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Economies **2024**, Volume 12, Issue 6, 128

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Published in:

Economies **2024**, Volume 12, Issue 6, 128

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Article

Investigating the Efficiency of Insurance Companies in a Developing Country: A Data Envelopment Analysis Perspective

Katerina Fotova Čiković [1,*], Violeta Cvetkoska [2] and Mila Mitreva [3]

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Abstract: Insurance companies play a pivotal role in the financial systems of developing countries, wielding substantial influence on systemic financial stability. Thus, understanding their efficiency, performance, and sustainability is paramount for policymakers and stakeholders alike. The aim of this paper is to evaluate the relative efficiency of insurance companies within the North Macedonian market spanning the years 2018 to 2022. Employing the input-oriented BCC DEA model, the study integrates capital and labour as inputs, while assessing risk-pooling/bearing services and intermediate function as outputs. Our findings underscore the fluctuating efficiency levels within North Macedonia's insurance sector. Notably, the sector exhibited its peak efficiency in 2018 at 83.62%, dipping to its lowest point of 73.81% in 2020. Moreover, discerning between life and non-life insurers, we observe an average relative efficiency of 0.8067 for non-life insurers, contrasted with a higher average efficiency score of 0.9011 for life insurance companies over the examined period. This study contributes significantly on multiple fronts. Firstly, it pioneers empirical investigation of the efficiency on the North Macedonian insurance market, encompassing pre- and post-COVID efficiency metrics. This fills a notable gap in the literature, particularly within the context of emerging European markets. Secondly, our comprehensive approach facilitates a holistic evaluation of the insurance sector's performance across a five-year span, offering insights into its overarching dynamics and efficacy. Thirdly, the implications of our findings extend to policymakers, regulators, and insurance company management, aiding in informed decision-making and strategic planning.

Keywords: insurance companies; North Macedonia; relative efficiency; DEA

Citation: Fotova Čiković, Katerina, Violeta Cvetkoska, and Mila Mitreva. 2024. Investigating the Efficiency of Insurance Companies in a Developing Country: A Data Envelopment Analysis Perspective. *Economies* 12: 128. https://doi.org/10.3390/economies12060128

Academic Editor: Tapas Mishra

Received: 7 April 2024
Revised: 7 May 2024
Accepted: 9 May 2024
Published: 22 May 2024

1. Introduction

The term 'insurance' is a financial construct developed to successfully manage risks or to hedge against uncertain loss. The insurance industry holds a vital position in the "social and economic development of every economy and society" (Stojaković 2017). Insurance companies hold a key role in the economic growth and international trade of developing countries (Outreville 1990). Moreover, systemic financial stability is largely influenced by the insurance industry, which has also contributed to mitigating financial risks (Häusler 2004). Nevertheless, the performance of the insurance sector directly impacts and stimulates other economic sectors (Omrani et al. 2022). While insurance companies play an important part in the economic development of developing countries, it is vital to ensure an efficient and competitive industry market. This could be accomplished with a consistent efficiency evaluation of the industry sector, i.e., the insurance companies operating in a certain market.

The efficient operations of insurance companies are vital, considering the role they play in the financial market's stability and economic growth (Učkar and Petrović 2022). Their importance also increases due to their financial intermediation role and performing various

functions of the financial system (Kjosevski 2012). As stated in Micajkova (2015), "saving mobilization, risk transfer and financial intermediation" are the main factors through which insurance companies have an important impact on the economy. Nevertheless, the higher the level of a country's financial development, the higher the participation and contribution of the insurance companies (Osmani and Imeri 2019).

Contrary to developed economies, emerging economies have been characterized by the process of insurance sector transformation according to their reached level of development. In this context, the North Macedonian insurance sector has not been an exception. Since the independence declaration in 1991 and the various challenges in the economy, the financial sector in North Macedonia has been slowly developing compared to developed countries. Therefore, its insurance sector is still in its infancy compared to the level of insurance sector development in the world (Dervishi 2020). According to the World Bank Global Financial Development database, insurance companies' assets to GDP (%) in North Macedonia have been slightly increasing throughout the years, from 2.8% in 2012 to 3.8% in 2022 (NBRNM 2023). This low participation in the GDP creates the need for testing the efficiency of insurance companies, which will further assist in developing policies for their evolvement and improvement. It is also worth mentioning that insurance companies in North Macedonia have managed to keep their solvency throughout the years despite uncertain conditions in the global financial markets. This is due to their activities that are mainly carried out on the domestic market. Their investment portfolio is composed of domestic government bonds and deposits in domestic banks, while foreign financial instruments participate with around 1% of the total assets of the insurance sector. Although the share of the insurance sector in the North Macedonian financial structure was only 3.5% in 2022, this was the third highest share in the total assets of the financial system. The banking institutions have the highest share in the total assets of the financial sector with 79.2%, followed by the pension funds with 13.5% (NBRNM 2023). On one hand, the activities of insurance companies can affect the performance of the financial sector, while on the other hand, the government sector and the domestic banking sector are vital for the stability of the insurance sector (NBRNM 2023). Another characteristic of North Macedonian insurance companies is their ownership structure, where 73.53% of insurance companies are owned by foreign legal entities (Insurance Supervision Agency 2023). Nonetheless, the insurance sector is stable, but determining its efficiency will contribute to a better understanding of its strong and weak points.

Efficiency is very important for insurance companies because they operate in a globalized and very competitive environment. Therefore, efficient carrying out of their activities is a necessity for being successful (Grmanová and Strunz 2017). In this context, efficiency refers to the peak level of performance of a company, where the least amount of inputs is used to obtain the highest amount of output. Efficiency can be measured with both parametric and nonparametric methodologies. Although testing the efficiency of the insurance sector has been of interest in several studies in the past decade, still, the literature that covers the North Macedonian insurance sector is still scarce. Therefore, in this study, the leading non-parametric DEA (data envelopment analysis) methodology was applied.

The overarching objective of this study is to investigate the relative efficiency of the insurance market in North Macedonia in the period 2018 to 2022. For this purpose, the BCC DEA model with two inputs (capital and labour) and two outputs (risk-pooling/bearing services and intermediate function) was employed.

The rest of the paper is structured as follows. In the Section 2, an extensive literature review on the efficiency evaluation of insurance companies in North Macedonia is presented. The Section 3 unveils the methodology, data, and research flow. The results of the applied DEA model are presented in Section 4, and thereafter, in the fifth section, a discussion and conclusions are provided.

2. Literature Review

Insurance companies as financial intermediaries are important for both the financial system and economic development. In order to achieve the goals of growth and development, efficiency is a necessary component of insurance companies' daily operations. Therefore, the interest in measuring the efficiency of insurance companies has been increasing in recent decades. Several studies have been conducted in this field, with a focus on different geographical regions. Moreover, data envelopment analysis (DEA) has been most commonly used for insurance companies' efficiency assessment. DEA methodology was initially mentioned in 1978 by Charnes et al. (Smętek et al. 2022) and it can be defined as a mathematical, non-parametric approach, which is used to estimate the DMU (decision-making unit) performance (Đurić et al. 2020). As it was mentioned in Abdin et al. (2022), efficiency can be measured by the input-oriented approach and the output-oriented approach. The first one is used when the company decreases the inputs in order to generate the optimal output, while the second approach is when the company increases its profits. In this context, Table 1 presented below includes some of the papers in which the efficiency of insurance companies was tested through the DEA methodology. Nevertheless, in the following paragraphs, a more detailed elaboration of the presented papers is provided.

Table 1. Literature review of insurance studies with the application of DEA.

Authors and Year of Publication	Analysed Country	Sample and Observed Period	Methodology	Variables	Findings
Tayebi et al. (2024)	Algeria	20 insurance companies; 2016–2020	SBM—slacks-based measure; DEA—data envelopment analysis.	*Inputs:* labour expense, agent expense and investments; *Outputs:* gross premiums, investment income, and gross claims.	Among the 20 insurance companies tested, only 5 achieved technical efficiency.
Abdin et al. (2022)	Indonesia	18 general insurance companies (8 foreign-owned and 10 national-owned); 2017–2018	Two stages of data envelopment analysis:1. DEA; 2. Tobit regression model.	*Inputs:* capital and expenses; *Outputs:* primary gross and investment.	- The efficiency level of general insurance companies experienced a positive trend.
Cvetkoska et al. (2022)	North Macedonia, Croatia, Serbia, and Slovenia	164 insurance companies; 2016–2019	Two-step methodology: DEA (input-oriented BCC model) and OLS	*Inputs:* material costs, agent costs, labour 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 longtail 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.
Đurić et al. (2020)	Serbia	9 insurance companies; 2007–2018	Output-oriented CRS and VRS DEA window	*Inputs:* insurance number, administration costs, and acquisition costs; *Outputs:* investment income and claims settled.	Very poor performance of the insurance sector as a whole.
Micajkova (2015)	North Macedonia	11 insurance companies; 2009–2013	DEA: CCR and BCC output-oriented models	*Inputs:* administrative expenses, commission expenses, and total capital; *Outputs:* gross written premium and gross claims.	Increase in the average efficiency during the observed period.

SOURCE: Authors' work.

Tayebi et al. (2024) measured the technical efficiency of 20 Algerian insurance companies from 2016 to 2020 using SBM and DEA models. The input variables that were used were labour expense, agent expense and investments, while the output variables were gross premiums, investment income and gross claims. The results from the analysis showed that among the 20 insurance companies, only 5 achieved technical efficiency.

The two-stage DEA, in combination with the Tobit regression model, was employed by Abdin et al. (2022), who aimed to analyse the efficiency performance of 18 general insurance companies (8 foreign-owned and 10 national-owned) in Indonesia for the period 2017–2018. The input variables used were capital and expenses, while the output variables were primary gross and investment. The results showed that the efficiency level of general insurance companies experienced a positive trend.

A sample of 164 insurance companies was used by Cvetkoska et al. (2022) to analyse the managerial ability and the determinants in the insurance companies in North Macedonia, Croatia, Serbia, and Slovenia for the period 2016–2019. For the analysis, they used a two-step methodology, DEA and OLS. As input variables, material costs, agent costs, labour costs, and capital costs were used, while as outputs, personal short-tail lines, personal long-tail lines, commercial short-tail lines, and commercial long-tail lines were used. The results showed that size, age, and personal long-tail lines have a statistically significant and negative relationship with firm efficiency. Moreover, financial leverage and personal short-tail lines showed a positive and statistically significant relationship. Additionally, the financial performance was negatively affected by the size. The findings from the second OLD regression method 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.

Đurić et al. (2020) highlighted the importance of insurance companies for the financial system and economic development. Hence, through DEA window analysis, they analysed the efficiency of nine insurance companies in Serbia during the period 2007–2018. Insurance number, administration costs, and acquisition costs were selected as input variables, while investment income and claims settled were used as output variables. The obtained results showed a poor performance of the insurance sector as a whole.

Micajkova (2015) estimated the efficiency of the insurance sector of North Macedonia for the period 2009–2013. Eleven insurance companies were encompassed in the analysis, and the DEA methodology, with both CCR and BCC output-oriented models, was employed. As input variables, administrative expenses, commission expenses, and total capital were chosen, whereas gross written premium and gross claims were selected as output variables. The results showed an increase in the average efficiency during the observed period.

The presented literature review reveals that most of the studies in which DEA has been used focus on different countries. The literature that analyses the insurance sector efficiency in North Macedonia is scarce. Hence, this literature gap creates a need for a more in-depth analysis of the insurance sector efficiency in North Macedonia. In this context, it should be mentioned that the insurance sector in North Macedonia has been analysed in several papers, but very few test efficiency through the DEA methodology (Cvetkoska et al. 2022; Micajkova 2015). For instance, Andreeski et al. (2012) analysed the development of the life insurance sector in recent history, and Gockov and Kamenjarska (2021) in their paper identified and assessed industry-specific and macroeconomic variables that determine the profitability of insurance companies in North Macedonia. Kjosevski (2012) investigated the impact of the insurance sector on economic growth through multiple regression for the period 1995–2010. Other authors who analysed the insurance sector from different perspectives are Nakov and Ivanovski (2019), Stojkoski et al. (2021), Milosevic and Filiposki (2018), etc. Undoubtedly, the insurance sector is of interest in North Macedonia, due to its importance for the North Macedonian financial system. Therefore, this paper aims to analyse the efficiency of all insurance companies (both life and non-life) through the DEA methodology in the pre- and post-COVID period, i.e., in the period from 2018 to 2022.

3. Methodology and Data

The DEA methodology is a linear programming model, mostly applied in Operations Research (OR) and economics for the estimation of production frontier, and the efficiency of a so-called decision-making unit (DMU) is assessed in relation to all the other DMUs in the analysed sample, "with the simple restriction that all DMUs lay on or below the extreme frontier" (Micajkova 2015). What makes the DEA a good choice of methodology to use is the option to include and simultaneously analyse more than one input and output. DEA is based on multiple inputs and outputs and creates a single efficiency score for each decision-making unit (DMU), in this case, for each insurance company operating in North Macedonia in the observed period, and it classifies the DMUs as relatively efficient (those with an efficiency score in the form of a single index of 1.00 or 100%) or relatively inefficient (those with an efficiency score less than 1.00 or 100%).

DEA is also a frontier approach, which captures extreme observations directed at the frontier rather than central tendencies. Relatively efficient DMUs form the so-called efficiency frontier against which all other inefficient DMUs in the sample are analysed and evaluated. This enables the identification of the relatively efficient units that comprise the efficiency frontier, and for inefficient ones, the targets of improvement can be calculated, which additionally serves as a prescription on what to do in the next period to become relative efficient (Micajkova 2015; Pervan et al. 2021; Pavić Kramarić et al. 2022).

Data envelopment analysis (DEA) has a rich history and ever since its introduction in 1978, it has evolved into a powerful tool for performance measurement (Cooper et al. 2011). It was originally developed as a tool for performance measurement of non-profit organisations, due to the lack of methodologies for the non-profit sector efficiency evaluation. However, its application has spread in various sectors and industries, and DEA is mostly applied in agriculture, banking, supply chain, transportation, and public policy (Emrouznejad and Yang 2018). In a more recent bibliometric study, the sectors of energy, banking, and education were identified as the sectors that most commonly employ the DEA in empirical research (Emrouznejad et al. 2022).

DEA has gained immense popularity and has noted a great variety of applications in the past few decades among scholars and practitioners; it has found extensive use in the evaluation of the efficiency of "many different kinds of entities engaged in many different activities in many different contexts in many different countries" (Cooper et al. 2007). There are two basic DEA models, namely, the CCR and the BCC model. The first was introduced in 1978, and the latter in 1984, and the main distinction is in the assumption regarding the returns to scale. The CCR model assumes a constant return to scale, and the BCC model runs under the variable return to scale assumption. Furthermore, there are three possible orientations of the DEA model: input orientation, output orientation, or non-orientation.

The research flow is presented in Figure 1. In the first step of the research, the identification and collection of the decision-making units (i.e., the insurance companies actively operating in the North Macedonian market) was made. The second, and most demanding step, included an extensive literature review of relevant published papers employing DEA in insurance, to identify and select input and output variables for the employed DEA model. In this study, we follow Pervan et al. (2021) in the selection of input and output variables. Namely, the input variables are capital (paid-in capital) and labour (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, as shown in Table 2. It should be noted that the selection of appropriate input and output variables is particularly demanding in the case of insurance companies compared to manufacturing entities where attributing inputs and outputs is less challenging (Micajkova 2015). The third step includes an application of the employed DEA model. We followed the recommendations of Cummins and Weiss (2013), who claimed that the majority of DEA applications in insurance thus far employ the input orientation of the BCC DEA model. The rationale behind this lies in the notion that the size of the insurance company does not impact the economies of scale, which leads to the conclusion that the

BCC DEA input-oriented model is the best one for the efficiency assessment of insurance companies (Pervan et al. 2021). Nevertheless, the insurance companies influence the inputs (in this case, the paid-in capital and the number of employees) considerably more than they influence the outputs (the net earned premiums and the total investment), and thereby the input-oriented DEA model is applied.

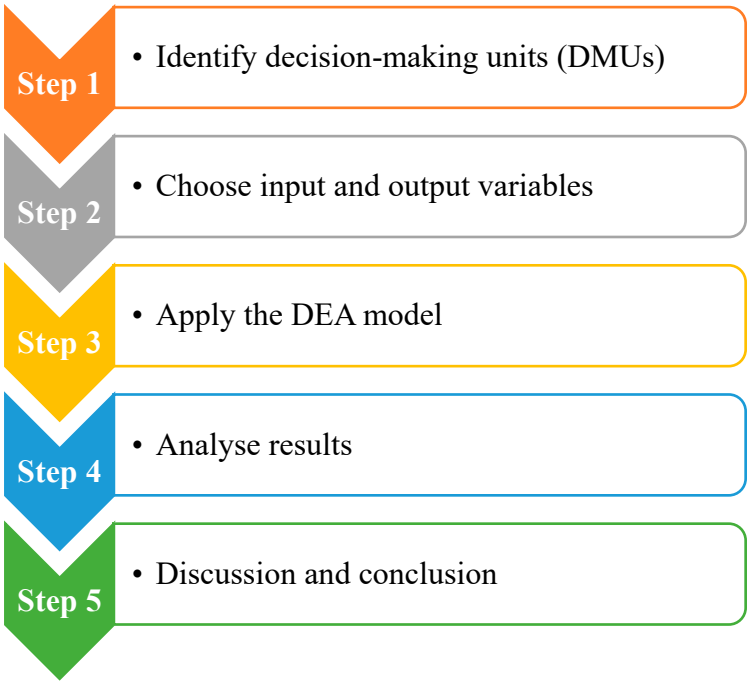


Figure 1. Research flow. SOURCE: Authors' work.

Table 2. DEA input and output variables.

Category	Variables	Definition
Inputs	Capital Labour	Paid-in capital Number of employees
Outputs	Risk-pooling/bearing services Intermediate function	Net earned premiums Total investment, i.e., investments, real estate, and intangible assets

SOURCE: Authors' work.

According to Cooper et al. (2007), the mathematical formulation of the input-oriented BCC DEA model can be presented as follows:

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

$$\text{subject to } \theta_B x_0 - X\lambda \geq 0$$

$$Y\lambda \geq y_0$$

$$e_n\lambda = 1$$

$$\lambda \geq 0$$

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 DMU0's inputs;
e is a row vector of n;
n is a number of DMUs.

In the context of the input-oriented BCC model, the efficiency evaluation of each DMU0 (0 = 1, …, n) is performed by solving the linear program (envelopment form) provided above.

The dual multiplier representation of this linear program (BCC_0) is formulated as follows:

$$\max_{v,u,u_0} z = uy_0 - u_0$$

$$\text{subject to } vx_0 = 1$$

$$-vX + uY - u_0 e \leq 0$$

$$v \geq 0,\ u \geq 0,\ u_0 \ free\ in\ sign,$$

where v and u are vectors, while z and u_0 are scalars. The latter, designated as 'free in sign', can assume positive, negative, or zero values. The corresponding BCC fractional program is derived from the dual program as follows:

$$max \frac{uy_0 - u_0}{vx_0}$$

$$\text{subject to } \frac{uy_j - u_0}{vx_j} \leq 1\ (j = 1, \ldots, n)$$

$$v \geq 0,\ u \geq 0,\ u_0\ free$$

The primal problem (BCC_0) is tackled through a two-phase approach. Initially, the objective is to minimize θ_B in the first phase, followed by maximizing the sum of the input excesses and the output shortfalls while maintaining $\theta_B = \theta_B^*$ (the optimal objective value obtained in Phase one) in the second phase. An optimal solution for (BCC_0) is denoted as (θ_B^*, λ^*, s^{-*}, s^{+*}), where s^{-*} *and* s^{+*} indicate the maximal input excesses and output shortfalls, respectively.

> *"If an optimal solution* (θ_B^*, λ^*, s^{-*}, s^{+*}) *obtained in this two-phase process for* (BCC_0) *satisfies* $\theta_B^* = 1$ *and has no slack* ($s^{-*} = 0$, $s^{+*} = 0$), *then the* DMU0 *is called BCC-efficienct, otherwise it is BCC-inefficient"*. (Cooper et al. 2007, p. 92)

For BCC-inefficient DMUs, a formula for improvement through the BCC-projection exists:

$$\hat{x}_0 = \theta_B^* x_0 - s^{-*}$$

$$\hat{y}_0 = y_0 + s^{+*}$$

The enhanced activity ($\hat{x}_0$, $\hat{y}_0$) achieves BCC efficiency.

The fourth step of this study included an analysis of the findings, and the last, fifth step revolved around the conclusions. In the last step, a discussion regarding the most important raised issues is provided. The whole research flow is presented graphically in Figure 1.

The aim of this paper is to measure the relative efficiency of insurance companies in North Macedonia with the application of the DEA methodology. The sample consists of 16 insurance companies actively operating in the Republic of North Macedonia in the observed period (2018 to 2022), out of which 5 are life insurers (Croatia Osiguruvanje–Život, Grawe Osiguruvanje AD Skopje, Triglav Osiguruvanje Život AD Skopje, Uniqa Life AD Skopje, and WINNER Life–Vienna Insurance Group AD Skopje), and 11 are non-life insurers (AD Osiguritelna Polisa Skopje, Ador Makedonija Skopje–Vienna Insurance Group, Croatia Osiguruvanje–Neživot AD Skopje, Eurolink Osiguruvanje AD Skopje, Evroins Osiguruvanje AD Skopje, Grawe Osiguruvanje AD Skopje, Halk Osiguruvanje

AD Skopje, Sava Osiguruvanje AD Skopje, Triglav Osiguruvanje AD Skopje, Uniqa AD Skopje, and WINNER-Vienna Insurance Group AD Skopje). For the sake of simplicity, the life insurance companies hereafter will be marked (L) after their title, whereas the non-life insurance companies will be marked (NL). The data were manually extracted from their officially published yearly financial reports. The descriptive analytics of the used variables is presented in Appendix A.

During the observed period, distinctive outliers within the realm of financial performance emerged within the insurance sector (Appendix B). Notably, Ador Makedonija Skopje–Vienna Insurance Group (NL) manifested outlier characteristics across the entirety of the studied period, indicative of its remarkable deviation from the sector's normative trends for the input capital. Furthermore, Halk Osiguruvanje AD Skopje (NL) exhibited outlier behaviour for the same input in 2019 and 2020, suggesting a sporadic departure from the anticipated industry dynamics.

In addition, the scrutiny of total investment yields revealed notable anomalies. Specifically, Croatia Osiguruvanje (L) showcased outlier tendencies across four consecutive years from 2019 to 2022, underscoring its distinctive financial trajectory within the sector. Similarly, Grawe Osiguruvanje AD Skopje (L) demonstrated outlier attributes in the preceding triennial period, indicating a divergence from the typical investment patterns observed within the insurance domain.

Given the absence of a singular insurance entity exhibiting outlier behaviour across all analysed variables throughout the entire study duration, it was deemed imperative to encompass all insurance companies within the framework of the data envelopment analysis (DEA) model. This comprehensive approach ensures a holistic assessment of the insurance sector's performance over the scrutinized five-year period, facilitating robust conclusions regarding its overall dynamics and efficacy.

4. Results

After running the input-oriented BCC DEA model in the MaxDEA software, we obtained the efficiency scores for each insurance company in the observed period as well as the average efficiency results for the whole insurance sector in North Macedonia in the period from 2018 to 2022. In Figure 2, the average relative efficiency of the whole insurance sector is presented by year. The highest relative efficiency is identified in the first observed year, i.e., in 2018 (83.62%), and a sharp decline followed thereafter, with the lowest average efficiency in 2020 (73.81%). Additionally, the average relative efficiency of the whole insurance sector remained low at 74.97% in 2022 (the last analysed year). Therefore, one can expect that the deterioration in efficiency among insurers could be seen as a result of the COVID-19 impact on the insurance sector. However, the actual influence of the pandemic on the efficiency scores is yet to be confirmed in future research. When analysing the average relative efficiencies of non-life and life insurance companies in North Macedonia, the average relative efficiency of the non-life insurers for the whole observed period amounted to 0.8067, whereas the life insurance companies noted an average efficiency score of 0.9011.

These results are not in line with the findings of Micajkova (2015), who revealed a "permanent growth during the whole observed period" from 2009 to 2013.

Figure 3 presents the average efficiency scores for each insurance company in the sample, thereby revealing the four relative efficient insurance companies in the whole observed period, which are Triglav Osiguruvanje AD Skopje, Sava Osiguruvanje AD Skopje, Croatia Osiguruvanje–Život, and Grawe Osiguruvanje AD Skopje. The least efficient insurance company operating in North Macedonia in the observed period is Ador Makedonija Skopje–Vienna Insurance Group, with an average efficiency score of 24.61%. The rationale for the lowest efficiency in the whole sample could be a result of the rise in their operating cost in aggregate value as their highest position in the structure of expenses, as well as the combined ratio reaching the devastating rate of 114% in 2022 (100% in 2021), due to the "increased number of property claims, as are the increase in

the acquisition costs, and the costs of high inflation, including energy, transportation, and other items" (ADOR Makedonija–Vienna Insurance Group 2023). These efficiency results could be related to the findings of Cvetkoska et al. (2022), whose results suggested that "CEOs with international expertise and know-how are likely to increase the efficiency and managerial ability of the insurance companies in which they operate".

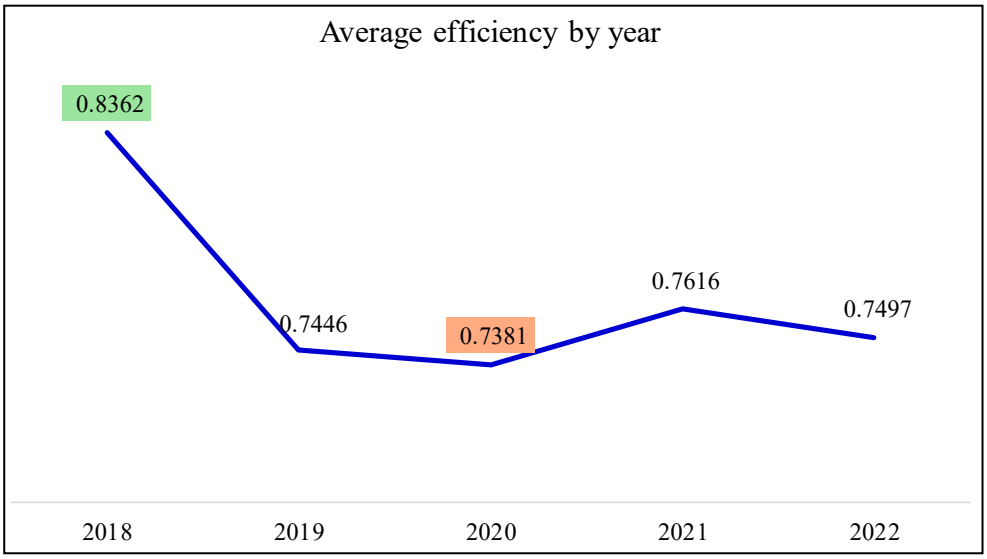


Figure 2. Average efficiency of the overall insurance market in North Macedonia (2018–2022). SOURCE: Authors' work.

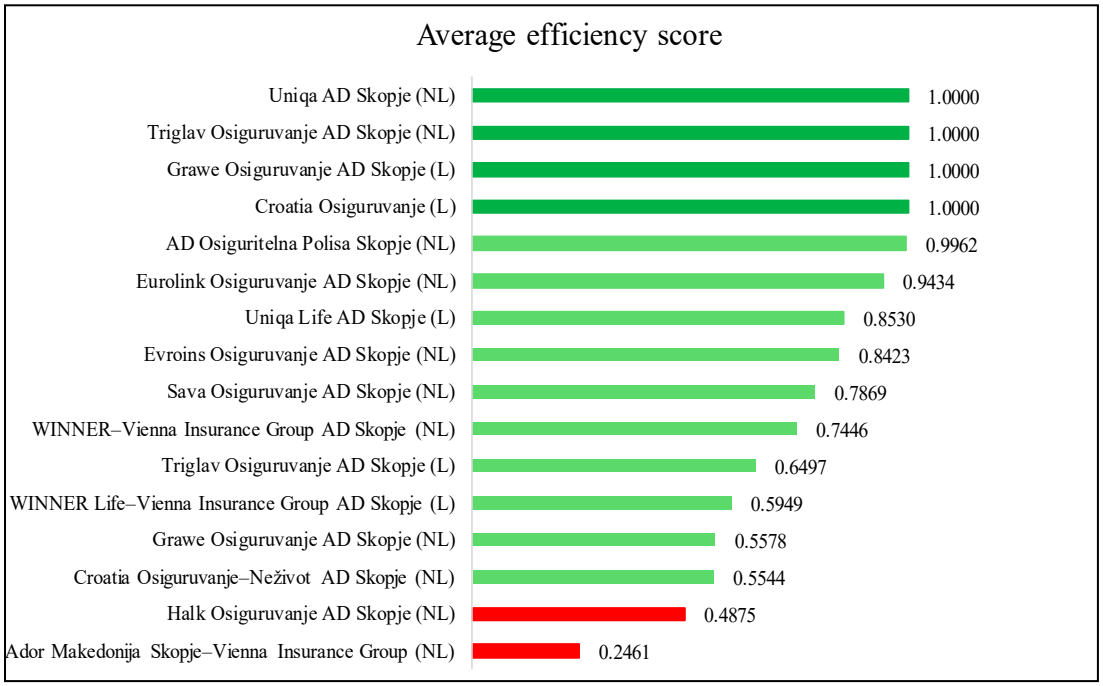


Figure 3. Average relative efficiency of each insurance company operating in North Macedonia (2018–2022). The darker green coloured insurance companies are relatively efficient (100%), the lighter green coloured insurance companies note relative efficiency higher than 50%, and the red coloured insurance companies noted an efficiency score lower than 50%. SOURCE: Authors' work.

Figure 4 reveals the relative efficiency scores for each insurance company by year. Additionally, a sparkline showing the trend of efficiency for the observed 5-year period is presented. This presentation provides a detailed analysis of the results and identifies somewhat unusual

trends in efficiency as well as the most efficient insurance companies (i.e., the DMUs that obtained a relative efficiency score of 100% in each of the analysed years). The green fields reveal the years in which a full relative efficiency of 100% was obtained.

NO	DMU	2018	2019	2020	2021	2022	Sparkline
1	AD Osiguritelna Polisa Skopje (NL)	0.9961	0.9962	0.9962	0.9962	0.9962	
2	Ador Makedonija Skopje–Vienna Insurance Group (NL)	0.2072	0.2238	0.2711	0.2743	0.2540	
3	Croatia Osiguruvanje–Neživot AD Skopje (NL)	0.5692	0.5697	0.4635	0.4252	0.7446	
4	**Croatia Osiguruvanje (L)**	**1.0000**	**1.0000**	**1.0000**	**1.0000**	**1.0000**	
5	Eurolink Osiguruvanje AD Skopje (NL)	0.9438	0.9444	0.9448	0.9420	0.9420	
6	Evroins Osiguruvanje AD Skopje (NL)	0.7726	0.7729	0.7733	0.8925	**1.0000**	
7	**Grawe Osiguruvanje AD Skopje (L)**	**1.0000**	**1.0000**	**1.0000**	**1.0000**	**1.0000**	
8	Grawe Osiguruvanje AD Skopje (NL)	**1.0000**	0.5118	0.5118	0.4070	0.3582	
9	Halk Osiguruvanje AD Skopje (NL)	0.8550	0.2851	0.2886	0.6360	0.3727	
10	Sava Osiguruvanje AD Skopje (NL)	0.7864	0.7865	0.7878	0.7872	0.7869	
11	Triglav Osiguruvanje AD Skopje (L)	**1.0000**	0.6250	0.5982	0.5982	0.4269	
12	**Triglav Osiguruvanje AD Skopje (NL)**	**1.0000**	**1.0000**	**1.0000**	**1.0000**	**1.0000**	
13	**Uniqa AD Skopje (NL)**	**1.0000**	**1.0000**	**1.0000**	**1.0000**	**1.0000**	
14	Uniqa Life AD Skopje (L)	0.8530	0.8530	0.8530	0.8530	0.8530	
15	WINNER–Vienna Insurance Group AD Skopje (NL)	0.7439	0.7448	0.7448	0.7448	0.7448	
16	WINNER Life–Vienna Insurance Group AD Skopje (L)	0.6524	0.6000	0.5769	0.6296	0.5155	
	Average	**0.8362**	**0.7446**	**0.7381**	**0.7616**	**0.7497**	

Figure 4. Relative efficiency of North Macedonian insurance companies by year (2018–2022). Insurance companies in bold are the ones relatively efficient in the whole observed period. The green highlighter reveals the years in which a relative efficiency of 100% is noted. SOURCE: Authors' work.

One of the notable advantages inherent in the non-parametric data envelopment analysis (DEA) methodology, as opposed to parametric approaches, lies in its capacity to furnish improvement targets for inefficient DMUs, facilitating their transition towards relative efficiency. In our study, we provide a concrete illustration featuring both a non-life insurance company, Sava Osiguruvanje AD Skopje (NL), and a life insurance company, Uniqa Life AD Skopje (L). Within the efficiency assessment of Sava Osiguruvanje AD Skopje (NL), the primary influencers are identified as three benchmark insurance entities—Croatia Osiguruvanje (L), Triglav Osiguruvanje AD Skopje (NL), and Uniqa AD Skopje (NL). Notably, Uniqa AD Skopje (NL) exhibits the highest lambda coefficient, indicating its pronounced impact on the overall efficiency score, followed by Triglav Osiguruvanje AD Skopje (NL) and Croacia Osiguruvanje (L). Furthermore, our findings suggest that for Sava Osiguruvanje AD Skopje (NL) to align with the efficient frontier, simultaneous reductions in both capital input to 184,196 (Table 3a) and the number of employees to 142 (Table 3b) are necessary, with no alterations required for the specified outputs (Table 3c,d).

Table 3. (**a**) Targets for the improvement of the input capital for Sava Osiguruvanje AD Skopje (NL) and Uniqa Life AD Skopje (L). (**b**) Targets for the improvement of the input number of employees for Sava Osiguruvanje AD Skopje (NL) and Uniqa Life AD Skopje (L). (**c**) Targets for the improvement of the output net earned premiums for Sava Osiguruvanje AD Skopje (NL) and Uniqa Life AD Skopje (L). (**d**) Targets for the improvement of the output total investment for Sava Osiguruvanje AD Skopje (NL) and Uniqa Life AD Skopje (L).

(a) (in thousands of Croatian kuna)

DMU	Score	Benchmark (Lambda)	Proportionate_Movement (Capital)	Slack_Movement (Capital)	Projection (Capital)
Sava Osiguruvanje AD Skopje (NL)	**0.7869**	Croatia Osiguruvanje (L)(0.048277); Triglav Osiguruvanje AD Skopje (NL)(0.152937); Uniqa AD Skopje (NL)(0.798785)	(49,876)	0	184,196
Uniqa Life AD Skopje (L)	**0.8530**	Grawe Osiguruvanje AD Skopje (L)(1.000000)	(31,707)	0	183,999

Table 3. *Cont.*

(b) (in thousands of Croatian kuna)

DMU	Score	Benchmark (Lambda)	Proportionate_ Movement (Number of employees)	Slack_Movement (Number of employees)	Projection (Number of employees)
Sava Osiguruvanje AD Skopje (NL)	**0.7869**	Croatia Osiguruvanje (L)(0.048277); Triglav Osiguruvanje AD Skopje (NL)(0.152937); Uniqa AD Skopje (NL)(0.798785)	(50)	(42)	142
Uniqa Life AD Skopje (L)	**0.8530**	Grawe Osiguruvanje AD Skopje (L)(1.000000)	(3)	(5)	15

(c) (in thousands of Croatian kuna)

DMU	Score	Benchmark (Lambda)	Proportionate_ Movement (Number of employees)	Slack_ Movement (Number of employees)	Projection (Number of employees)
Sava Osiguruvanje AD Skopje (NL)	**0.7869**	Croatia Osiguruvanje (L)(0.048277); Triglav Osiguruvanje AD Skopje (NL)(0.152937); Uniqa AD Skopje (NL)(0.798785)	0	0	922,216
Uniqa Life AD Skopje (L)	**0.8530**	Grawe Osiguruvanje AD Skopje (L)(1.000000)	0	186,691	468,686

(d) (in thousands of Croatian kuna)

DMU	Score	Benchmark (Lambda)	Proportionate_ Movement (Net earned premiums)	Slack_ Movement (Net earned premiums)	Projection (Net earned premiums)
Sava Osiguruvanje AD Skopje (NL)	**0.7869**	Croatia Osiguruvanje (L)(0.048277); Triglav Osiguruvanje AD Skopje (NL)(0.152937); Uniqa AD Skopje (NL)(0.798785)	0	0	1,200,097
Uniqa Life AD Skopje (L)	**0.8530**	Grawe Osiguruvanje AD Skopje (L)(1.000000)	0	2,914,935	3,630,360

Note: There should be a minus sign before all the numbers in brackets. SOURCE: Authors' work.

We can analyse the targets for improvement for each inefficient insurance company by utilizing the lambda (λ) of each benchmark for that inefficient unit in the following manner (see Figure 5). We will focus on one inefficient insurance company, Sava Osiguruvanje AD Skopje (NL). This company has three benchmark units: Croatia Osiguruvanje (L) with λ = 0.048277, Triglav Osiguruvanje AD Skopje (NL) with λ = 0.152937, and Uniqa AD Skopje (NL) with λ = 0.798785. The capital input of Sava Osiguruvanje AD Skopje (NL) is HRK 234,072 thousand (Croatian Kuna), and its target value is HRK 184,196 thousand (Croatian Kuna). How is this value estimated? To calculate the target value for each input or output, it is essential to iteratively multiply each benchmark's lambda value by its respective input, followed by summation as outlined in the formula presented in the formula bar on Figure 5. Similarly, the target value for the number of employees is estimated in an analogous way, while the value for the outputs remains unchanged after estimation.

C16 =(B16*B10)+(B17*B3)+(B18*B9)

	A	B	C	D	E
1	**Insurance companies**	**Capital**	**Number of employees**	**Net earned premiums**	**Total investment**
3	Triglav Osiguruvanje AD Skopje (NL)	185,223	219	1,025,781	1,666,159
4	Sava Osiguruvanje AD Skopje (NL)	234,072	234	922,216	1,200,097
9	Uniqa AD Skopje (NL)	184,003	131	914,988	943,781
10	Croatia Osiguruvanje (L)	184,132	87	713,726	3,964,610
11					
12	**Inputs**				**Outputs**
13					
14	**Capital**				**Net earned premiums**
15					
16	Croatia Osiguruvanje (L)	0.048277	184,196		922,215
17	Triglav Osiguruvanje AD Skopje (NL)	0.152937			
18	Uniqa AD Skopje (NL)	0.798785			
19					
20					
21	**Number of employees**				**Total investment**
22					
23	Croatia Osiguruvanje (L)	0.048277	142		1,200,095
24	Triglav Osiguruvanje AD Skopje (NL)	0.152937			
25	Uniqa AD Skopje (NL)	0.798785			

Figure 5. Targets for improvement with λ value for Sava Osiguruvanje AD Skopje (NL). SOURCE: Authors' work.

5. Discussion

The majority of the sample (i.e., 11 out of 16 insurance companies) experienced very stable relative efficiency results with no fluctuations whatsoever in the whole observed period (these are AD Osiguritelna Polica Skopje (NL), Ador Makedonija Skopje–Vienna Insurance Group (NL), Croatia Osiguruvanje (L), Eurolink Osiguruvanje AD Skopje (NL), Grawe Osiguruvanje AD Skopje (L), Sava Osiguruvanje AD Skopje (NL), Triglav Osiguruvanje AD Skopje (NL), Uniqa AD Skopje (NL), Uniqa Life AD Skopje (L), WINNER–Vienna Insurance Group AD Skopje (NL), and WINNER Life–Vienna Insurance Group AD Skopje (L)).

The largest fluctuations and variations in efficiency were noted in the efficiency scores obtained for Croatia Osiguruvanje–Neživot AD Skopje (NL), Evroins Osiguruvanje AD Skopje (NL), Grawe Osiguruvanje AD Skopje (NL), Halk Osiguruvanje AD Skopje (NL), and Triglav Osiguruvanje AD Skopje (L).

In the case of Croatia Osigiruvanje–Neživot AD Skopje (NL), the efficiency deteriorated in 2020 and 2021, and thereafter rose to 74.46% in 2022. In the cases of Grawe Osiguruvanje AD Skopje (NL), Halk Osiguruvanje AD Skopje (NL), and Triglav Osiguruvanje AD Skopje (L), the highest efficiency results were noted in 2018, thereafter declining sharply in 2019 and 2020. Evroins Osiguruvanje AD Skopje (NL) noted rather untypical results, starting with relatively stable efficiency results in the first three years of the analysis (2018–2020) and thereafter experiencing a rise in efficiency in 2021 and a full efficiency of 100% in 2022.

As stated in Section 2, a range of studies have explored the application of data envelopment analysis (DEA) in the insurance industry. Cummins and Weiss (2013) undertook a comprehensive scholarly review on studies tackling firm performance, and focused on insurance companies. What they found is that the DEA was the most applied methodol-

ogy in this industry, and more importantly, they recognized a growing consensus among researchers on the definitions of inputs, outputs, and prices. Bao et al. (2018) tackled the "increasing competition in the industry" and emphasize the need for effective performance measurement in insurance. Kaffash et al. (2020) found that the influence of the novel insurance developments on efficiency is rarely empirically examined and that the newly developed data envelopment analysis models are less applied in insurance. Moreover, they emphasized the rising need to further apply the DEA methodology in insurance, especially in light of the recent changes such as Insurtechs and market transparency. All of these studies collectively underscore the importance of DEA in the efficiency and performance evaluation of insurance companies.

6. Conclusions

The findings of our study provide valuable insights into the efficiency dynamics of insurance companies operating in North Macedonia over the period from 2018 to 2022. Utilizing an input-oriented BCC DEA model, we examined the relative efficiency of these companies, considering capital and labour as inputs, and risk-pooling/bearing services and intermediate function as outputs. Our analysis revealed notable fluctuations in efficiency levels across the observed years, with the sector reaching its peak efficiency of 83.62% in 2018, followed by a concerning decline to its lowest point of 73.81% in 2020. This downward trend persisted, with the average relative efficiency remaining subdued at 74.97% in 2022. One can argue that this mirrors the impact of the COVID-19 pandemic, which further exacerbated this decline, reflecting the challenges faced by the insurance sector amidst the unprecedented disruptions brought about by the global health crisis. However, this is yet to be investigated in further research, encompassing additional inputs and outputs connected with the COVID-19 pandemic.

Furthermore, our investigation into efficiency patterns among life and non-life insurers uncovered intriguing disparities. Non-life insurers exhibited an average relative efficiency of 0.8067, while life insurance companies demonstrated a superior average efficiency score of 0.9011 over the examined period. These findings shed light on the nuanced dynamics within the North Macedonian insurance market, highlighting potential avenues for further research and strategic interventions aimed at enhancing sectoral efficiency and resilience.

Despite the insights gleaned from our study, it is imperative to acknowledge its limitations. Firstly, the reliance on the DEA methodology, while valuable for assessing relative efficiency, is subject to certain constraints. Sensitivity to variations in input and output variables underscores the need for a cautious interpretation of results and the potential for differing conclusions under alternative specifications. Additionally, the scope of our analysis was confined to the insurance sector in North Macedonia, limiting the generalizability of findings to broader regional or global contexts. Future research endeavours should therefore consider expanding the geographic scope of analysis to encompass other European and Western Balkan countries, facilitating comparative assessments and enriching our understanding of efficiency dynamics within the wider insurance landscape.

Moreover, while our study provides insights into efficiency trends over the observed period, it does not delve into the underlying drivers of inefficiency within individual insurance companies. Future research efforts should therefore endeavour to explore the determinants of efficiency disparities, considering factors such as managerial practices, technological innovation, regulatory frameworks, and market competition. Such analyses could yield actionable insights for policymakers, regulators, and industry practitioners, informing targeted interventions aimed at bolstering sectoral efficiency and enhancing overall financial system stability. Additionally, the application of DEA in combination with the Malmquist Index provides an assessment of the productivity changes and efficiency dynamics of insurance companies. Esmaeili et al. (2021) proposed a novel approach, i.e., the interval network Malmquist Productivity Index, to account for data uncertainty in evaluating the productivity changes of insurance companies, which demonstrates the

potential of the Malmquist Index with DEA in the insurance industry and suggest future research endeavours in this area.

Author Contributions: Conceptualization, K.F.Č. and V.C.; methodology, V.C.; software, V.C.; validation, V.C. and K.F.Č.; formal analysis, K.F.Č.; investigation, M.M. and K.F.Č.; resources, M.M.; data curation, M.M.; writing—original draft preparation, K.F.Č.; writing—review and editing, K.F.Č. and V.C.; visualization K.F.Č., M.M. and V.C.; supervision, K.F.Č. and V.C.; project administration, K.F.Č. and V.C.; funding acquisition, K.F.Č. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by University North, Croatia grant number [UNIN-DRUŠ-24-1-8].

Informed Consent Statement: Not applicable.

Data Availability Statement: Data supporting reported results was manually extracted and can be found in the official and public available financial statements of each insurance company in North Macedonia for the period 2018–2022, available at their official web sites: AD Osiguritelna Polica Skopje (https://www.insurancepolicy.com.mk/GodisniIzvestai, accessed on 23 November 2023), Ador Makedonija Skopje–Vienna Insurance Group (https://www.insumak.mk/za-nas/izveshtai/, accessed on 23 November 2023), Croatia Osiguruvanje–Neživot AD Skopje (https://web.crosig.mk/finansiski-izvestai/, accessed on 23 November 2023), Croatia Osiguruvanje AD Skopje (https://cro.mk/%D0%A4%D0%B8%D0%BD%D0%B0%D0%BD%D1%81%D0%B8%D1%81%D0%BA%D0%B8_%D0%B8%D0%B7%D0%B2%D0%B5%D1%88%D1%82%D0%B0%D0%B8.aspx, accessed on 23 November 2023), Eurolink Osiguruvanje AD Skopje (https://eurolink.com.mk/za-nas/, accessed on 23 November 2023), Evroins Osiguruvanje AD Skopje (https://euroins.com.mk/revidirani-finansiski-izvestai/, accessed on 23 November 2023), Grawe Osiguruvanje AD Skopje–L & NL (https://www.grawe.mk/rezultati-od-rabote%D1%9Aeto/, accessed on 23 November 2023), Halk Osiguruvanje AD Skopje (https://www.halkinsurance.com.mk/informacii.html, accessed on 23 November 2023), Sava Osiguruvanje AD Skopje (https://mk.sava.insure/mk-mk/documents/sava-godishni-izveshtai-za-rabotenjeto/, accessed on 23 November 2023), Triglav Osiguruvanje AD Skopje–L & NL (https://www.triglav.mk/za-nas/finansiski-izvestai, accessed on 23 November 2023), Uniqa AD Skopje (https://uniqa.mk, accessed on 23 November 2023), Uniqa Life AD Skopje (https://uniqa.mk, accessed on 23 November 2023), WINNER–Vienna Insurance Group AD Skopje (https://www.winner.mk/godisni-izvestai/, accessed on 23 November 2023), and WINNER Life–Vienna Insurance Group AD Skopje (https://winnerlife.mk/finansiski-izvestai/, accessed on 23 November 2023).

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

2018 (in thousands of Croatian kuna)

Measure	*Capital*	*Number of employees*	*Net earned premiums*	*Total investment*
Mean	270,419	122	498,083	1,014,375
Standard Error	43,424	20	71,748	177,557
Median	215,294	127	524,141	801,228
Mode	#N/A	#N/A	#N/A	#N/A
Standard Deviation	173,695	80	286,993	710,229
Kurtosis	12.30	-1.13	0.05	0.61
Skewness	3.37	-0.02	0.32	1.29
Range	704,592	244	1,099,510	2,278,656
Minimum	183,716	7	18,655	306,561
Maximum	888,308	251	1,118,165	2,585,217
Sum	4,326,710	1,950	7,969,330	16,230,002
Count	16	16	16	16

Figure A1. *Cont.*

2019 (in thousands of Croatian kuna)

Measure	*Capital*	*Number of employees*	*Net earned premiums*	*Total investment*
Mean	308,311	115	525,812	1,126,169
Standard Error	48,626	17	67,869	202,237
Median	236,098	127	550,863	879,678
Mode	#N/A	127	#N/A	#N/A
Standard Deviation	194,505	70	271,477	808,950
Kurtosis	5.17	-0.80	-0.77	1.57
Skewness	2.29	0.00	-0.08	1.53
Range	704,309	223	961,458	2,757,320
Minimum	183,999	15	36,764	314,386
Maximum	888,308	238	998,222	3,071,706
Sum	4,932,974	1,832	8,412,989	18,018,709
Count	16	16	16	16

2020 (in thousands of Croatian kuna)

Measure	*Capital*	*Number of employees*	*Net earned premiums*	*Total investment*
Mean	312,938	117	514,098	1,184,166
Standard Error	48,938	18	59,341	225,134
Median	236,098	129	557,543	898,794
Mode	#N/A	#N/A	#N/A	#N/A
Standard Deviation	195,754	72	237,366	900,536
Kurtosis	4.68	-1.02	-0.62	2.31
Skewness	2.17	0.05	-0.25	1.74
Range	704,309	217	852,317	3,093,909
Minimum	183,999	15	62,856	328,003
Maximum	888,308	232	915,173	3,421,912
Sum	5,007,015	1,876	8,225,564	18,946,659
Count	16	16	16	16

2021 (in thousands of Croatian kuna)

Measure	*Capital*	*Number of employees*	*Net earned premiums*	*Total investment*
Mean	340,217	118	561,711	1,287,005
Standard Error	60,801	18	56,595	236,932
Median	236,098	126	559,556	961,658
Mode	#N/A	#N/A	#N/A	#N/A
Standard Deviation	243,205	72	226,378	947,729
Kurtosis	3.01	-0.94	-1.35	2.66
Skewness	1.96	0.09	-0.20	1.84
Range	769,548	223	687,143	3,239,242
Minimum	183,999	17	198,315	419,819
Maximum	953,547	240	885,458	3,659,061
Sum	5,443,470	1,894	8,987,372	20,592,086
Count	16	16	16	16

Figure A1. *Cont.*

2022 (in thousands of Croatian kuna)

Measure	*Capital*	*Number of employees*	*Net earned premiums*	*Total investment*
Mean	351,782	119	631,280	1,375,535
Standard Error	61,572	17	60,477	251,132
Median	236,098	127	622,702	1,029,320
Mode	#N/A	#N/A	#N/A	#N/A
Standard Deviation	246,287	69	241,906	1,004,528
Kurtosis	2.25	-0.98	-1.39	3.35
Skewness	1.75	0.06	0.04	2.03
Range	769,548	219	743,786	3,395,056
Minimum	183,999	15	281,995	569,554
Maximum	953,547	234	1,025,781	3,964,610
Sum	5,628,508	1,908	10,100,472	22,008,556
Count	16	16	16	16

Figure A1. Descriptive statistics (2018–2022). Note: N/A = not applicable.

Appendix B

2018 (in thousands of Croatian kuna)

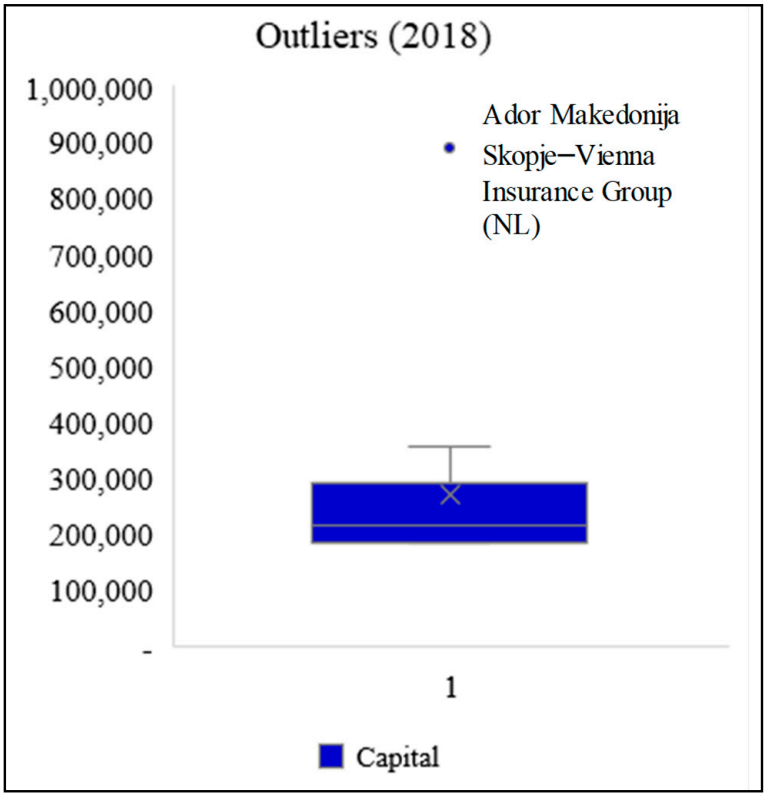
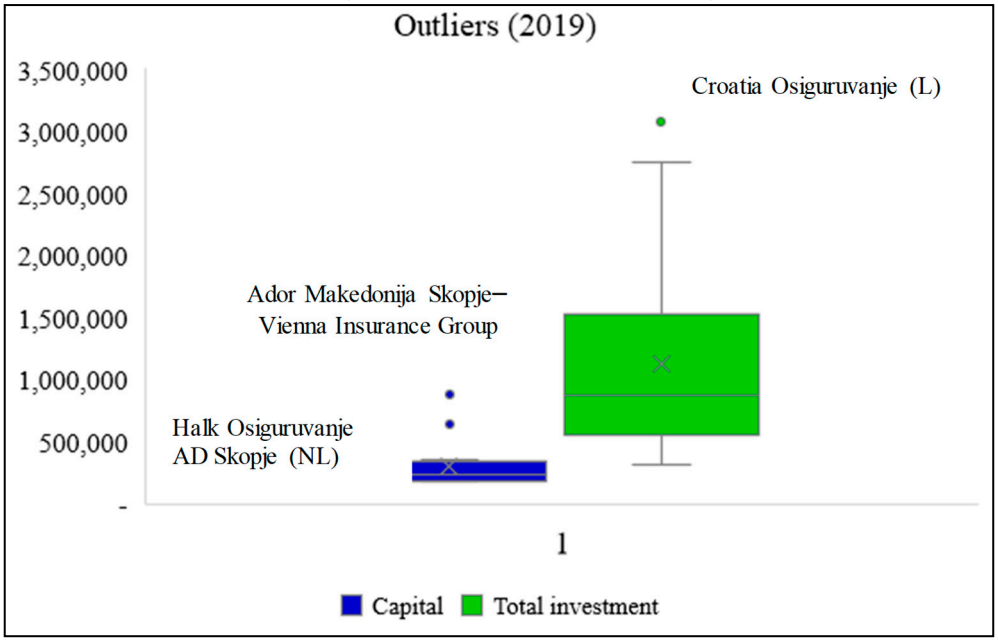


Figure A2. *Cont.*

2019 (in thousands of Croatian kuna)



2020 (in thousands of Croatian kuna)

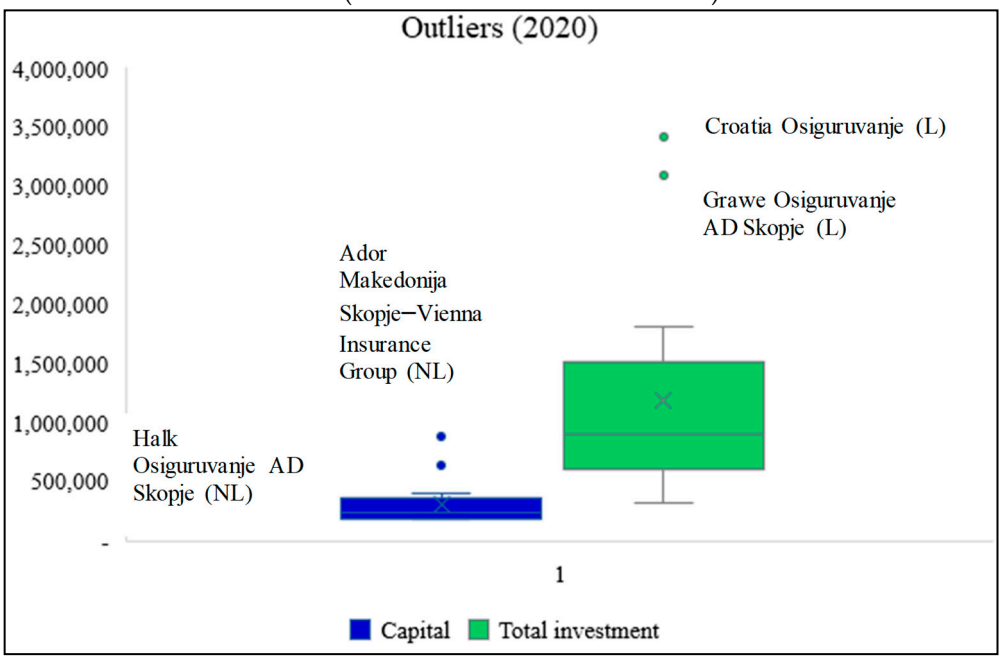


Figure A2. *Cont.*

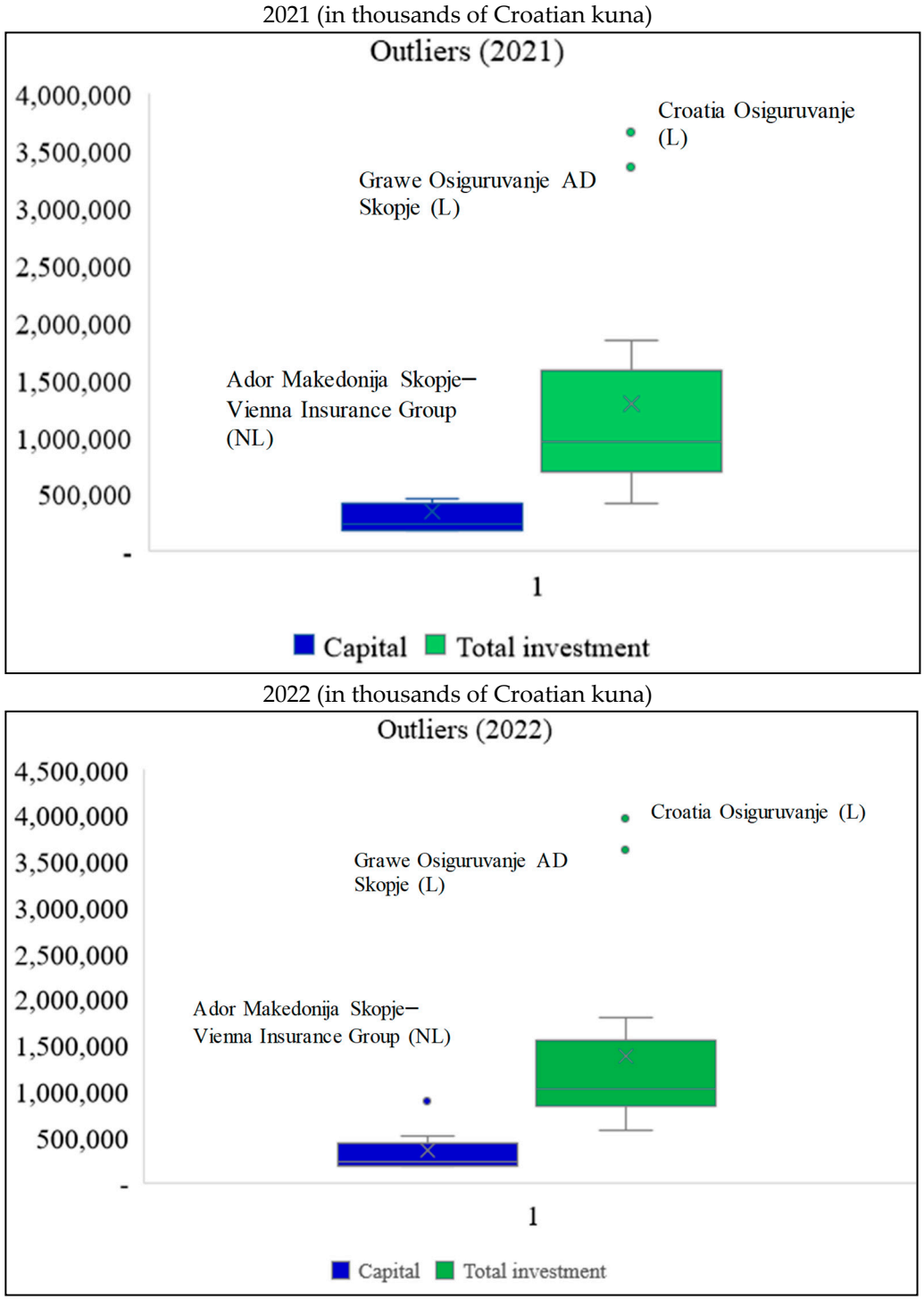


Figure A2. Outliers (2018–2022).

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