Veland Ramadani ·
Abdylmenaf Bexheti · Hyrije Abazi-Alili ·
Christina Theodoraki · Gadaf Rexhepi ·
Besnik A. Krasniqi *Editors*

Economic Resilience and Sustainability—Vol. 1

8th International Scientific Conference on Business and Economics (ISCBE), Tetovo, North Macedonia, May 2025

Springer

Springer Proceedings in Business and Economics

Springer Proceedings in Business and Economics brings the most current research presented at conferences and workshops to a global readership. The series features volumes (in electronic and print formats) of selected contributions from conferences in all areas of economics, business, management, and finance. In addition to an overall evaluation by the publisher of the topical interest, scientific quality, and timeliness of each volume, each contribution is refereed to standards comparable to those of leading journals, resulting in authoritative contributions to the respective fields. Springer's production and distribution infrastructure ensures rapid publication and wide circulation of the latest developments in the most compelling and promising areas of research today.

The editorial development of volumes may be managed using Springer Nature's innovative EquinOCS, a proven online conference proceedings submission, management and review system. This system is designed to ensure an efficient timeline for your publication, making Springer Proceedings in Business and Economics the premier series to publish your workshop or conference volume.

This book series is indexed in SCOPUS.

Veland Ramadani · Abdylmenaf Bexheti ·
Hyrije Abazi-Alili · Christina Theodoraki ·
Gadaf Rexhepi · Besnik A. Krasniqi
Editors

Economic Resilience and Sustainability—Vol. 1

8th International Scientific Conference on
Business and Economics (ISCBE), Tetovo,
North Macedonia, May 2025

Springer

Editors
Veland Ramadani (ID)
Faculty of Business and Economics
South East European University
Tetovo, North Macedonia

Hyrije Abazi-Alili (ID)
Faculty of Business and Economics
South East European University
Tetovo, North Macedonia

Gadaf Rexhepi (ID)
South East European University
Tetovo, North Macedonia

Abdylmenaf Bexheti
Faculty of Business and Economics
South East European University
Tetovo, North Macedonia

Christina Theodoraki
IAE Aix-Marseille University
Puyricard, France

Besnik A. Krasniqi
Academy of Sciences and Arts
Prishtina, Kosovo

If disposing of this product, please recycle the paper.

Preface

This volume comprises the papers presented at the 8th International Scientific Conference on Business and Economics (ISCBE 2024), which took place from May 8–9, 2025, in Tetovo, North Macedonia. The conference theme, "Economic resilience and sustainability: contemporary challenges," was carefully chosen, and it explores the interplay between green and digital transformations, highlighting how businesses and economies can leverage technology and innovation to achieve sustainability goals. Key discussions were focused on sustainable business models, digital integration for green growth, economic policies for resilience, circular economy practices, and the role of finance in fostering sustainability. The conference also addressed the impact of global economic tensions and competitive market struggles on sustainability efforts, offering strategies to navigate these complex challenges.

The ISCBE conference has seen significant growth and evolution, building on the success of previous editions. This year, the conference received an overwhelming response, with over 90 submissions. Each submission underwent rigorous review by at least two reviewers and an average of one program committee member, resulting in a diverse program featuring 164 authors from 19 countries participating both online and onsite.

The call for papers was announced in February 2025, and ongoing communication with authors ensured a robust application period. The conference program included insightful keynote addresses delivered by internationally renowned professors:

- Prof. Dr. Christina Theodoraki, IAE Aix-Marseille University, France
- Acad. Prof. Dr. Abdylmenaf Bexheti, South East European University, North Macedonia
- Acad. Prof. Dr. Besnik A. Krasniqi, Academy of Sciences and Arts, Kosovo

The conference commenced with opening remarks from Prof. Dr. Besa Arifi, Vice-Rector of South East European University (SEEU), alongside conference co-chairs Prof. Dr. Hyrije Abazi-Alili and Prof. Dr. Veland Ramadani.

We extend our heartfelt gratitude to South East European University for their exceptional hospitality, unwavering support, and invaluable insights throughout the conference. Special thanks go to our esteemed keynote speakers for accepting our

invitation to share their expertise. We also acknowledge the dedication of the orga-
nizing committee and the contributions of the Public Relations Offices of SEEU,
along with all staff members whose efforts ensured the success of this event at our
magnificent venue.

We are deeply appreciative of the preparation invested by all speakers, panelists,
and participants, and eagerly anticipate their contributions to the 9th ISCBE in 2026.
We look forward to collaborating with you all again in the future.

Sincerely,

Tetovo, North Macedonia	Veland Ramadani
Tetovo, North Macedonia	Abdylmenaf Bexheti
Tetovo, North Macedonia	Hyrije Abazi-Alili
Puyricard, France	Christina Theodoraki
Tetovo, North Macedonia	Gadaf Rexhepi
Prishtina, Kosovo	Besnik A. Krasniqi

Contents

About the Editors

Veland Ramadani is a professor of Entrepreneurship and Family Business at the Faculty of Business and Economics, South-East European University, North Macedonia. His primary areas of research focus on entrepreneurship, family businesses, innovation, and sustainability. Dr. Ramadani has an extensive body of work to his name, having authored or co-authored over 150 research articles, 80 book chapters, 15 textbooks, and 35 edited books. His research contributions are notably featured in prestigious academic journals, including the *Journal of Business Research*, *Technological Forecasting and Social Change*, *Technology in Society*, *International Journal of Entrepreneurial Behavior & Research*, and *Review of Managerial Science*, among others. Furthermore, his research influence is underscored by his consistent inclusion among the world's top 2% of the most influential researchers, as determined by Elsevier and Stanford University for the last four consecutive years. Dr. Ramadani has remained actively engaged in various projects, including those funded by the European Union and universities in Saudi Arabia, Kuwait, and the United Arab Emirates. Additionally, he regularly offers consultancy services to private companies.

Abdylmenaf Bexheti is an academician and full professor of Public Finance and Macroeconomics at the Faculty of Business and Economics, South East European University, Republic of North Macedonia. Dr. Bexheti has published five books (alone) and several books as a co-author, more than 50 research papers, 50 projects, and more than 250 analyses and columns in different newspapers. During 1996–1998, Dr. Bexheti was, firstly, a Minister for Development and then a Minister for Transport and Communication in the Government of the Republic of Macedonia. He is also a full member of the Macedonian Academy of Science. His recent books are *Public Finance* (2nd edition) and *Economic Development*.

Hyrije Abazi-Alili is a full professor at South-East European University, Republic of North Macedonia. She earned a Ph.D. degree at Staffordshire University. She teaches undergraduate and postgraduate courses in Research Methodology, Corporate Finance, and Economics. Her research interests include finance, economics, microeconomics, female entrepreneurship, social entrepreneurship, etc. She has

authored research articles in several international and national journals. Besides her work as a lecturer, she has also managed UNDP and RRPP projects within the South-East European University, North Macedonia. She has shown advanced skills in econometric analysis.

Christina Theodoraki is a full professor in Entrepreneurship at IAE Aix-Marseille University. She is elected Program Chair at the Academy of Management, Entrepreneurship Division. She is an advisory board member at the Institute for Development Strategies at Indiana University, a research associate at the Chair of Entrepreneurship Territory Innovation (ETI)—IAE Paris-Sorbonne, Business Development Manager at the Entrepreneurial Ecosystem Research Network (EERN), Editor of Small Business Economics, Associate Editor of the Journal of Small Business Management, Management & Prospective—Gestion 2000, and Revue Internationale PME, and member of several editorial boards.

Gadaf Rexhepi is a full professor of Strategy and Innovation at the South-East European University, Republic of North Macedonia. He has published more than 70 research articles in different peer and refereed journals, such as *Business Strategy and the Environment*, *Sustainable Development*, *Corporate Social Responsibility and Environment Management*, *Review of Managerial Science*, *and Industrial Marketing Management*. Most of his work in the last decade has been in the field of CSR and sustainability. Starting in 2020, he is a member of the Council of National Bank of North Macedonia for a seven-year term. He received the Award for Excellence 2016—Outstanding Paper by Emerald Group Publishing (Journal of Enterprising Communities: People and Places in the Global Economy).

Besnik A. Krasniqi is a Fulbright Postdoctoral Scholar, holds MA and PhD in Economics from Staffordshire University (UK). He teaches Small Business and Entrepreneurship, Innovation Management, and Research Methods at the University of Prishtina in graduate and postgraduate studies. His professional career spans teaching and research in entrepreneurship at Maastricht School of Management (the Netherlands), Indiana University (USA) and University of Michigan (USA), Staffordshire University (UK), State University of Tetovo (Macedonia), and Riinvest Institute for Development Research (Kosovo). He has authored several books, numerous research reports, and consultancy assignments. His research work in the area of entrepreneurship, firm growth, institutions, SME finance, informal economy, and transition and emerging economies appeared in international journals such as Entrepreneurship Theory and Practice, Small Business Economics, International Entrepreneurship and Management Journal, and Economic Systems. He is a full member of the Academy of Sciences and Arts, Republic of Kosovo.

Chapter 12
Are Croatian Insurance Companies Meeting the Efficiency Frontier?

Katerina Fotova Čiković (ID)**, Violeta Cvetkoska** (ID)**, and Mila Mitreva** (ID)

Abstract This paper utilizes Data Envelopment Analysis to assess the relative efficiency of 14 insurance companies in the Republic of Croatia from 2018 to 2022, considering inputs (capital and number of employees) and outputs (net earned premiums and total investment). Despite an overall sectoral average efficiency of 79.67%, the study reveals a consistent decline in efficiency, interrupted only by a marginal improvement in 2021. Identifying seven relatively efficient and seven inefficient companies, the analysis highlights 2018 as the peak of sector-wide efficiency, contrasting with a decline to its nadir in 2022. The significance of these findings lies in their contribution to both academic understanding and practical implications. The research offers insights by outlining targeted improvement objectives for inefficient insurance companies and guiding management in resource allocation.

12.1 Introduction

The insurance industry plays a vital role in the enhancement of national financial and economic development and growth, by providing individuals and businesses with broad spectrum of financial security products and being a key player in the process of financial intermediation (Karim & Jhantansana, 2005). Insurance companies are one of the leading institutional investors that are beneficial to the economy through the various roles that they play (Cvetkovska et al., 2021). The importance of insurance companies is increasing mainly due to the various services they offer and the complexity of their operations. Existing literature shows that insurance companies

K. F. Čiković (✉)
University North, Koprivnica, Croatia
e-mail: kcikovic@unin.hr

V. Cvetkoska
Ss. Cyril and Methodius University in Skopje, Skopje, North Macedonia
e-mail: vcvetkoska@eccf.ukim.edu.mk

M. Mitreva
Goce Delcev University, Štip, North Macedonia
e-mail: mila.mitreva@ugd.edu.mk

as financial intermediaries have a very important role in the financial systems, for which Croatia is not an exception (Novikov & Novikova, 2020). According to the data obtained from the Croatian Insurance Bureau (2021), the assets of the insurance companies have been slightly increasing in the past several years and amounted to 6,432 million euros in 2021, 6,303 million euros in 2020, and 6,127 million euros in 2019. Taken average for the period 2019–2021, the insurance companies have employed around 7900 individuals. It is worth mentioning that a slight increase in the number of non-life insurance policies can be detected for the period 2018–2021 (8.891.017 in 2018; 9.342.254 in 2019; 9.615.813 in 2020, and 10.647.081 in 2021). However, for the same period, a slight decrease in the number of life insurance policies has occurred (1.488.702 in 2018; 1.450.307 in 2019; 1.406.382 in 2020, and 1.349.454 in 2021). Moreover, when it comes to assessing the importance of the Croatian insurance companies for the Croatian financial system, analyzing the share of their assets in relation to the total assets of all financial institutions is the most accurate measure. The statistical data shows that the share of their assets in 2018 was 6.94%, in 2019 was 7.12%, in 2020 was 6.95% and in 2021 was 6.47%. Hence, the relatively low participation is mainly because the Croatian financial system is bank-centric (Croatian Insurance Bureau, 2021; 2020; 2019; 2018).

Nonetheless, the insurance companies in Croatia are among the largest institutional investors taking a share of 6.47% in the total assets of all financial institutions. If analyzed globally, in 2020, the Croatian insurance market had a 0.1% share of the European Insurance Market and 0.03% in the total world premiums (Croatian Insurance Bureau, 2021). However, insurance companies today compete and operate under dynamic and challenging market circumstances and in a rapidly changing environment, which emphasizes the need to consistently and continuously measure individual performance and efficiency (Kaffash et al., 2020). In the case of the Croatian insurance companies, the accession of Croatia to the European Union in 2013 contributed to increased competition from European competitors, which notably emphasized the need for better resource allocation and higher efficiency (Pavić Kramarić et al., 2022). Measuring efficiency gives insights into the competitiveness of different insurance systems, in order to get a more detailed picture of good or bad practices. This way, existing problems or shortcomings in some practices can be at least partially solved or alleviated, which will have a favorable effect not only on the insurance system of a country but also on its overall economic development (Škrinjarić, 2016). Moreover, the efficiency measurement of insurance companies has sparked interest from investors, financial market analysts, insurance regulators, and scholars (Kaffash et al., 2020).

In this context, when it comes to measuring the efficiency of insurance companies, various methods can be used. Some of the most used measures are the financial indicators (Učkar & Petrović, 2022). Those financial indicators include ROI (return on investments), ROE (return on equity), ROA (return on assets), claims ratio, expense ratio, and debt ratio. Nevertheless, according to the literature review of Emrouznejad & Yang (2018), banking is one of the most used sectors for application with the leading non-parametric methodology for measuring organizational performance, the Data envelopment analysis (DEA). The more recent bibliometric

study of Emrouznejad et al., 2022) notes that energy, banking, and education are the industries that mostly apply the DEA in empirical research.

DEA is a frontier methodology that measures the efficiency of decision-making units (DMUs) that use the same inputs to generate the same outputs which can be in different measurement units. Despite the application of DEA for measuring the efficiency of the banking sector (Cvetkoska & Savić, 2017), this tool is used for measuring the efficiency of the insurance companies (Kaffash et al., 2020; Kaffash & Marra, 2017). Identifying the efficiency of the insurance companies is necessary for determining the top performers and detecting the need for further improvement. Although several studies analyze the efficiency of insurance companies, existing literature that focuses specifically on the Croatian insurance companies' efficiency is limited. Nevertheless, the review of the existing literature showed that there has been progress in Croatian insurance efficiency, with different factors affecting it.

Nonetheless, not much research has been conducted to test the efficiency of Croatian insurance companies. This literature gap, especially for the past several years, was a determining factor for creating this research. Having in mind that the DEA methodology is the main approach used for efficiency testing, the main purpose of this paper is to analyze whether the Croatian insurance companies are meeting the efficiency frontier through the DEA methodology. Therefore, it is expected that the results from this paper will offer valuable contributions not only to the academia but also to all of the parties within the insurance sector.

The rest of the paper is organized as follows. Section 2 presents the existing literature on the insurance sector efficiency in Croatia. Section 3 presents the methodology and data used, whereas in Section 4 the obtained results are presented and discussed. Practical implications are presented in Section 5 while Section 6 concludes the paper.

12.2   Literature Review

Academic research examining the efficiency of insurance sectors using the Data Envelopment Analysis (DEA) approach remains limited in many regions. For instance, Bawa and Ruchita (2011) investigated the efficiency of ten general insurance companies in India—including four from the public sector—over an eight-year period from 2002–03 to 2009–10. Their analysis used equity capital and labor (which included commissions, agent fees, referral costs, and other expenditures) as input variables, and net premium as the output. They found that companies operating in the health insurance segment achieved an average technical efficiency of 73%, with pure technical efficiency at 92% and scale efficiency at 78%.

Similarly, Abidin and Cabanda (2011) applied DEA to evaluate 23 Indonesian non-life insurance firms from 2005 to 2007. Their results indicated a slight improvement in efficiency in 2006, followed by a decline in 2007. Larger firms generally demonstrated higher efficiency levels than smaller ones, while captive market status and ownership structure (private or government) did not show a consistent effect.

Tobit regression analysis further revealed that net profit margin had a positive effect on DEA scores, whereas return on assets showed a negative relationship.

Given the limited scope of existing research, there has been growing interest in recent years to explore this field more thoroughly. In line with this, the following section provides a detailed review of the literature, including a summary of studies that have applied the DEA method to evaluate insurance sector efficiency across various countries, as shown in Table 1. The main components in the presented table include the author/s, the analyzed sample, methodology, and variables used, as well as the main findings obtained. However, in the following paragraphs, a more elaborative presentation of the existing literature is provided.

Medved & Kavčič (2012) used the DEA methodology to analyze the efficiency of the insurance sector in Slovenia and Croatia for the period 2006–2010. In their study, inputs were: monthly gross salary, salaries, commission, and business services costs and capital, whereas outputs were: gross written premium for life business and gross written premium for non-life business. The results showed that the mergers and acquisitions that occurred in Croatia contributed to the improvement of the insurance sector efficiency. Additionally, the Slovenian insurance sector was dominant in terms of cost and technical efficiency.

Jurčević & Žaja (2013) used the DEA method to test the efficiency of 30 banks and 19 insurance companies in Croatia for the period 2005–2010. They used two sets of inputs and outputs, separately for the banks and the insurance companies. As inputs for the insurance sector were net operating expenses, investment costs, and claims incurred, while as outputs, earned premiums and investment income. The results for the insurance industry showed that the lowest efficiency scores were detected in 2007, which may be mainly due to the global financial crisis that occurred during that time.

Sjauš & Žaja (2020) did a similar DEA analysis. In their paper, they examined the efficiency of the banking and insurance industry in Croatia for the period 2012–2018. Regarding the insurance sector, inputs were net operating expenses, investment costs, and claims incurred, while outputs were earned premiums and investment income. The results showed that the highest efficiency scores were in 2014, while the lowest efficiency scores were in 2016. The introduction of the regulatory framework Solvency II has affected the efficiency scores because it forced insurance companies to meet the basic objective of capital management and maintain the required level of stability.

Cvetkoska et al. (2021) measured the managerial ability and identified the determinants in the insurance companies in N. Macedonia, Croatia, Serbia, and Slovenia for the period 2016–2019. They used a sample of 164 insurance companies and utilized a two-step methodology, DEA and OLS. As inputs material costs, agent costs, labor costs, and capital costs were used, while as outputs insurance lines with similar characteristics such as personal short-tail lines, personal long-tail lines, commercial short-tail lines, and commercial long-tail lines were used. The main findings showed that size, age, and personal long-tail lines have a statistically significant and negative relationship with firm efficiency, while financial leverage and personal short-tail lines showed a positive and statistically significant relationship. Nevertheless, size

Table 1 DEA applications in the insurance sector in Croatia.

Author(s) & year of publication	Analyzed country/sample	Methodology	Variables	Findings
Medved & Kavčič (2012)	Slovenia and Croatia, 2006–2010	CCR DEA model	*Inputs:* Monthly gross salary; Salaries, commission and business services costs; Capital *Outputs:* gross written premium for life business and gross written premium for non-life business	The results from the intra-country analysis showed that the recent mergers and acquisitions in Croatia have contributed to the improvement of the Croatian insurance sector's efficiency. The inter-industry analysis indicated that in terms of cost and technical efficiency, the insurance sector in Slovenia is more dominant compared to the Croatian market;
Jurčević & Žaja (2013)	Croatia, 2005–2010 30 banks and 19 insurance companies	DEA (input-oriented CCR model; output-oriented CCR model; input-oriented BCC model; output-oriented BCC model)	*Inputs:* net operating expenses, investment costs, claims incurred *Outputs:* earned premiums, investment income	DEA efficiency scores for the insurance industry had the lowest values in 2007;

(continued)

Table 1 (continued)

Dalkılıç & Ada (2014)	Turkey, 2010–2011 - 20 life insurance companies and life insurance and/or private pension companies	DEA (input-oriented BCC model)	*-4 input variables*: shareholders' equity, operating expenses, number of agencies and number of staff employed by insurance companies *-3 output variables*: net gross written premiums, net claims incurred and net technical provisions	Life insurance companies are more efficient than life insurance and/or private pension companies - The average scale efficiency of the companies was 92% in 2010 and 88.7% in 2011. In 2011 a decrease of 3.3% is measured. While 14 companies were efficient in 2010, 12 companies were efficient in 2011;
Knezevic et al. (2015)	Serbia, 2009, 2011, and 2020	Input-oriented CCR DEA model	*Inputs*: data on commercial assets, wages, salaries and other personnel costs, and equity; *Outputs*: business functional revenue before tax (EBT)	Efficiency varied from year to year and from company to company: some had an upward and some a downward trend
Micajkova (2015)	Macedonia, 2009–2013 11 insurance companies	DEA (CCR and BCC output-oriented model)	*Inputs:* Administrative Expenses, Commission Expenses, and Total Capital *Outputs:* Gross Written Premium and gross claims settled	-Increase of the average efficiency during the almost whole observed period; -main source of inefficiency is scale inefficiency;

(continued)

Table 1 (continued)

Grmanova & Strunz (2017)	Slovakia, 2013–2015 15 commercial insurance companies in Slovakia	Descriptive statistics, correlation analysis, Tobit regression, Mann Whitney U test, and DEA (BCC and CCR model)	*Inputs*: claims incurred and operating expenses *Outputs:* earned premiums and investment income In addition to indicators on the input and output side: ROA and ROE	-Relationship between the technical efficiency score and the group formed based on ROA and the group formed based on ROE was not confirmed; -Insurance companies with ROA equal to or higher than 2 achieved higher average efficiency scores in the CCR model than the insurance companies in a group with ROA of 1%,2%);
Sjauš & Žaja (2020)	Croatia 2012-2018	Input-oriented CCR DEA model	*Inputs:* net operating expenses, investment costs, claims incurred. *Outputs:* earned premiums and investment income	-Highest efficiency scores were in 2014 due to the conservative investment policies to achieve a high level of liquidity and investment certainty; -The lowest efficiency score was in 2016;

(continued)

Table 1 (continued)

Cvetkoska et al. (2021)	N. Macedonia, Croatia, Serbia, Slovenia -Sample: 164 insurance year-observations -Period: 2016-2019	Two-step methodology: DEA (input-oriented BCC model) and OLS	*Inputs:* material costs, agent costs, labor costs, and capital costs *Outputs:* insurance lines with similar characteristics such as personal short-tail lines, personal long-tail lines, commercial short-tail lines, and commercial long-tail lines	-Size, age, and personal long-tail lines have a statistically significant and negative relationship with firm efficiency; -Financial leverage and personal short-tail lines show a positive and statistically significant relationship;
Pervan et al. (2021)	Croatia, Hungary, Poland, 2018	Input-oriented BCC DEA model and ANOVA-one-way analysis of variance	*Inputs:* Capital (Paid-in capital) and Labor (Number of employees). *Outputs:* Risk-pooling/ bearing services (Net earned premiums) and Intermediation function (total investments).	Hungarian non-life insurers are the most efficient ones in terms of OTE, PTE, and SE; They are followed by the Croatian insurers, leaving the Polish insurers behind; Regarding the life insurance sector, the domination of the Croatian insurers is recorded, while the Hungarian ones were found to be the least efficient;

Table 1 (continued)

Šikalo & Berilo (2021)	Bosnia and Herzegovina, 2015-2019	Input-oriented BCC DEA model	*Inputs:* employees and capital *Outputs:* accrued premiums, claims payments, total income	-Significant inefficiencies in the insurance sector in B&H; -The insurance sector is more efficient in the Federation of Bosnia and Herzegovina (FbiH) compared to Republic of Srpska (RS);
Banker et al. (2022)	India and Iran/ 2013-2018, 20 insurers in India; 18 insurers in Iran	Three-stage estimation process: 1. Radial DEA BCC model, 2. Ordinary Least Squares (OLS), 3. General Additive Model regression	*Input variables:* operating expenses (OE), claims incurred (CI) *Output variables:* Net premium income (NPI), income from investments (IFI) *Contextual variables:* Market share (MS), Solvency ratio (SR), Insurer size (IS), Insurer age (IA), Time series dummy (TSD), Diversification dummy (DD)	-The average technical efficiency and managerial ability of Iranian insurers were greater than the scores of Indian insurers; -Iranian insurers were better than Indian on the basis of mean managerial ability;

Table 1 (continued)

Kramarić et al. (2022)	18 insurance companies in Croatia, 2009-2021	Two-step analysis: 1. DEA (BCC input-oriented model) 2. Truncated regression	*Inputs:* number of employees; paid in capital *Outputs:* premiums written and total investments	- Age and ownership influence the efficiency of non-life insurance companies in Croatia, while the companies' size, leverage, and product diversification are not confirmed as significant determinants of the efficiency;
Učkar & Petrović (2022)	Croatia, 2015-2020	Traditional financial indicators and DEA (CCR and BCC input-oriented models)	**Operating approach:** *Inputs:* operating costs, investment costs, and claims incurred *Outputs:* earned premiums and investment income **Intermediation approach:** *Inputs:* total equity and total investments *Outputs:* earned premiums and investment income	Large insurers in general achieve above-average ROI, ROE, and ROA values and below-average claims, expense, and debt ratios; They achieve above-average or full efficiency according to the DEA methodology. In addition, some small insurance companies tend to be efficient, while for medium insurance companies the results are more complicated;

Source Authors

has been shown to affect negatively financial performance. The results from the OLS regression showed that CEO duality, board size, board composition, gender diversity, and CEO gender insignificantly affect managerial ability, while the diversity of nationalities of the CEO positively affects managerial ability.

Pervan et al. (2021) performed a comparative analysis of the efficiency of life and non-life sectors in selected CEE countries: Croatia, Hungary, and Poland in 2018. The main purpose of their study was to analyze the overall technical efficiency (OTE), pure technical efficiency (PTE), and scale efficiency (SE) through the DEA method. Additionally, ANOVA-one-way analysis of variance was used to find out whether statistically significant differences between the estimated levels of the efficiency of non-life and life insurance sectors exist. Capital and labor (number of employees) were selected as inputs, while risk-pooling/bearing services (net earned premiums) and Intermediation function (total investments) as outputs. Hence, in terms of OTE, PTE, and SE, the Hungarian non-life insurers were shown to be mostly efficient, followed by Croatian insurers and the Polish insurers. In regards to the life insurance sector, the most efficient were Croatian insurers, while the least efficient were Hungarian insurers. The inefficiency that was detected in the insurance sector was more related to scale inefficiency rather than managerial inefficiency. The results from the ANOVA test showed a statistically significant difference between the tested insurers.

Učkar and Petrović (2022) aimed to detect whether large insurers are more efficient than the medium and small insurers in Croatia for the period 2015-2020. For the analysis, they used traditional financial indicators and the non-parametric DEA (both operating and intermediation approach). The inputs for the operating approach were operating costs, investment costs, and claims incurred, while the outputs were earned premiums and investment income. For the intermediation approach, the inputs were total equity and total investments, while the outputs used were earned premiums and investment income. The results showed that larger insurers accomplish better than average ROI, ROE, and ROA values and below-average claims, expense and debt ratios. According to the DEA methodology's results, they achieve full efficiency. For all insurance companies, the average efficiency has improved. However, the gap between the small, medium, and large insurers has widened.

Pavić Kramarić et al. (2022) examined the determinants of the efficiency of non-life insurance companies in Croatia for the period 2009–2021. They have used two-step analysis: DEA and Truncated regression. Hence, factors used in Truncated regression analysis were age, size, ownership, product diversification, and leverage, while for the DEA analysis, the inputs used were number of employees and paid-in capital, while the outputs used were premiums written and total investments. The results showed that the efficiency of the non-life insurance companies in Croatia is influenced by age and ownership, while size, leverage, and product diversification did not show any significant results. Another factor that affected the efficiency of the Croatian insurance companies was the pressure of the foreign insurance companies.

12.3 Methodology

There are "two main approaches" to evaluating the efficiency of entities: parametric and non-parametric (Pervan et al. 2021; Cvetkoska and Fotova Čiković, 2020). The most popular and applied non-parametric approach is Data Envelopment Analysis, which has been introduced in the seminal paper of Charnes et al. (1978). However, the concept of technical efficiency dates back to the paper by Farrell (1957).

What makes DEA a good choice to use is the inclusion of more than one input and output. DEA is a frontier approach, so efficient units comprise the efficiency frontier, and for inefficient ones, the targets of improvement can be calculated which serves as a prescription for what to do in the next period to become relative efficient.

According to Cummins and Weiss (2013), "most of the DEA applications in insurance are input-oriented BCC DEA models," and the reason for this is twofold. First of all, the two basic DEA models are the CCR and the BCC models, and the main difference between them is the assumption regarding the return to scale. Namely, the CCR model assumes a constant return to scale, whereas the BCC model runs under the variable return to scale assumption. Therefore, in insurance, "the economies of scale do not change as the size of insurers increases," which brings us to the conclusion that the BCC DEA model "is a more appropriate approach in the evaluation of insurance companies and their efficiencies" (Pervan et al., 2021). Second, the DEA model can be input-oriented, output-oriented, or non-oriented. In insurance, the Decision-Making Units (i.e., the insurance companies) have a greater impact on the inputs than outputs, thus the input-oriented DEA model is most suited and most applied, as shown in Table 1.

According to Cooper et al. (2007) and Paradi et al. (2018), "the mathematical formulation of the input-oriented BCC model assessing the efficiency of DMU 0 (0=1,…,n) by solving the linear program, can be presented in the following way:

$$\min_{\theta_B, \lambda} \theta_B$$

subject to $\theta_B x_0 - X\lambda \geq 0$

$$Y\lambda \geq y_0$$

$$e_n \lambda = 1$$

$$\lambda \geq 0$$

where

x_0 denotes column vectors of inputs for DMU0, y_0 denotes column vectors of outputs for DMU0, X and Y denote the matrices of input and output vectors for all DMUs

λ is the column vector of intensity variables denoting linear combinations of DMUs,

θ (objective function) is a radial contraction factor that can be applied to DMUo's inputs,

e is a row vector of n, n is a number of DMUs."

In the selection of input and output variables, we follow Pervan et al. (2021). The input variables are "capital (Paid in capital) and Labor (Number of employees), whereas Risk-pooling bearing services (Net earned premiums) and Intermediate function (Total investment i.e., investments, real estate, and intangible assets)" were selected as output variables.

The Croatian insurance market is a vital component of the financial market, and at the end of 2022, a total of 14 insurance companies actively operated in the market, out of which 8 are composite insurance companies (that offer both life and non-life insurance, these companies are: Allianz Hrvatska d.d., Croatia osiguranje d.d., Generali osiguranje d.d., Grawe Hrvatska d.d., Merkur osiguranje d.d., Triglav osiguranje d. d., Uniqa osiguranje d.d., Wiener osiguranje Vienna Insurance Group d.d.), 4 are non-life insurance companies (Adriatic osiguranje d.d., Euroherc osiguranje d.d., HOK-osiguranje d.d., Hrvatsko kreditno osiguranje d.d.), 2 are life insurance companies (Groupama osiguranje d.d. and AGRAM LIFE osiguranje d.d.), and there are no reinsurance companies (Učkar & Petrović, 2022). The sample subject of our panel data is made up of these 14 Croatian insurance companies observed over the period ranging from 2018 to 2022. The data was extracted manually from the officially issued annual financial statements, available on their websites. We used a balanced panel data set for the sample and obtained the results with the help of the licensed version of the MaxDEA 8 Ultra software.

Descriptive statistics for the key inputs, namely capital and labor, as well as outputs, including net earned premiums and total investment, are presented in Appendix 1. What is evident and in line with previous studies of Pervan et al. (2021) and Pervan et al. (2021), the "average amount of paid in capital, number of employees, and net earned premiums for non-life insurers were almost twice as large as those recorded for life insurance companies." To identify outliers within our sample of 14 insurance companies, we employed box and whisker charts for each variable across separate years, detailed in Appendix 2. Notably, we identified an insurance company with maximum values as an outlier for both inputs and net earned premiums in 2018, extending to all variables from 2019 to 2021. In 2022, this company, along with another with the minimum capital input, was identified as an outlier. Additionally, the outlier from the previous year persisted as an outlier for the input number of employees and output total investment in 2022. Despite these outliers, we made a deliberate decision to retain all insurance companies in the sample, supported by robust evidence. This decision was substantiated by rigorous analyses and consideration of the potential impact of outliers on the overall findings, revealing that excluding these companies could compromise the representativeness of the sample and the generalizability of our results.

12.4 Findings and Discussion

The efficiency results of the input-oriented BCC DEA model revealed that the average efficiency of the whole insurance sector for the whole observed period is 0.7967. This result implies a vast potential for further improvement and better resource allocation for Croatian insurance companies. The annual mean efficiency score of the whole Croatian insurance market is calculated as an average of the efficiency scores for each insurance company in the current year. The BCC model identified 7 relative efficient insurance companies in the whole observed period (2018 to 2022), and 7 relative inefficient insurance companies in the observed period. The relative efficiency scores obtained with the DEA MaxDEA 8 Ultra software are presented in Table 2. Moreover, a sparkline has been added as a graphical addition to Table 2. The large number of relatively efficient insurance companies (namely 7) in the whole observed period is in line with the findings of Pavić Kramarić et al. (2022), who found nine relatively efficient insurance companies in 2021. The insurance companies from the efficiency frontier, i.e., the ones that are relatively efficient in the whole observed period could represent benchmarks for the inefficient insurance companies in Croatia. Moreover, the efficiency results obtained in this study reveal the same trend and could represent a continuation of the findings of Sjauš and Žaja (2020), who found that there was a negative effect of the market liberalization (as a consequence of Croatian's accession to the EU) on the efficiency results from 2014. Namely, in their study (as well as ours), there is a consistent and evident decline in efficiency in the insurance sector in the whole observed period from 2012 to 2018 and 2018 to 2022, respectively.

The results regarding large insurance companies reveal rather untypical and unexpected results. Namely, the largest insurance company in Croatia is Croatia osiguranje d.d., which is fully efficient in the whole observed period, the same as the second largest insurance company, namely, Allianz Hrvatska d.d. These results are so far in line with the results of Učkar and Petrović (2022). However, the efficiency results for the third and fourth largest insurance companies (Grawe Hrvatska d.d. and Wiener osiguranje Vienna Insurance Group d.d.) do not reflect the same findings. What is more, it is evident that these large insurance companies are among the three insurance companies that noted the lowest relative efficiency results in the sample as follows: Triglav osiguranje d.d. (which belongs to the medium insurance companies) with 0.2989, Wiener osiguranje Vienna Insurance Group d.d. with 0.4399 and Grawe Hrvatska d.d. with 0.4877. Another exception among large insurance companies is Uniqa osiguranje d.d., whose efficiency declined each consecutive year (from 0.6841 in 2018 to 0.6520 in 2022), which is also shown in the findings of Učkar and Petrović (2022).

Regarding small insurance companies (Groupama osiguranje d.d., HOK-OSIGURANJE d.d., and Hrvatsko kreditno osiguranje d.d.), their efficiency results reveal that they are most relatively efficient as a group, which is somewhat in line with the study of Učkar and Petrović (2022), as shown in Table 3. Medium-sized insurance companies (ADRIATIC OSIGURANJE d.d., AGRAM LIFE osiguranje d.d.,

Table 2 Relative efficiency results for the Croatian insurance sector (2018 – 2022)

NO	DMU	Score (2018)	Score (2019)	Score (2020)	Score (2021)	Score (2022) (Sparkline line)	Average efficiency by DMU
1	Adriatic osiguranje d.d.	1	1	1	1	1	1
2	Agram life osiguranje d.d.	1	1	1	1	1	1
3	Allianz Hrvatska d.d.	1	1	1	1	1	1
4	Croatia osiguranje d.d.	1	1	1	1	1	1
5	Euroherc osiguranje d.d.	1	1	1	1	1	1
6	Generali osiguranje d.d.	0.7966	0.6076	0.5701	0.6275	0.5702	0.6164
7	Grave Hrvatska d.d.	0.5021	0.4991	0.4625	0.4773	0.4984	0.4877
8	Groupama osiguranje d.d.	1	1	0.9826	0.9953	1	0.9952
9	Hok-osiguranje d.d.	1	1	1	1	1	1
10	Hrvatsko kreditno osiguranje d.d.	1	1	1	1	1	1
11	Merkur osiguranje d.d.	0.6705	0.6592	0.6531	0.64	0.6775	0.6593
12	Triglav osiguranje d.d.	0.2792	0.2679	0.3249	0.3541	0.266	0.2989
13	Uniqa osiguranje d.d.	0.6841	0.6633	0.6723	0.6421	0.6556	0.664
14	Wiener osiguranje Vienna Insurance Group d.d.	0.3935	0.463	0.4805	0.4687	0.3937	0.4399

Source Authors' work

EUROHERC osiguranje d.d., GENERALI OSIGURANJE d.d., MERKUR OSIG-URANJE d.d., and TRIGLAV OSIGURANJE d.d.) tend to achieve mixed results, therefore there is an evident need for further research and exploration of this group in future research.

What can be drawn from these results is that the classification of insurance companies as large, medium, and small does not offer any generalization or assumptions regarding their relative efficiency, since there are exceptions and mixed results in

Table 3 Insurance companies in Croatia classified by size and type of insurance.

Insurance companies	Average efficiency	Size	Type of Insurance
ADRIATIC OSIGURANJE d.d.	1	medium	non-life
AGRAM LIFE osiguranje d.d.	1	medium	life
Allianz Hrvatska d.d.	1	large	composite
CROATIA osiguranje d.d.	1	large	composite
EUROHERC osiguranje d.d.	1	medium	non-life
GENERALI OSIGURANJE d.d.	0.6164	medium	composite
GRAWE Hrvatska d.d.	0.4877	large	composite
Groupama osiguranje d.d.	0.9852	small	life
HOK-OSIGURANJE d.d.	1	small	non-life
Hrvatsko kreditno osiguranje d.d.	1	small	non-life
MERKUR OSIGURANJE d.d.	0.6593	medium	composite
TRIGLAV OSIGURANJE d. d.	0.2989	medium	composite
UNIQA osiguranje d.d.	0.6664	large	composite
Wiener osiguranje Vienna Insurance Group d.d.	0.4399	large	composite

Source Authors

every group. There is, however, a classification that reveals more insights. Namely, when comparing efficiency results by type of insurance, life insurance companies achieved near full efficiency (with Groupama osiguranje d.d. noting 0.9852 and Agram life osiguranje d.d. 1.00), non-life insurance companies achieved full efficiency and are the most efficient group, and the composite insurance companies noted mixed results. And lastly, very large and very small insurance companies in Croatia note relative efficiency, whereas those insurance companies in the middle note mixed and inconsistent results, which once more, is in line with previous studies of Učkar and Petrović (2022) and Jermic and Vujčić (2002) regarding different parts of the Croatian financial system. In Figure 1, we present the average relative efficiency of the Croatian insurance sector by years, and the average relative efficiency of the Croatian insurance sector in the whole period is 79.67%. As shown in Figure 1, the relative average efficiency of the whole insurance sector in Croatia noted a decrease in every consecutive year, except for 2021, when it noted a small increase from 0.7947 in 2020 to 0.7981. This result could be elaborated and backed up with the factual situation in the Croatian economy in 2021, and with the end of 2020 (the so-called COVID-19 year). Moreover, the gross premiums earned at the end of 2021 were "22% higher than at the end of 2020" and in 2022, the insurance market recorded a marked increase in gross premiums of 8.4% (HANFA, 2023). The average efficiency in the first analyzed year, i.e., 2018 was 0.8021, whereas the efficiency results for the last observed year (2022) showed the lowest relative efficiency results (0.7899).

Source Authors
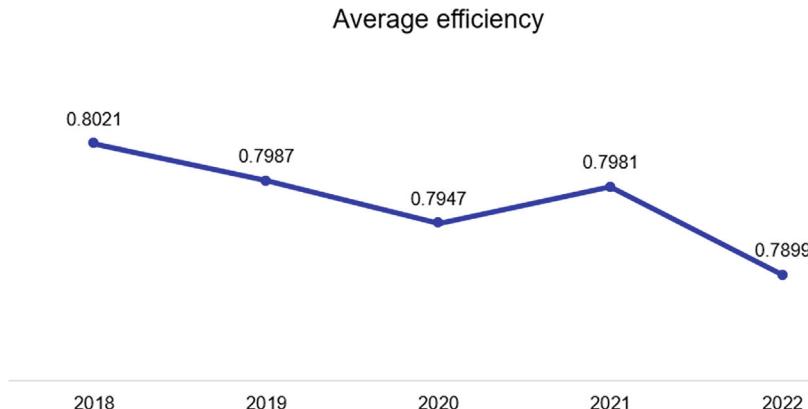
Figure 1   The average efficiency of the whole Croatian insurance sector

Despite its other numerous advantages, the information for targets for improvement is one of the main advantages of the DEA methodology (Cvetkoska et al., 2021). In Table 4, we unveil targeted improvement objectives for two underperforming insurance companies, exemplified by Generali osiguranje d.d. with an efficiency score of 0.5702. The reference set, comprising benchmarks for this company, includes three notable insurance entities: Adriatic osiguranje d.d., Allianz Hrvatska d.d., and HOK-osiguranje d.d. The primary benchmark influencing Generali's efficiency is HOK-osiguranje d.d., marked by the highest lambda. To enhance its efficiency, Generali osiguranje d.d. should strategically reduce capital by 34,816 to reach the optimal value of 46,184. Simultaneously, a reduction in the second input, the number of employees, by 330 to a target of 438 is recommended. Maintaining the net earned premiums at 633,529, Generali should consider a substantial increase in total investments by 95,676, aiming for a revised value of 597,745. These specific improvement targets provide a clear roadmap for Generali osiguranje d.d. to enhance its relative efficiency within the industry.

12.5   Practical Implications for Stakeholders in Enhancing Insurance Sector Efficiency

The empirical findings of this research carry practical implications for a spectrum of stakeholders involved in the Republic of Croatia's insurance sector. These actionable insights aim to guide decision-making, strategic planning, and policy formulation to foster a more efficient and resilient financial landscape. Below are the key practical implications for various stakeholders:

Table 4 Targets for improvements (in 000s of Croatian kuna)

DMU	Score	Benchmark (Lambda)	Proportionate Movement (Capital)	Proportionate Projection (Capital)	Proportionate Movement (Number of employees)	Proportionate Projection (Number of employees)	Slack Movement (Net earned premiums)	Projection (Net earned premiums)	Slack Movement (Total investment)	Projection (Total investment)
Generali osiguranje d.d.	0.5702	Adriatic osiguranje d.d.(0.220226), Allianz Hrvatska d.d.(0.186943), Hok osiguranje d.d.(0.613831), Agram life osiguranje d.d.(0.1815077),	-34816	46104	-330	438	0	635629	96876	597745
Merkur osiguranje d.d.	0.6775	Groupama osiguranje d.d.(0.282344), Hok-osiguranje d.d.(0.100878)	-27018	56761	-58	121	40445	285459	0	1150772

Source Authors

- **Insurance Company Executives**. *Insight:* Recognize the observed decline in sector-wide efficiency and variations based on company size. *Action:* Implement targeted improvement objectives to optimize resource allocation and enhance operational efficiency. Tailor strategies to the company's size and structure for maximum impact.
- **Policymakers and Regulators**. *Insight:* Understand the overall sectoral average efficiency and its decline over time, along with the importance of specific improvement targets. *Action:* Formulate policies that address identified challenges, informed by improvement targets. Leverage findings to refine regulatory practices, ensuring compliance with industry standards and fostering a more efficient insurance sector.
- **Industry Regulators and Management Bodies**. *Insight:* Embrace the significance of specific improvement targets for inefficient companies, recognizing the need for enhanced resource allocation. *Action:* Utilize practical insights to enhance resource allocation strategies, contributing to the overall stability and performance of the sector. Incorporate improvement targets into regular assessments to refine regulatory practices and ensure sector-wide compliance.
- **Cross-National Analysts and Researchers.** *Insight:* Recognize the need for a broader regional context in assessing efficiency dynamics. *Action:* Contribute industry-specific knowledge to ongoing research collaborations. Foster a comparative understanding of efficiency across different countries, drawing insights into best practices and areas for improvement.
- **Investors:** *Insight:* Acknowledge the nuanced efficiency dynamics and variations among different-sized companies. *Action:* Utilize the study's findings as a tool for assessing the viability and performance of insurance companies in the Republic of Croatia. Consider efficiency trends, company-specific data, and regional comparisons for informed investment decisions.
- **Academic and Research Community:** *Insight:* Contribute to a more holistic understanding of efficiency dynamics in the insurance sector. *Action:* Build upon this research to delve deeper into specific aspects, refine strategies, and contribute to ongoing academic discourse. Explore the identified drivers of efficiency and validate improvement targets for a more comprehensive understanding.

These practical implications provide a framework for stakeholders to leverage the study's insights and contribute to the overarching goal of fortifying the efficiency landscape within the Republic of Croatia's insurance sector. This collaborative and informed approach is essential for sustaining a resilient and stable financial system, ensuring the sector's continued growth and development.

12.6   Conclusions

The stability of any economy hinges significantly on the robustness of its financial system, with insurance companies serving as pivotal contributors. This study, spanning the years 2018 to 2022, utilized the DEA methodology to assess the efficiency of Croatian insurance companies, focusing on inputs such as capital and number of employees, and outputs encompassing net earned premiums and total investment. The primary objective was to provide insights crucial for the sustained stability and performance of the Croatian financial system, aligning with the ongoing evaluations undertaken by both management and regulatory bodies.

The key achievement of this research lies in its nuanced examination of efficiency dynamics within the Croatian insurance sector. Despite an overall average efficiency of 79.67%, the study uncovers a consistent decline, interrupted only by a marginal improvement in 2021. The segmentation of companies into relative efficiency categories challenges conventional size-based classifications. Large entities, such as Croatia osiguranje d.d. and Allianz Hrvatska d.d., exhibit expected efficiency, while inefficiencies emerge among the third and fourth largest companies. Similarly, small insurance companies, considered as a group, display contrasting efficiency compared to mixed results among medium-sized entities.

The revelation of specific improvement targets for inefficient companies, a hallmark of the DEA methodology, adds a practical dimension to the study. Management is provided with actionable insights for resource allocation enhancement, contributing to the overall operational effectiveness of the sector. However, the research is constrained by a relatively short observation period, which may limit the ability to capture longer-term trends or cyclical patterns within the insurance industry. Additionally, the exclusive focus on a single country, while providing indepth insights into the intricacies of the Croatian market, limits the generalizability of findings to a broader international context.

Looking ahead, the study delineates future research directions designed not only to surmount the inherent limitations of the current research but also to deepen our comprehension of efficiency trends and the evolving landscape of the financial sector. Expanding the geographical scope, the inclusion of EU-27 and Western Balkan countries in assessments aims to furnish a broader regional context, fostering a comparative understanding of insurance sector efficiency dynamics. This cross-national analysis seeks to uncover commonalities and disparities that may illuminate best practices and potential areas for improvement across diverse regulatory and economic landscapes.

Additionally, the study underscores the imperative of investigating the factors driving efficiency within the insurance sector. Future research endeavors will delve into the intricacies of these determinants, seeking to identify and understand the key drivers that influence the operational performance of insurance companies. Notably, this exploration will consider variables such as regulatory frameworks, market structures, and economic conditions, providing a more comprehensive picture of the forces shaping efficiency outcomes.

Furthermore, recognizing the transformative impact of emerging technologies on the financial industry, particularly in insurance, future research will scrutinize how advancements such as big data analytics and artificial intelligence (AI) influence efficiency results. The integration of these technologies has the potential to reshape traditional operational models, optimizing processes, risk management, and customer interactions. Understanding the implications of these technological advancements will be instrumental in preparing insurance companies for the evolving landscape and harnessing the benefits of innovation to enhance overall efficiency.

References

Abidin, Z., & Cabanda, E. (2011). Efficiency of non-life insurance in Indonesia. *Journal of Economics, Business, and Accountancy Ventura, 14*(3), 197–202.

Banker, R. D., Amirteimoori, A., & Sinha, R. P. (2022). An integrated Data Envelopment Analysis and generalized additive model for assessing managerial ability with application to the insurance industry. *Decision Analytics Journal, 4*, 1–9.

Bawa, S., & Ruchita, R. (2011). Efficiencies of health insurance business in India: An application of DEA. *American Journal of Social and Management Sciences, 2*(2), 237–247.

Charnes, A., Cooper, W. W., & Rhodes, E. L. (1978). Measuring efficiency of decision–making units. *European Journal of Operational Research, 2*(6), 429–444. https://doi.org/10.1016/0377-2217(78)90138-8

Cooper, W., Seiford, L., & Tone, K. (2007). *Data Envelopment Analysis: A Comprehensive Text with Models*. Boston, MA. Springer.

Croatian Insurance Bureau (CIB). (2018). Key Facts: Insurance Market in Republic of Croatia 2018. *Croatian Insurance Bureau.*. Retrieved from: https://huo.hr/upload_data/site_files/1304211059222512886881942457_huo-key-facts-web_2018.pdf

Croatian Insurance Bureau (CIB). (2019). Key Facts: Insurance Market in Republic of Croatia 2019. Croatian Insurance Bureau. Retrieved from: https://huo.hr/upload_data/site_files/key-facts-2019.pdf

Croatian Insurance Bureau (CIB). (2020). Key Facts: Insurance Market in Republic of Croatia 2020. Croatian Insurance Bureau. Retrieved from: https://huo.hr/upload_data/site_files/9810279518866869558724400654_key-facts-2020-web.pdf

Croatian Insurance Bureau (CIB). (2021). Key Facts: Insurance Market in Republic of Croatia 2021. Croatian Insurance Bureau. Retrieved from: https://huo.hr/upload_data/site_files/key-facts-2021-web.pdf

Cummins, J. D., & Weiss, M. A. (2013). Analyzing firm performance in the insurance industry using frontier efficiency and productivity methods. In G. Dionne (Ed.), *Handbook of insurance* (pp. 795–861). Springer.

Cvetkoska, V., Eftimov, L., Ivanovski, I., & Kamenjarska, T. (2021). Measuring the Managerial Ability in the Insurance Companies in the Republic of North Macedonia, Croatia, Serbia, and Slovenia, and Identifying its Determinants. *International Journal of Banking, Risk and Insurance, 10*(1), 51–67.

Cvetkoska, V., & Fotova Čiković, K. (2020). Assessing the relative efficiency of commercial banks in the Republic of North Macedonia: DEA window analysis. *Croatian operational research review, 11*(2), 217–227. https://doi.org/10.17535/crorr.2020.0017

Cvetkoska, V., Fotova Čiković, K., & Tasheva, M. (2021). Efficiency of Commercial Banking in Developing Countries. *Mathematics, 9*, 1597. https://doi.org/10.3390/math9141597

Cvetkoska, V., & Savić, G. (2017). Efficiency of bank branches: empirical evidence from a two-phase research approach. *Economic research - Ekonomska istraživanja, 30*(1), 318–333. https://doi.org/10.1080/1331677X.2017.1305775

Dalkılıç, N., & Ada, A. A. (2014). Efficiencies of Life/Pension Insurance Industry in Turkey: An Application of Data Envelopment Analysis. *Journal of Applied Finance & Banking, 4*(1), 181–191.

Emrouznejad, A., & Yang, G. (2018). A survey and analysis of the first 40 years of scholarly literature in DEA: 1978–2016. *Socio-Economic Planning Sciences, 61*, 4–8. https://doi.org/10.1016/j.seps.2017.01.008

Emrouznejad, A., Yang, G. L., Khoveyni, M., & Michali, M. (2022). Data Envelopment Analysis: Recent Developments and Challenges. In S. Salhi & J. Boylan (Eds.), *The Palgrave Handbook of Operations Research.* Palgrave Macmillan. https://doi.org/10.1007/978-3-030-96935-6_10

Farrell, M. (1957). The measurement of productive efficiency. *Journal of the Royal Statistical Society, Series A, 120*, 253–281.

Grmanova, E., & Strunz, H. (2017). Efficiency of insurance companies: Application of DEA and Tobit analyses. *Journal of International Studies, 10*(3), 250–263.

HANFA (2023). 2022 Tržište osiguranja u Hrvatskoj. Hrvatski ured za osiguranje.. Retrieved from: https://huo.hr/upload_data/site_files/trziste-osiguranja-2022.pdf

Jemrić, I., & Vujčić, B. (2002). Efficiency of Banks in Croatia: A DEA Approach. *Comparative Economic Studies, 44*(2-3), 169–193. https://doi.org/10.1057/ces.2002.13

Jurčević, B., & Žaja, M. M. (2013). Banks and insurance companies efficiency indicators in the period of financial crisis: The case of Republic of Croatia. *Ekonomska istrazivanja-Economic Research, 26*(1), 203–224.

Kaffash, S., Azizi, R., Huang, Y., & Zhu, J. (2020). A survey of data envelopment analysis applications in the insurance industry 1993–2018. *European Journal of Operational Research, 284*(3), 801–813.

Kaffash, S., & Marra, M. (2017). Data envelopment analysis in financial services: a citations network analysis of banks, insurance companies and money market funds. *Annals of Operations Research, 253*(14), 307–344.

Karim, M. Z. A., & Jhantansana, C. (2005). Cost efficiency and profitability in Thailand's life insurance industry: a stochastic cost frontier approach. *International Journal of Applied Econometrics and Quantitative Studies, 2*(4), 19–36.

Knezevic, S., Markovic, M., & Brown, A. (2015). Measuring the efficiency of Serbian Insurance companies. *Acta Oeconomica, 65*(1), 91–105.

Medved, D., & Kavčič, S. (2012). An Empirical Study of Efficiency in Croatia and Slovenia Insurance Markets. *Economic Research-Ekonomska Istraživanja, 25*(1), 87–98.

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

Novikov, A. & Novikova, I. (2020). Financial development and economic growth: Problems and models. In: Novgorodov, P., Maric, M. & Burilovic, L. (Eds.): *Book of Proceedings of the 54th International Scientific Conference on Economic and Social Development-Novosibirsk* (pp. 1-5).

Paradi, J. C., Sherman, H. D., & Tam, F. K. (2018). *Data Envelopment Analysis in the Financial Service Industry: A guide for practitioners and analysts working in Operations Research using DEA.* Springer.

Pavić Kramarić, T. P., Pervan, M., & Ćurak, M. (2022). Determinants of Croatian Non-Life Insurance Companies' Efficiency. *Croatian Operational Research Review, 13*(2), 149–160.

Pervan, M., Ćurak, M., & Pavić-Kramarić, T. (2021). Has Accession to the European Union Affected the Efficiency of Croatian Insurance Companies? *Zagreb International Review of Economics & Business, 24*(1), 67–98. https://doi.org/10.2478/zireb-2021-0004

Pervan, M., Pavić-Kramarić, T., & Ćurak, M. (2021). A comparative analysis of the efficiency of life and non-life sectors in selected CEE countries. *Ekonomski Vjesnik/Econviews, 34*(2), 279–290.

Šikalo, M., & Berilo, A. A. (2021). Efficiency Analysis of the Insurance Sector in Bosnia and Herzegovina. *Economic Review–Journal of Economics and Business, 19*(1), 49–62.

Sjauš, T. B. & Žaja, M. M. (2020). Croatian banking and insurance industry: overview of cost efficiency performance after accession to the European Union. In: Leko Šimić, M. & Crnković, B. (eds.) *9th International Scientific Symposium Region Entrepreneurship Development.*

Škrinjarić, T. (2016). Analiza relativne efikasnosti industrije osiguranja europskih zemalja korištenjem analize omeđivanja podataka. *Ekonomski pregled: mjesečnik Hrvatskog društva ekonomista, 67*(1), 3–26.

Učkar, D., & Petrović, D. (2022). Efficiency of insurance companies in Croatia. *Ekonomska misao i praksa, 31*(1), 49–79. https://doi.org/10.17818/EMIP/2022/1.3

Katerina Fotova Čiković ,PhD is an Assistant Professor at the Department of Economy at University North in Croatia. Her research interests are finance, banking, FinTech, and AI in finance. She authored or co-authored more than 100 research articles. She has received the Best Paper Award at the EMAN conference in 2021 and the TooSEE Conference (Tourism in Southern and Eastern Europe 2023 "Engagement & Empowerment: A path toward sustainable tourism") Best Paper Award in 2023.

Violeta Cvetkoska is a Professor of Operational Research and Machine Learning for Management, Coordinator of the Fundamentals of Business Analytics course, and Head of the EUi at Ss. Cyril and Methodius University in Skopje, Faculty of Economics—Skopje. She holds a master's degree in Operational Research and Quantitative Methods from the University of Belgrade, alongside a PhD in Economics from Ss. Cyril and Methodius University in Skopje. A passionate educator and mentor, Prof. Cvetkoska seamlessly translates her extensive knowledge into real-world impact, empowering students and managers to become data-driven professionals. Her work in operational research, business analytics, and AI strategically supports companies in gaining a competitive edge. Prof. Cvetkoska's international perspective is shaped by academic visits and active participation in conferences, symposia, and workshops across Europe, the Americas, and Asia. Beyond her research, Prof. Cvetkoska contributes to the scholarly community by serving on editorial boards of international journals, on scientific boards of major conferences, and as an active member of professional societies such as the Croatian Operational Research Society (CRORR), the Society for Economic Measurement (SEM), the EURO Working Groups on Multi-criteria Decision Aiding and Behavioral Operational Research (BOR). Her current research interests span digital transformation, the green economy, performance measurement, banking, and finance, continually driving innovation and excellence in the dynamic field of business analytics.

Mila Mitreva Phd, is a Teaching Assistant in the Finance Department at the Faculty of Economics, University Goce Delcev-Shtip, Republic of North Macedonia. She holds a Bachelor's degree in Accounting and Finance and a Master's degree in Banking and Finance from the University of Sheffield. Additionally, she earned an MBA from University Goce Delcev and a PhD from Ss. Cyril and Methodius University of Skopje. She has authored and co-authored numerous papers published in International Journals and Conference Proceedings, and actively participates in conferences, workshops, and projects. Her areas of scientific interest include: Finance, Financial Management, Banking, Financial Institutions and Markets, Institutional Investors, and Business Statistics.