. https://doi.org/10.1080/03796205.2021.2012507

48. Nektarios, M., & Barros, C. P. (2010). A Malmquist Index for the Greek Insurance Industry. *Geneva Papers on Risk and Insurance-Issues and Practice, 35,* 309-324. https://doi.org/10.1057/GPP.2010.2

49. Rahmani, I., Barati, B., Majazi Dalfard, V., & Hatami-Shirkouhi, L. (2014). Nonparametric frontier analysis models for efficiency evaluation in insurance industry: A case study of Iranian insurance market. *Neural Computing and Applications, 24*(5), 1153-1161. https://doi.org/10.1007/S00521-012-1320-8

50. Rizwanullah, M., Nasrullah, M., & Liang, L. (2021). On the asym-

metric effects of insurance sector development on environmental quality: challenges and policy options for BRICS economies. *Environmental Science and Pollution Research, 29,* 10802-10811. https://doi.org/10.1007/S11356-021-16364-2

51. Rubio-Misas, M., & Fernández-Moreno, M. (2017). Solvency surveillance and financial crisis: evidence from the Spanish insurance industry. *Spanish Journal of Finance and Accounting, 46*(3), 272-297. https://doi.org/10.1080/02102412.2017.1291167

52. Sahoo, B. K., Tone, K., Sahoo, B. K., & Tone, K. (2022). Evaluating the potential efficiency gains from optimal industry configuration: A case of life insurance industry of India. *Managerial and Decision Economics, 43*(8), 3996-4009. https://doi.org/10.1002/MDE.3642

53. Savitha, B., Banerjee, S., & Shetty, A. (2019). Product diversification versus technical efficiency of conglomerate life microinsurance companies: evidence from India. *Geneva Papers on Risk and Insurance-Issues and Practice, 44,* 527-547. https://doi.org/10.1057/S41288-019-00128-8

54. Seog, S. H. (2009). Insurance Markets with Differential Information. *The Journal of Risk and Insurance, 76*(2), 279-294. Retrieved from http://www.jstor.org/stable/40247554

55. Siddiqui, M. H., & Ghosh Sharma, T. (2010). Measuring the Customer Perceived Service Quality for Life Insurance Services: An Empirical Investigation. *International Business Research, 3*(3), 171-186. Retrieved from https://ccsenet.org/journal/index.php/ibr/article/view/5927

56. Siddiqui, S. A. (2020). Evaluating the efficiency of Indian life insurance sector. *Indian Journal of Economics and Development, 16*(1), 72-80. Retrieved from https://www.semanticscholar.org/paper/Evaluating-the-Efficiency-of-Indian-Life-Insurance-Siddiqui/9f58f0be7c4cb70ec3594a2606ef910b78f75f51

57. Sinha, R. (2012). Are Indian Life Insurance Companies Cost Efficient? Some Recent Empirical Evidence. *Prajnan, 16*(3), 181-201.

58. Sinha, R. P. (2017). Dynamic Performance Benchmarking of Indian General Insurers. *Journal of Quantitative Economics, 15,* 543-564. https://doi.org/10.1007/S40953-016-0061-4

59. Wanke, P., & Barros, C. (2016). Efficiency drivers in Brazilian insurance: A two-stage DEA meta frontier-data mining approach. *Economic Modelling, 53,* 8-22. https://doi.org/10.1016/j.econmod.2015.11.005

60. Wu, J., Xu, G., Zhu, Q., & Zhang, C. (2021). Two-stage DEA models with fairness concern: Modelling and computational aspects. *Omega, 105,* 102521. https://doi.org/10.1016/J.OMEGA.2021.102521

61. Xie, X. (2010). Are publicly held firms less efficient? Evidence from the US property-liability insurance industry. *Journal of Banking and Finance, 34*(7), 1549-1563. https://doi.org/10.1016/J.JBANKFIN.2010.01.007

62. Yazdi, A. K., Wang, Y. J., & Kahorin, M. M. (2019). Performance benchmarking on export credit agencies: A data envelopment analysis. *International Journal of Productivity and Quality Management, 28*(3), 340-359. https://doi.org/10.1504/IJPQM.2019.103528

63. Yuengert, A. M. (1993). The measurement of efficiency in life insurance: Estimates of a mixed normal-gamma error model. *Journal of Banking and Finance, 17*(2-3), 483-496. https://doi.org/10.1016/0378-4266(93)90047-H

64. Zhao, T., Pei, R., & Pan, J. (2021). The evolution and determinants of Chinese property insurance companies' profitability: A DEA-based perspective. *Journal of Management Science and Engineering, 6*(4), 449-466. https://doi.org/10.1016/j.jmse.2021.09.005

65. Zhu, J. (2022). DEA under big data: data enabled analytics and network data envelopment analysis. *Annals of Operations Research, 309*(2), 761-783. https://doi.org/10.1007/S10479-020-03668-8

http://dx.doi.org/10.21511/ins.15(1).2024.07

APPENDIX A

Table A1. Summary of DEA application in the insurance industry (2010–2023)

	Findings
Efficiency Analysis	Ennsfellner et al. (2004) examine the production and, most importantly, study the Efficiency of Austrian insurers and find the positive effects of deregulation on Efficiency. Micajkova (2015) explores the Efficiency of insurance companies in Macedonia using Data Envelopment Analysis (DEA). M. Garg and S. Garg (2020) examine operating and investment efficiency in general insurance companies. Medved and Kavčič (2012) explore efficiency in the insurance markets of Croatia and Slovenia and could involve a comparative analysis of companies and identify factors affecting their performance. The research extends to specific markets and regions. For instance, Yazdi et al. (2019) investigate insurance efficiency in the Gulf Cooperation Council (GCC) countries, providing insights into the performance of insurers in this region. Siddiqui and Ghosh Sharma (2010) delve into the Indian segment of the life insurance sector, examining the productivity and efficiency of both public and private insurers. The research extends to specific markets and regions. For instance, Chakraborty and Harper (2017) investigate insurance efficiency and productivity in the Gulf Cooperation Council (GCC) countries, providing insights into the performance of insurers in this region.
Impact of Deregulation and Conglomeration	Ennsfellner et al. (2004) discuss the impact of deregulation on the efficiency of insurance companies, highlighting the potential benefits of regulatory changes on the insurance industry. Berger et al. (2000) and Savitha et al. (2019) give more importance to exploring the effects of conglomeration and strategic focus in the insurance industry. Barros et al. (2005) examine the effect and considerable impact of the deregulation and consolidation's impact on efficiency in the Spanish insurance industry. J. David Cummins and Xiaoying Xie (2008) analyze the mergers and acquisitions' productivity and efficiency effects in the U.S. property-liability insurance industry.
Global Insurance Industry	Eling and Jia (2019) provide a global perspective by analyzing the connection between efficiency, profitability and productivity in the insurance industry, emphasizing the industry's unique characteristics and regional variations. They find that the efficiency-profitability relationship is industry-dependent, with different dynamics for life and non-life insurers. Lim et al. (2021) find out the factors that impact efficiency, productivity and competitiveness in the Malaysian insurance sector. Joy Chakraborty (2018) analyzes the efficiency and productivity of general insurance firms in India using a Malmquist approach. Sahoo et al. (2022) tested the impact of inputs and outputs sustainability in understanding the nonparametric production analysis – life insurance industry in India. Brockett et al. (2004) study efficiency and assess solvency in different types of organizations and marketing sectors, in the US private insurance companies.
Specific Markets and Regions	Al-Amri et al. (2012) investigate insurance efficiency in the Gulf Cooperation Council (GCC) countries, providing insights into the performance of insurers in this region. Ndlovu (2021) aims to understand and assess the efficiency, productivity, and the impact of economies of scale in the healthcare insurance market of South Africa. Zhou, Wang, Zhang, and Liu (2023) – The significant contribution of this paper lies in an in-depth examination of China's engineering insurance sector from a macro perspective, utilizing theories of industrial organization. R. P. Sinha (2017) uses a two-stage DEA of efficiency in the Indian General Insurance Sector. Ndlovu (2021), R. Sinha (2012) – The significant contributions of these papers are related to efficiency and productivity. They give some picture of returns to skill economics in South Africa's healthcare insurance market. Cummins and Weiss (2013**)** analyzed firm performance and productivity in the insurance industry. Nonparametric front television and productivity methods and their types were explored.
Impact of Internationalization	Grace and Sjoquist (2012) explore the impact of internationalization on the demand for directors' and officers' (D&O) liability insurance in response to corporate scandals. It highlights how global events can influence insurance demand patterns. Xie (2010) – cost efficiency plays a significant role in African insurance companies, and this study uses the infinity mixture model. Harrington and Nelson (1986) introduce a methodology for assessing solvency surveillance in the property-liability insurance industry. Cummins and Xie (2008) analyze efficiency, productivity, and scale economies in the US property-liability insurance industry. Luhnen (2009) provides a broad understanding of an analysis of efficiency and productivity in the German property-liability insurance industry. Cansong et al. (2016) gives an understanding of operating efficiency, especially in the spatial evolution of property insurance companies and its influence factors based on geographical information systems. Li et al. (2021) measure and evaluate the operating efficiency in the predominantly China-based pension insurance sector. The study takes on a stage DEA model.

Table A1 (cont.). Summary of DEA application in the insurance industry (2010–2023)

	Findings
Risk Management and Crisis	Berger et al. (1992) investigate the liability insurance crisis of the mid-1980s, emphasizing the role of reinsurance market disruptions in contributing to the severity of the crisis. This study sheds light on the interconnectedness of insurance markets and broader financial stability. Chen, Chang-Chih, Chang, Chia-chien, Sun, Edward W, and Yu, Min-Teh (2013) – Primary work on optimal dynamic wealth allocation solutions with life insurance to reduce health risk in various competitive markets.
Social and Economic Context	Albouy and Blagoutine (2001) contextualize insurance within broader economic transitions and societal changes, as in the case of the Russian insurance market's shift toward a market-based system. Kaigorodova and Mustafina (2014) study the influence of forms of insurance coverage organizations on different populations' life quality. The study plays a significant role in understanding the efficiency in life insurance measurement. It also estimates the mix of the average gamma error model. Bhatia and Mahendru (2022), Yuengert (1993) – "On the asymmetric effects of insurance sector development on environmental quality: challenges and policy options for BRICS economies" by Rizwanullah et al. (2021). Ilyas and Rajasekaran (2019) aim to understand the productivity level of the Indian non-life insurance sector and study the new evidence employing the fare-Primont index approach.
Insurance Market Reforms	Ghosh (2013) investigates the relationship between reforms in the Indian life insurance sector and its subsequent growth. Bhatia and Mahendru (2022) give revenue efficiency evaluation of life insurance and study companies in India: identification of leaders and laggards. Ndlovu (2021) aims to understand the efficiency and productivity and returns to scale economies in South Africa's healthcare insurance market. Zhou, Wang, Zhang, and Liu (2023) conducted the macro investigation in China's engineering insurance industry; this study was based on industrial organization theories. Kaigorodova and Mustafina (2014) – Primary purpose of this paper is to study the influence of forms and types of insurance coverage in an organization on population's life quality.
Market Structure and Performance	Mahlberg and Url (2010) explored the single market effects and its impact on productivity in the German insurance industry. John Cummins and Mary A. Weiss (2008) discuss the application of efficiency analysis in the insurance industry using frontier efficiency methods. Fenn et al. (2008) examine the relationship between market structure and performance in property-liability insurers in Europe. Enz (2000) focuses on modelling the income elasticity of demand for insurance and its implications for insurance penetration.
Governance and Deficiency in Takaful Insurance	Rahmani et al. (2014) use DEA to assess the efficiency of Iranian insurance. Almulhim (2019) ("Analysis of Takaful vs. Conventional Insurance Firms' Efficiency: Two-stage DEA of Saudi Arabia's Insurance Market"). This paper focuses on efficiency analysis in the insurance industry. Lee et al. (2019) compared Takaful with conventional insurance firms in Saudi Arabia. The research extends to specific markets and regions. For instance, Al-Amri et al. (2012) investigate insurance efficiency in the Gulf Cooperation Council (GCC) countries, providing insights into the performance of insurers in this region.
Environmental Impact of Insurance Sector	Brockett et al. (2005) – The study is purely based on understanding the financial intermediates and the production approach to study the efficiency of marketing and its distribution system within the organization structure of insurance companies Zhao et al. (2021) want to stand the evolution and determine what impact it has on Chinese property insurance companies. This study gives more information about property insurance companies. Jaloudi (2019) tries to understand the efficiency of Jordan insurance companies and DEA, study the determinants using DEA slack and logit modes ("The efficiency of Jordan insurance companies and its determinants using DEA, slacks, and logit models"). Akyüz (2022) studies the evolution of topics and various methods in financial performance analysis of life insurance components. Ashiagbor et al. (2023) – The study is purely on understanding and measuring the efficiency and productivity changes in Ghanaian life insurance companies. Eling and Schaper (2015) – The main objective of this paper is to examine how the environment affects the productivity and efficiency of European life insurance companies.
European Insurance Market Analysis and Health Insurance	Diacon et al. (2002) aim to understand how the size and efficiency impact European long-term insurance companies. It is an international comparison study. Biener and Eling (2012) – To understand how organization and efficiency impact the international insurance industry using cross Frontier Analysis. Rubio-Misas and Fernández-Moreno (2017) – This study is purely based on understanding the solvency surveillance and the impact of financial crisis. The paper is an empirical study of the Spanish insurance industry. Cozad and Wichmann (2013) aim to explore the efficiency of healthcare delivery system and the impacts of health insurance coverage. Litvak and Bisognano (2011) – This paper attaches greater importance to the analysis of the technical efficiency of hospitals in China, as well as its influence on the effect of health insurance reforms.

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