EFFICIENCY ANALYSIS OF THE INSURANCE SECTOR IN BOSNIA AND HERZEGOVINA

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Abstract

We analyzed the efficiency of the insurance industry in Bosnia and Herzegovina (BiH) in the period from 2015 to 2019 in order to identify good and bad practices, sources of inefficiency and to propose guidelines for the necessary efficiency improvements based on the results. Efficiency measurement was performed using the nonparametric Data Envelopment Analysis (DEA) technique as the most commonly used tool for efficiency analysis in finance. We used one output and two input variables according to the input-oriented approach assuming a variable return to scale (VRS). Empirical research was conducted on all insurance companies from BiH, which are grouped according to the size of assets, type of insurance, and headquarters in order to determine whether there are differences in the efficiency of insurance companies in terms of their size, type of insurance, or depending on whether it operates in the Federation of Bosnia and Herzegovina (FBiH) or Republic of Srpska (RS). The results of the analysis indicate significant inefficiencies in the insurance sector in BiH, but also differences among the observed groups. The insurance sector is more efficient in FBiH compared to RS, and insurance companies in the composite insurance market are significantly more efficient than companies in the non-life insurance market. Finally, the research has showed a relatively high level of positive correlation between the size of an insurance company and its efficiency. According to all efficiency indicators, there is significant potential for efficiency improvement. Based on the analysis, the main causes of inefficiency were identified and guidelines for improving efficiency were proposed.

Keywords: data envelopment analysis, technical efficiency, insurance sector efficiency, the insurance industry in Bosnia and Herzegovina

JEL: C52, G22, L25

1. Introduction

The insurance industry is one of the most important catalysts for economic growth (Škrinjarić, 2016). Through the wide range of products, it offers to individuals and legal entities, it plays a significant role in financial intermediation, thus contributing to financial and overall economic development (Karim & Jhantansana, 2005). In this regard, the state is interested in the success and efficiency of the insurance sector, because the general economic development, i.e., living standard and level of national income are directly proportional to the development of insurance within an economy (Kozarević, 2010).

Insurance companies belong to the group of institutional investors, whose main function is to collect non-deposit funds (insurance premiums) and invest in the capital market. Insurers channel the savings accumulated by collecting insurance premiums into various investments and increase the efficiency of the financial market as a whole. The fact that they, as institutional investors, raise funds in non-deposit forms gives them an advantage in financing larger projects compared to banks that raise funds through deposits and are an ideal source of long-term financing of economic development (Kozarević, 2010).

Due to this role, in recent times, there has been an increased interest in measuring the efficiency of insurance companies. Measuring efficiency provides insight into the competitiveness of the insurance industry, intending to gain a more detailed picture of good or bad practices within it and at least partially resolving or mitigating existing problems or shortcomings, which has a positive impact on the country's overall economic development (Karim & Jhantansana, 2005).

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Taking into account the current opportunities in the insurance market in Bosnia and Herzegovina (BiH) and anticipating future changes, the management of insurance companies must create and implement an optimal strategy following the capabilities of the organization. For this purpose, it is necessary to measure the efficiency of business, which is the subject of this paper in which the Data Envelopment Analysis (DEA) is applied to assess the insurance sector in BiH.

The paper starts with literature review about efficiency in insurance, followed by the situation in insurance market in BiH and methodology. Analysis and main findings are presented in the sections titled empirical research and conclusion.

2. Theoretical fundamentals with literature review

The DEA method was developed more than four decades ago and has been used to test the efficiency of different sectors in many states. However, the application of this method in BiH has been updated only in the last ten years and has been used to examine the efficiency of the banking sector (Efendić & Avdić, 2011, Memić & Škaljić-Memić, 2013), microcredit organizations (Efendić & Hadžiahmetović, 2018), municipalities (Soko & Zorič, 2018), higher education (Figurek *et al.*, 2019), *etc*. So, to date, no work has been done in the BiH insurance industry. However, this method examined the efficiency of insurance companies in developed countries, and more recently in developing countries, which includes some countries in the region. Most of the analyses are focused on examining efficiency at the micro level. In doing so, the most important issue is the choice of inputs and outputs for analysis. The authors use different measures as inputs and outputs, without paying too much attention to their choice.

The efficiency of the banking and insurance sector in Croatia in the period before, during and after the crisis 2007–2008 is analyzed by Jurčević & Mihelja-Žaja (2013). The inputs used for insurance companies are net operating expenses, investment costs and incurred claims, and the outputs are earned premiums and investment income. The analysis shows the decline in efficiency in a crisis, i.e., the movement of efficiency in accordance with economic cycles. Similarly, Micajkova (2015) analyzes the efficiency of micro-level insurance companies in Macedonia in the five years following the crisis. In this analysis, the author uses administrative costs, commission costs, and total capital as inputs, and gross premiums written and gross claims paid as outputs. Knežević *et al*. (2015) analyze the efficiency of insurance companies in Serbia in the period 2009-2011. The analysis focuses on common balance sheet categories, so they use total assets, labor costs, and share capital as inputs, and total pre-tax income and profit as outputs.

Turkan, Polat, and Gunay (2013) apply the DEA method to the analysis of non-life insurance efficiency in Turkey using number of agents, number of brokers, fixed assets, and share capital as input, and investment income and collected premiums as output. The existence of significant differences in efficiency between life and non-life insurance is showed by Nektarios and Barros (2010), calculating the Malmquist Index for the Greek insurance industry. The final list of inputs includes labor costs, operating costs, and share capital, while selected outputs are invested funds, incurred losses, reinsurance reserves, and own reserves.

Some authors compare the efficiency of insurance in different countries. Thus, Škrinjarić (2016) analyzes the relative efficiency of the insurance industry of 29 European countries using the DEA method in the period between 2004 and 2013. It uses share of employees, paid premiums, and number of branches as inputs, and collected premiums, investments in investment portfolios, and the share of collected premiums in GDP as outputs.

From all the above, we can conclude that there is no consensus in terms of choosing the best inputs and outputs for analysis. Moreover, the authors pay very little attention to this issue, even though it is crucial for analysis. Although they use a wide range of measures as inputs or outputs, we see that the most common inputs are number of employees or labor costs, total or share capital, operating costs, investments, total assets, while the outputs are accrued or collected premiums, investment income, claims paid *etc*.

3. Overview of the insurance market in BiH

Insurance and reinsurance companies participate with BAM1.97 billion in the total assets of the financial sector in BiH, or 5.37%, which is a small share given the importance of the insurance sector as an institutional investor. If we look at the entities, Federation of Bosnia and Herzegovina (FBiH) and Republika Srpska (RS) separately, we notice that there is no significant difference. The amount of the total assets has a growth trend in absolute terms but is decreasing in relative terms, which indicates a highly bank-centric financial system in BiH with a trend of further strengthening the position of banks in it.

In the insurance market of BiH in 2019, there were 26 insurance companies and one reinsurance company. Out of a total of 26 insurance companies, 11 insurance companies have their headquarters in FBiH and 15 insurance companies have their headquarters in RS.

The BiH insurance market is characterized by the presence of a large number of bidders and none of them has a significant influence on the market. Given that the number of insurers changes frequently, we can conclude that there is a high degree of freedom of entry and exit from the industry (Kozarević, 2010). Therefore, the efficiency analysis needs to be performed on an unbalanced data panel.

several acquisitions and restructuring were carried out, so the data for certain companies in some years are inadequate. The insurance market in this period is characterized by a growth trend that can be observed through the growth of insurance premiums at an average annual rate of 6.92% and growth of total assets by 9.65%, but the general underdevelopment of the market is visible from the realized structure of premiums on the market, where compulsory insurance represents 49.73% (in FBiH 41%, in RS 70%) of the premium structure (Figure 1).

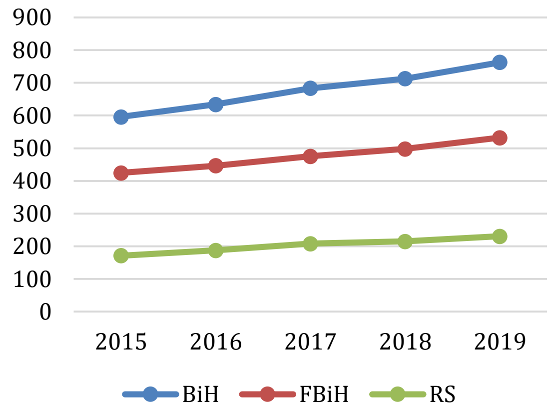

Figure 1. *Gross insurance premium in BiH, FBiH, and RS in the period 2015-2019 in millions of BAM*
Source: Authors' research

Figure 2 shows that out of 11 insurance companies in FBiH, four are engaged in non-life insurance and seven of them are in composite insurance.

Table 1. *Number of insurance companies in BiH for the period 2015-2019*

Year		*2015*	*2016*	*2017*	*2018*	*2019*
Number of insurance companies	*BiH*	24	27	27	26	26
	FBiH	12	13	13	11	11
	RS	12	14	14	15	15

Source: Authors' research

Table 1 shows number of insurance companies in BiH for the period 2015–2019. As we focused in this paper on analyzing the efficiency of the insurance sector in BiH through this period, the final sample consisted of 125 observations. The number of companies per year differs from the number of units for analysis because the companies established in the observed period do not have all the necessary data. In addition,

In RS, 12 companies deal with non-life insurance and only three with composite insurance. Of the total number of insurance and reinsurance companies, 15 are majority domestically and 12 are majority foreign-owned. However, companies with majority foreign capital participate in the total premium with 56.42%, and the share of companies with majority foreign capital in the life insurance market in 2019 is 97.39%.

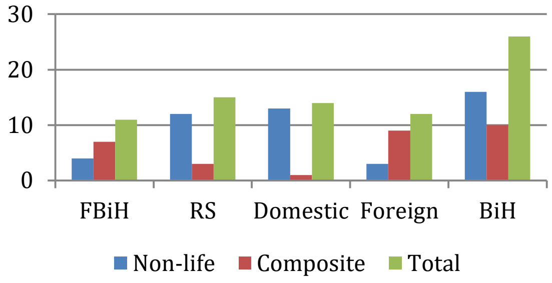

Figure 2. *Structure of insurance companies by type of insurance, ownership, and headquarters*
Source: Authors' research

4. Methodology

DEA is a nonparametric method of efficiency analysis based on linear programming that is used to evaluate the relative efficiency of comparable objects based on empirical data on predetermined inputs and outputs (Rabar, 2010). The DEA method makes it possible to compare the efficiency of units (Decision Making Unit - DMU) based on several input and output characteristics and detects areas of improvement for inefficient units (in our case, these are insurance companies). Some of the units represent a "benchmark" and form an efficient frontier, while for other units a relative position in relation to the benchmark is determined. Efficient units are assigned a coefficient of 1, and all others have coefficients ranging from 0 to 1. Inefficient DMUs achieve their efficiency by projecting to the efficiency frontier, and they can achieve it by reducing input or increasing output. For each inefficient DMU, there are several solutions to improve efficiency. The two basic DEA approaches are the CCR model (Charnes *et al.*, 1978) and the BCC model (Banker *et al.*, 1984). The CCR method is a quantitative model for estimating relative efficiency under the assumption of a constant return to scale. On the other hand, the BCC method uses a variable return to scale. Based on the DEA model, it is possible to formulate the model in two ways: as input-oriented, with the aim of minimizing input assuming constant output, or output-oriented, with the aim of maximizing output assuming constant input. In our analysis, we opted for the input-oriented DEA analysis with the assumption of variable return on scale (VRS). If we label the input variables for the DMU_j by x_{ij}, and y_{rj} the output variables, then we can formulate the model as follows:

$$\theta^* = min\theta \quad (1)$$

$$\sum_{j=1}^{n} x_{ij}\lambda_j \leq \theta^* x_{i0} \quad for \quad i = \overline{1,m} \quad (2)$$

$$\sum_{j=1}^{n} y_{rj}\lambda_j \geq y_{r0} \quad for \quad r = \overline{1,s} \quad (3)$$

$$\sum_{j=1}^{n} \lambda_j = 1 \quad (4)$$

$$\lambda_j \geq 0 \qquad j = 1,2,\dots,n \quad (5)$$

where θ is the technical efficiency of DMU_0, λ_j is a dual variable assigned to DMU_j and can be used for efficiency improvement, m is the number of inputs, s is the number of outputs, and n is the number of DMUs. The BCC model divides the technical efficiency (TE) obtained by the CCR model into two parts: pure technical efficiency (PTE) and scale efficiency (SE). PTE ignores the influence of scale size by comparing DMU units and measures how a DMU unit uses sources under exogenous conditions. On the other hand, SE shows how scale size affects efficiency and is expressed as:

$$SE = \frac{TE}{PTE} \quad (6)$$

A critical point in conducting a DEA efficiency analysis is the choice of inputs and outputs for the model. Based on a review of the recent literature, we can conclude that there is no unique position on which are the most important inputs and outputs of the insurance company. Moreover, unlike research in other industries, there is no clear distinction between inputs and outputs either. For example, Škrinjarić (2016) and Eling and Huang (2013) use invested funds in investment portfolios as output, although in most papers these investments represent inputs. The broader list of potential variables used to assess efficiency in this paper is largely limited by the available balance sheet data and is formed based on the literature in this field. Potential inputs are number of employees, capital, investments, and total assets. On the other hand, potential outputs include: accrued premiums, claims payments, total income. Given that we do not have data on investments for all companies for the entire observed period, and that the total assets were rarely used in previous surveys as input for the insurance sector, the final list of inputs includes number of employees and capital.

Table 2. *Correlation matrix of potential inputs and outputs*

	Gross premiums	*Claims payments*	*Total income*	*Capital*	*Total assets*	*Number of employees*
Gross premiums	1.000					
Claims payments	0.891	1.000				
Total income	0.888	0.913	1.000			
Capital	0.738	0.699	0.650	1.000		
Total assets	0.764	0.668	0.753	0.692	1.000	
Number of employees	0.815	0.847	0.789	0.668	0.518	1.000

Source: Authors' research

Table 2 presents the correlation matrix of potential inputs and outputs. The correlation coefficients among observed inputs are positive, but not high enough to eliminate any of them. On the other hand, there is an extremely high degree of correlation among potential outputs which allows us to reduce output list.

According to the basic definition of insurance, it represents the transfer of risk from the insured to the insurer, which assumes the obligation to compensate potential losses from the fund formed from collected insurance premiums (Kozarević, 2010) and from which it is clear that the company aims to increase the amount of insurance premium.

Considering previous and the fact that in most researches gross premium represents the most significant output, we conclude that the calculated premiums represent an appropriate output. In the second phase of the analysis, for a more complete understanding of efficiency changes, we used the Malmquist Index to measure technological progress defined by Fare *et al.* (1994), which allows the analysis of DEA efficiency time series. The Malmquist Index shows the productive power of units (x_t, y_t) compared to (x_{t+1}, y_{t+1}):

$$M(y_t . x_t . y_{t+1} . x_{t+1}) = \frac{D^{t+1}(y_{t+1} . x_{t+1})}{D^t(y_t . x_t)} \cdot \left[\frac{D^t(y_{t+1} . x_{t+1})}{D^{t+1}(y_{t+1} . x_{t+1})} \cdot \frac{D^t(y_t . x_t)}{D^{t+1}(y_t . x_t)}\right]^{\frac{1}{2}} \qquad (7)$$

where M is the geometric mean of the two indices of the total technology factor productivity in time *t* and *t+1*. $D^t(y_t, x_t)$ is a distance function that is inverse to Farrell's technical efficiency. The higher value of this function means more efficient production and a higher level of technical efficiency. The Malmquist Index is divided into changes in technical efficiency and technological changes. Technological efficiency greater than one represents production decision-making on units being closer to marginal production, and technological efficiency being increased. Technological changes indicate technical progress and show a shift in the technical limit in the period from *t* to *t+1*. If the technological change is greater than one, it means that it is technological progress and, in the opposite, technological regression.

Since the calculation of the Malmquist Index of technological progress requires a balanced panel sample, we reduced the sample to 21 companies that achieved business continuity over the observed five years. If the Malmquist Productivity Index (M) is greater than 1, it means that there is a positive growth (*i.e.*, an increase) in total factor productivity (TFP) between *t* and *t+1*. A value less than 1 means the opposite.

5. Empirical results

Based on the defined sample and methodology, we formed a grand frontier, which allows us to compare the average efficiency over time (Figure 3).

The results of the DEA analysis for the BiH insurance industry in the period 2015-2019 are presented in Appendices 1-4.

Based on the initial results, we can conclude that technical efficiency had a trend of slight growth during the observed period, with a significant decline in FBiH during 2016 and stagnation in RS in the period 2016-2018. In general, there was a very low efficiency with a potential for improvement of almost 50%, *i.e.*, insurance companies overall waste twice as much input than is necessary for a given level of output.

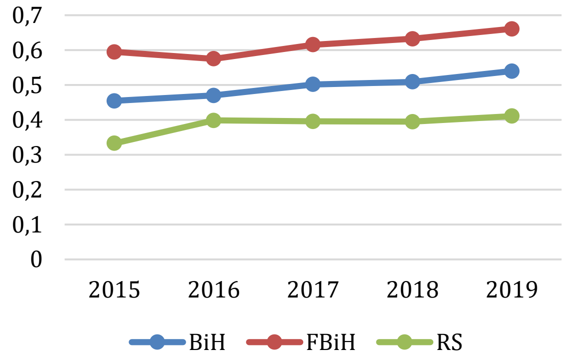

Figure 3. *Change of VRS technical efficiency of insurance companies in BiH in the period 2015-2019*
Source: Authors' research

Given the relatively low overall efficiency of the sector and the fact that the DEA is very sensitive to measurement errors, in the additional analysis, we omitted from the sample all units that primarily formed the efficient frontier *i.e.*, that proved to be 100% efficient.

There were 17 such companies and they were fairly evenly distributed during the observed period.

Eight companies from the primary efficient border represent a benchmark for more than 10 other companies, which indicates their real dominance in efficiency compared to other companies. The common characteristic of all companies on this frontier is many times above-average total assets, *i.e.*, we can conclude that these are large insurance companies.

However, the difference in results with and without these units is significant and shows a change in efficiency of 19 percentage points (Figure 4).

The efficiency results on the reduced sample show that efficient banks are special cases and that the first assessment is not reliable.

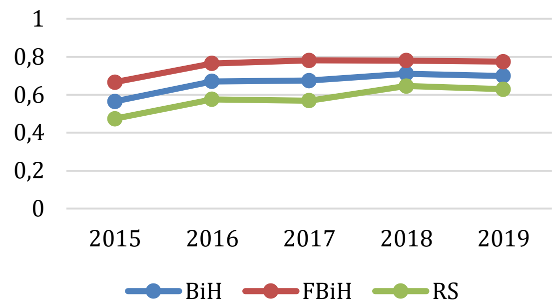

Figure 4. *Change of VRS technical efficiency of insurance companies in BiH in the period 2015-2019 with primarily efficient companies excluded*
Source: Authors' research

Based on the obtained results, we can conclude that the efficiency of insurance companies in BiH with the assumption of variable return to scale increased in the analyzed period by 14 percentage points. The increase in efficiency is largely due to the growth of output (gross premium) with an equally used level of input (capital and employees). Looking at the two analyzed cases separately, a significant difference is observed in the deviation of the measurement efficiency with the assumption of constant return to scale and variable return to scale. In the complete sample, the difference of variable return to scale technical efficiency (VRSTE) and constant return to scale technical efficiency (CRSTE) is expressed, which indicates the existence of scale inefficiency in a large number of companies.

That is, most companies could improve efficiency indicators by changing the volume of activities or the percentage of capacity utilization, or by making better use of economies of scale. However, without primarily efficient companies, the relationship between CRSTE and VRSTE is much more uniform. Also, regardless of which of the analyzed cases we observe, we notice a significant difference in the efficiency of the insurance sector between the two entities, FBiH and RS. To test the distribution equality hypothesis, we used the nonparametric Man Whitney U test, which is used to test differences between independent samples. The results of the Man Whitney U test confirmed the existence of a significant difference in the efficiency of insurance companies depending on the location of the insurance company.

Table 3. *Results of the Mann Whitney U and Kruskal Wallis test to compare the differences between (1) FBiH and RS, (2) composite and non-life insurance, (3) large, medium and small companies*

Ranks					*Test Statistics*	
Mann Whitney test		*N*	*Mean*	*Sum of Ranks*		*VRSTE*
VRSTE	*FBiH*	*63*	*49.97*	*3148.00*	*M-W U*	*1132.000*
	RS	*62*	*76.24*	*4727.00*	*Z*	*-4.058*
	BiH	*125*			*Asymp. Sig. (2-tailed)*	*0.000*
Ranks					*Test Statistics*	
Mann Whitney test		*N*	*Mean*	*Sum of Ranks*		*VRSTE*
VRSTE	*Composite*	*50*	*88.47*	*4423.50*	*M-W U*	*601.500*
	Non-life	*75*	*46.02*	*3451.50*	*Z*	*-6.425*
	Total	*125*			*Asymp. Sig. (2-tailed)*	*0.000*
Ranks					*Test Statistics*	
Kruskal Wallis Test		*N*		*Mean*		*VRSTE*
VRSTE	*Large*	*22*		*40.69*	*Chi-Square*	*29.082*
	Medium	*66*		*65.66*	*df*	*2*
	Small	*37*		*92.55*	*Asymp. Sig.*	*0.000*

Source: Authors' research

Although the movement of efficiency indicators in both entities over the years is highly correlated, the technical efficiency of insurance companies in FBiH is constant by 16-30 percentage points above the efficiency in RS. This indicates the existence of significant systemic differences between the two BiH entities.

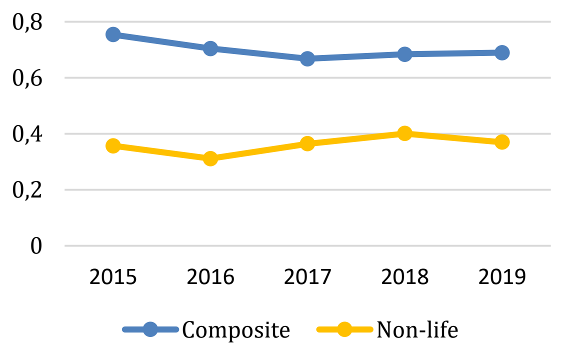

Figure 5. *Change in VRS technical efficiency concerning the type of insurance in the period 2015-2019*
Source: Authors' research

These results are caused by the fact that in FBiH insurance companies dealing with composite insurance predominate, while in RS dominant insurance companies are those dealing with non-life insurance.

We tested the hypothesis of a difference in efficiency between these two types of insurance companies and confirmed the existence of a significant difference. It can also be caused by the fact that almost all companies dealing with composite insurance are majority foreign-owned.

Finally, all insurance companies can be divided into three groups according to the size of assets, and in this sense, we distinguish: large (whose assets exceed BAM100 million), medium (with assets between BAM20 million and 100 million) and small (with assets less than BAM20 million). Figure 6 shows VRSTE for these three groups.

By testing the differences among the three independent samples by the Kruskal Wallis test, we come to the conclusion that the differences in efficiency are significant depending on the size of the insurance company. The average value for each of the groups indicates that large insurance companies are significantly more efficient than medium and small ones.

Additionally, the Pearson correlation coefficient between the technical efficiency of companies and their size is 0.59.

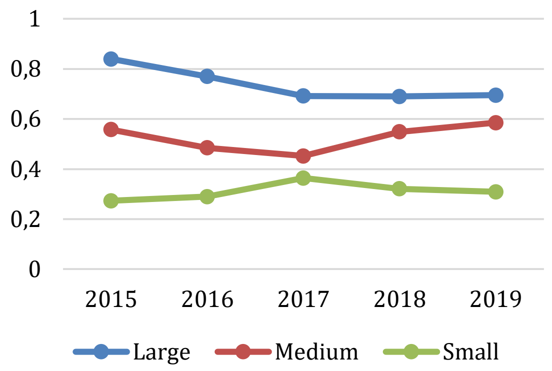

Figure 6. *Change in VRS technical efficiency given the size of the insurance company's assets in the period 2015-2019*
Source: Authors' research

In further analysis, we calculated the Malmquist efficiency change index and found strong technological progress at the beginning of the observed period between 2015 and 2016, and stagnation over the next two years, which even declined during 2019 (Figure 7). The results of the analysis of the Malmquist index of efficiency change in the period 2015-2019 are presented in Appendix 5.

The indicator of total factor efficiency is positively correlated with the movement of scale efficiency, and negatively correlated with pure technical efficiency. Also, the general index of efficiency change in all years is above 1, which indicates a slight shift of the frontier from year to year and an increase in efficiency. However, here too it is important to note that the growth is lower from year to year and that a more complete picture will be obtained by including it in the analysis of the following years.

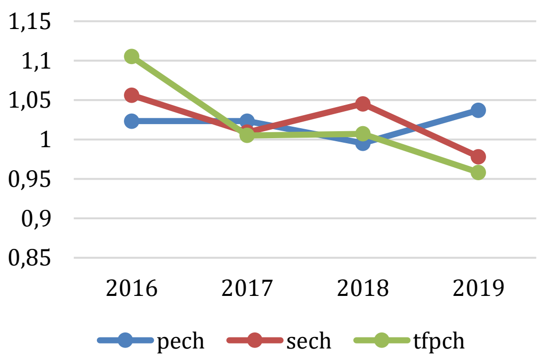

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Figure 7. *Total factor efficiency of insurance companies in BiH in the period 2015-2019 measured by the Malmquist efficiency index*

Source: Authors' research

The DEA analysis enables the identification of efficient units but also a post-optimal analysis that indicates a possible increase in the efficiency of the DMU by reducing inputs or increasing output. A linear combination of dual variables and efficient DMUs is a benchmark for inputs or outputs of inefficient units. Improving efficiency in the insurance sector can be sought by analyzing the selected inputs and outputs in the model.

According to Kozarević and Čivić (2013), some of the obstacles that slow down development of the insurance sector in BiH are the lack of experience in risk management and lack of managerial and actuarial experience, as well as unregulated issue of educating the staff who should perform actuarial activities.

These disadvantages are substituted by the larger number of employees needed to achieve the given output, which reduces efficiency. Graph 5 shows the dominance in the efficiency of companies based on composite insurance comparing to non-life insurance. The insufficient representation of life and property insurance and the orientation of insured persons to compulsory insurance is an indirect consequence of the aforementioned shortcomings of managerial and actuarial experience.

This greatly reduces the potential for serious gross premium growth. Currently, in the structure of insurance premiums, life insurance, and property insurance participate with only 28%, so the growth potential from this aspect certainly exists. Closely related to this problem is the evident loss of confidence in the insurance sector due to frequent insolvency of insurers and delays in the payment of claims. Therefore, efficiency and better management of claims pay consequently lead to greater efficiency of the entire sector.

The cause of inefficiency is also the limited growth of output, insurance premiums, as a result of poor investment policies, which can be caused by accumulated problems due to poor investment policy in the past, but also an underdeveloped financial market that limits investment opportunities.

In this sense, the efficiency of the insurance sector depends on the development of the financial market in BiH, and the development of the financial market would result in a significant increase in efficiency.

It is also necessary to observe the impact of the structural characteristics of the entire industry because it largely determines the performance of insurance companies. In this sense, the concentration of a large number of insurers in a relatively small and underdeveloped market and unfair competition make it impossible to increase productivity. Many insurance companies use the strategy of dumping prices when calculating the premium, which has a negative effect on the amount of the premium in the entire sector (Ševkušić, 2018.). In this regard, regulators also play a very important role in increasing efficiency.

Reforms lead to a more regulated market, and this attracts foreign investors. The analysis showed the dominance of large insurance companies in efficiency over the small ones. Therefore, the trend of consolidation of companies and acquisition of smaller companies by the large ones, which was present in the last two years, should lead to increased efficiency.

Finally, in the introduction of the paper, we pointed out that the development of the economy, in general, leads to the development of insurance. Therefore, raising the standard of living and national income will lead to an increase in savings, and consequently to higher total premiums and an increase in the efficiency of insurance.

6. Conclusion

In the presented paper, we analyzed the efficiency of the insurance sector in BiH in the period between 2015 and 2019 using the DEA method.

Measuring efficiency is extremely important for understanding market movements as a whole because a developed insurance industry improves the competitiveness of the whole economy and the efficiency of capital allocation. The obtained results can be observed in several stages.

The formation of the primary efficiency frontier provides an image of the relatively low level of efficiency of the entire sector. Inefficiency is equally caused by pure technical inefficiency, but also by underutilization of economies of scale. However, several insurance companies that make up an efficiency frontier are dominantly more efficient than others. When these companies are excluded from the analysis, the average relative efficiency is higher by 19 percentage points and almost at the level of 70% in 2019.

The analysis also identified a significant difference in the efficiency of insurance in the entities of FBiH and RS, which indicates the existence of systemic differences and opens door to new research in the context of the causes of such deviations. Also, it was found that companies dealing with composite insurance are significantly more efficient than companies dealing only with non-life insurance, but also that the efficiency of insurance companies is positively correlated with their size.

Additionally, we analyzed the efficiency trend using the Malmquist efficiency change index and determined a declining rate of technological progress over the observed period, with a decline in 2017. We noticed significant differences in efficiency between defined groups but also established the potential for efficiency growth in the coming period through the elimination of the main causes of inefficiency.

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APPENDIX

Appendix 1. *Results of the DEA analysis for the BiH insurance industry in the period 2015-2019*

	2015.	*2016.*	*2017.*	*2018.*	*2019.*
CRSTE	0.1979	0.2243	0.2128	0.2017	0.2482
VRSTE	0.4302	0.4916	0.4543	0.4696	0.5017
SCALE	0.5455	0.5306	0.5248	0.4858	0.5298
No. CRSTE efficient	0	0	1	0	1
No. VRSTE efficient	4	4	2	2	2
No. SCALE efficient	0	0	1	0	1

Appendix 2. *Results of the DEA analysis for the BiH insurance industry in the period 2015-2019 after switching off the DMU on the primary frontier*

	2015.	*2016.*	*2017.*	*2018.*	*2019.*
CRSTE	0.5209	0.5908	0.6214	0.6193	0.6320
VRSTE	0.5650	0.6707	0.6750	0.7108	0.6987
SCALE	0.9131	0.8915	0.9168	0.8744	0.8930
No. CRSTE efficient	0	1	1	1	0
No. VRSTE efficient	0	3	1	3	2
No. SCALE efficient	0	1	1	1	0

Appendix 3. *Results of the DEA analysis*

	crste	*vrste*	*scale*	
1	0.194	0.248	0.783	irs
2	0.198	0.672	0.294	drs
3	0.104	0.161	0.647	irs
4	0.238	0.689	0.345	drs
5	0.213	0.788	0.271	drs
6	0.132	0.312	0.423	drs
7	0.548	1.000	0.548	drs
8	0.162	1.000	0.162	drs
9	0.141	0.326	0.432	drs
10	0.255	1.000	0.255	drs
11	0.118	0.396	0.297	drs
12	0.112	0.225	0.496	drs
13	0.134	0.153	0.877	drs
14	0.134	0.136	0.986	drs
15	0.188	0.267	0.705	drs
16	0.087	0.149	0.587	drs
17	0.807	1.000	0.807	irs
18	0.125	0.272	0.458	drs
19	0.102	0.154	0.662	irs
20	0.098	0.271	0.363	irs
21	0.202	0.211	0.954	irs
22	0.112	0.261	0.431	irs
23	0.120	0.204	0.589	irs
24	0.203	0.228	0.892	irs
25	0.195	0.633	0.308	drs
26	0.126	0.157	0.806	irs
27	0.267	0.964	0.277	drs
28	0.222	0.849	0.262	drs
29	0.130	0.331	0.392	drs
30	0.504	1.000	0.504	drs
31	0.160	0.981	0.163	drs
32	0.145	0.339	0.426	drs
33	0.282	1.000	0.282	drs
34	0.115	0.364	0.316	drs
35	0.114	0.258	0.440	drs
36	0.609	1.000	0.609	drs
37	0.136	0.137	0.994	drs
38	0.193	0.335	0.577	drs
39	0.100	0.155	0.641	drs
40	0.914	1.000	0.914	irs
41	0.099	0.141	0.705	irs
42	0.108	0.230	0.472	irs
43	0.194	0.195	0.994	irs
44	0.122	0.223	0.547	irs
45	0.163	0.672	0.243	irs
46	0.138	0.204	0.675	irs
47	0.131	0.402	0.325	drs
48	0.197	0.298	0.661	drs
49	0.198	0.634	0.312	drs
50	0.142	0.156	0.906	irs
51	0.293	0.845	0.347	drs

52	0.240	0.814	0.295	drs
53	0.140	0.364	0.386	drs
54	0.470	0.929	0.506	drs
55	0.159	0.687	0.231	drs
56	0.156	0.389	0.401	drs
57	0.290	1.000	0.290	drs
58	0.122	0.402	0.305	drs
59	0.122	0.387	0.316	drs
60	0.089	0.129	0.691	irs
61	0.136	0.158	0.863	drs
62	0.215	0.470	0.458	drs
63	0.091	0.166	0.551	drs
64	1.000	1.000	1.000	-
65	0.102	0.142	0.723	irs
66	0.112	0.199	0.560	irs
67	0.184	0.210	0.878	drs
68	0.129	0.198	0.650	irs
69	0.252	0.606	0.417	irs
70	0.136	0.191	0.713	irs
71	0.112	0.529	0.211	drs
72	0.204	0.405	0.505	drs
73	0.200	0.649	0.309	drs
74	0.153	0.158	0.966	irs
75	0.060	0.135	0.445	irs
76	0.293	0.897	0.326	drs
77	0.211	0.753	0.281	drs
78	0.142	0.381	0.373	drs
79	0.383	0.749	0.512	drs
80	0.159	0.567	0.280	drs
81	0.170	0.479	0.356	drs
82	0.293	1.000	0.293	drs
83	0.136	0.519	0.263	drs
84	0.123	0.407	0.301	drs
85	0.118	0.121	0.974	irs
86	0.139	0.163	0.854	drs
87	0.236	0.527	0.447	drs
88	0.112	0.227	0.493	drs
89	0.162	0.384	0.421	irs
90	0.966	1.000	0.966	drs
91	0.066	0.218	0.301	irs
92	0.133	0.211	0.628	irs
93	0.192	0.235	0.816	drs
94	0.143	0.162	0.881	irs
95	0.363	0.671	0.540	irs
96	0.074	0.937	0.079	irs
97	0.135	0.189	0.713	irs
98	0.127	0.535	0.237	drs
99	0.205	0.497	0.413	drs
100	0.194	0.623	0.312	drs
101	0.112	0.144	0.777	irs
102	0.175	0.638	0.275	drs
103	0.257	0.802	0.321	drs
104	0.205	0.708	0.290	drs
105	0.140	0.452	0.311	drs
106	0.376	0.779	0.483	drs
107	0.151	0.578	0.261	drs
108	0.184	0.546	0.338	drs
109	0.281	0.958	0.293	drs
110	1.000	1.000	1.000	-
111	0.112	0.281	0.398	drs
112	0.140	0.261	0.536	drs
113	0.148	0.195	0.760	drs
114	0.219	0.488	0.449	drs
115	0.125	0.291	0.429	drs
116	0.174	0.306	0.567	irs
117	0.955	1.000	0.955	drs
118	0.042	0.198	0.214	irs
119	0.130	0.198	0.660	irs
120	0.198	0.260	0.762	drs
121	0.139	0.151	0.923	drs
122	0.404	0.680	0.594	irs
123	0.135	0.615	0.220	irs
124	0.137	0.180	0.758	irs
125	0.162	0.717	0.226	drs
Mean	**0.216**	**0.471**	**0.519**	

Appendix 4. *Results of DEA analysis with DMU excluded on the primary frontier*

	crste	*vrste*	*scale*	
1	0.674	0.774	0.871	irs
2	0.714	0.723	0.987	drs
3	0.391	0.466	0.839	irs
4	0.748	0.760	0.985	drs
5	0.810	0.833	0.972	drs
6	0.449	0.462	0.971	irs
7	0.368	0.369	0.998	irs
8	0.703	0.711	0.988	irs
9	0.881	0.898	0.98	irs
10	0.374	0.404	0.927	irs
11	0.460	0.507	0.908	irs
12	0.637	0.684	0.931	irs
13	0.378	0.400	0.945	irs
14	0.425	0.442	0.962	irs
15	0.356	0.422	0.843	irs
16	0.304	0.419	0.724	irs
17	0.433	0.465	0.932	irs
18	0.364	0.476	0.764	irs
19	0.428	0.520	0.822	irs
20	0.727	0.819	0.889	irs
21	0.686	0.697	0.984	drs
22	0.725	0.802	0.904	irs
23	1.000	1.000	1	-
24	0.843	0.938	0.898	drs
25	0.445	0.455	0.978	irs
26	0.576	1.000	0.576	drs
27	0.372	0.374	0.994	drs
28	0.677	0.687	0.985	irs
29	0.864	0.880	0.981	irs
30	0.451	0.495	0.91	irs
31	0.654	0.693	0.944	irs
32	0.542	0.569	0.951	irs
33	0.368	0.432	0.851	irs
34	0.348	0.445	0.783	irs

35	0.413	0.450	0.919	irs
36	0.416	0.514	0.81	irs
37	0.645	1.000	0.645	irs
38	0.487	0.576	0.846	irs
39	0.577	0.588	0.981	irs
40	0.873	0.929	0.939	irs
41	0.674	0.692	0.974	drs
42	0.806	0.876	0.919	irs
43	0.875	0.905	0.967	drs
44	0.838	0.884	0.948	drs
45	0.463	0.470	0.984	irs
46	1.000	1.000	1	-
47	0.547	0.731	0.748	drs
48	0.392	0.415	0.945	drs
49	0.702	0.712	0.986	irs
50	0.973	0.977	0.996	irs
51	0.528	0.598	0.882	irs
52	0.470	0.512	0.918	irs
53	0.732	0.761	0.963	irs
54	0.370	0.391	0.946	irs
55	0.328	0.380	0.862	irs
56	0.375	0.460	0.815	irs
57	0.407	0.437	0.933	irs
58	0.444	0.529	0.841	irs
59	0.714	0.945	0.756	irs
60	0.478	0.559	0.856	irs
61	0.681	0.688	0.991	drs
62	0.908	0.951	0.955	irs
63	0.685	0.706	0.97	drs
64	0.911	0.979	0.931	irs
65	0.522	0.667	0.783	irs
66	0.856	0.943	0.908	drs
67	0.755	0.834	0.905	drs
68	0.464	0.468	0.99	irs
69	0.868	0.873	0.994	irs
70	0.564	0.627	0.9	drs
71	0.430	0.507	0.849	drs
72	0.812	0.815	0.996	irs
73	1.000	1.000	1	-
74	0.695	0.747	0.931	irs
75	0.478	0.521	0.919	irs
76	0.779	0.805	0.968	irs
77	0.388	0.406	0.954	irs
78	0.633	0.822	0.771	irs
79	0.180	0.295	0.61	irs
80	0.431	0.515	0.837	irs
81	0.427	0.455	0.939	irs
82	0.526	0.594	0.885	irs
83	0.811	1.000	0.811	irs
84	0.200	1.000	0.2	irs
85	0.471	0.550	0.856	irs
86	0.689	0.691	0.997	drs
87	0.900	0.932	0.966	irs
88	0.644	0.669	0.962	drs
89	0.665	0.739	0.901	irs
90	0.949	0.956	0.993	irs
91	0.779	0.842	0.925	drs
92	0.715	0.781	0.916	drs
93	0.499	0.502	0.994	drs
94	0.865	0.865	0.999	irs
95	0.548	0.638	0.858	drs
96	0.475	0.575	0.826	drs
97	0.947	1.000	0.947	drs
98	0.777	0.793	0.98	irs
99	0.539	0.570	0.946	irs
100	0.501	0.540	0.927	irs
101	0.727	0.752	0.967	irs
102	0.491	0.510	0.963	irs
103	0.616	0.756	0.815	irs
104	0.124	0.255	0.488	irs
105	0.422	0.499	0.846	irs
106	0.445	0.470	0.946	irs
107	0.564	0.614	0.919	irs
108	0.876	1.000	0.876	irs
109	0.407	0.805	0.505	irs
110	0.473	0.546	0.866	irs
111	0.853	0.858	0.994	drs
Mean	**0.601**	**0.669**	**0.897**	

Appendix 5. *Results of the analysis of the Malmquist efficiency change index in the period 2015-2019.*

	effch	*techch*	*pech*	*sech*	*tfpch*
2016.	1.081	1.023	1.023	1.056	1.105
2017.	1.030	0.976	1.023	1.007	1.005
2018.	1.040	0.969	0.995	1.045	1.007
2019.	1.015	0.944	1.037	0.978	0.958
Average	1.041	0.977	1.019	1.021	1.018