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Has Accession to the European Union Affected the Efficiency of Croatian Insurance Companies?

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Abstract: *Accession of Croatia to the EU brought legal, regulatory and market changes for the insurance companies. The question that arises is whether the new environment in which the companies operate has improved their efficiency. Accordingly, the aim of this paper is to separately estimate the efficiency of non-life and life insurance industry in Croatia and to compare it through the period before (2009-2012) and after (2013-2018) Croatian accession to the EU. The research is based on the Data Envelopment Analysis and the obtained results indicate an average increase in overall technical efficiency in both, non-life and life sector in period after Croatia's accession to the EU. Still, this increase was not proved to be significant. Additionally, although increase in pure technical efficiency was significant in non-life sector, an insignificant slight decrease is recorded in life sector. Finally, insurers conducting (non)life business activities are mainly operating at increasing returns to scale.*

Keywords: efficiency; Croatian insurance companies; accession to the EU; DEA

JEL Classification: G22, C67, D22

Introduction

Frontier methodologies that measure the performance of the company in comparison to the "best practice" frontier, made from the most efficient companies in the industry, have growing application in the insurance literature. According to Cummins & Weiss

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(2013), these methodologies could be used for testing economic hypotheses and for comparison of efficiency across insurance markets in different countries. Additionally, they provide information for regulators that are important for regulatory responses to the developments in the market and economy, as well for the managers of insurance companies to get known about the effects of applied strategies and technologies.

Eling & Luhnen (2010b), Cummins & Weiss (2013) and Kaffash & Marra (2017) provide comprehensive review of the existing literature on efficiency of insurance business from the perspectives of the application field, input and output, industry segment, methodology and countries. Although the majority of the existing studies in the field of efficiency of insurance companies consider a specific country, Croatia is rarely encompassed in the research. According to the authors best knowledge there are two studies on efficiency of Croatian insurance companies (Medved & Kavčič, 2012; Jurčević & Mihelja Žaja, 2013) and one study at cross-country level that includes Croatian insurance industry (Škrinjarić, 2016). However, neither of the existing studies analyse the effect the accession to the European Union (hereinafter: EU) might have on the efficiency of Croatian insurance companies. However, among other legal, regulatory and economic transformations, accession of Croatia to the EU was related to numerous changes in legislation, regulation and structure of Croatian insurance market, all of which could affect efficiency of the insurance companies. Thus, in the context of Croatian accession to the EU in 2013, Croatian insurance market represents particularly interesting background in which to investigate efficiency. Specifically, with the aim of ensuring full integration of the Croatian insurance market into the single European market and the application of legal provisions in Croatia and other EU member states, alignments with the *acquis communautaire* were constantly made prior to the accession to the EU. Hence, all the related directives had been implemented in Croatian legal framework before Croatian accession to the EU, but as of July 1, 2013, these were put into force opening Croatian insurance market to cross-border competitors. This means that insurers with the headquarters in Croatia were permitted to actively take part in insurance markets in EU and vice versa. Therefore, an increase of efficiency could be expected. Furthermore, Croatian insurance industry is an essential part of the total financial market with approximately 7% stake in 2018 (Croatian Financial Services Supervisory Agency and Croatian National Bank, 2019) while the implementation of new regulatory framework as a part of the integration process has set both challenges and opportunities for insurance companies.

Consequently, the main aim of the research is to analyse and compare the efficiency of Croatian insurers in the period before the accession of Croatia to the EU (2009-2012) and the period after the integration to the single market (2013-2018). In this way the authors tested how efficiency has changed over that time providing evidence whether joining the EU and becoming a part of a single EU market has increased efficiency. The analysis is based on the sample of non-life, life and composite insurance companies by separating non-life and life insurance segments.

The study contributes to the research of the efficiency of insurance business in several ways. It is the first study in the domestic literature that compares the efficiency of insurance business segments prior to and after becoming a member of the EU. Moreover, it is the only study that separately analyses Croatian non-life and life insurance segment while estimating overall technical, pure technical and scale efficiency. Furthermore, the research bridges the gap in the domestic insurance literature by examining returns to scale. Finally, the study adds to the research on the efficiency of insurance business in less developed insurance markets.

The paper is structured as follows. The next section provides the literature review. Section 3 describes methodology and specifies the inputs and outputs used in the analysis, while section 4 presents the results. Robustness check follows afterwards while the last section concludes.

Literature review

Starting with the pioneer work of Farrell (1957) the frontier efficiency analysis has been applied in numerous studies of efficiency of companies operating in various industries. In the last decades there is growing number of studies in the field of financial industry, especially banking (514 out of 620 papers with DEA application in analysing efficiency of financial services' providers, that are reviewed by Kaffash & Marra (2017), belong to banking industry), but there is an increasing number of works in the insurance literature, too. While the initial research was primarily conducted on the sample of U.S. insurance companies, latter studies analyse efficiency of insurance companies operating in other countries, especially in Europe. In the last years, more research has been done in emerging countries.

There are three comprehensive reviews of the existing studies in the field of efficiency of insurance companies. Eling & Luhnen (2010b) provide review of frontier efficiency measurement in insurance business, analysing 95 studies. The second review of the research was given by Cummins & Weiss (2013) providing the analysis of 74 studies in the field of insurance companies efficiency and productivity. Kaffash & Marra (2017) review papers that apply data envelopment analysis (DEA) in financial services – banks, insurance companies and money market funds. They analyse 620 papers and 59 of them refer to studies of insurance companies' efficiency. While the last study is focused on DEA methodology application, the first two studies provide review of the literature from the perspectives of inputs and outputs, methodology, industry segment, the application field, and country. The summary of the main issues follow with the special focus on the review of the research on the effect of regulatory change on efficiency of insurance companies and the research of Croatian insurers' efficiency.

According to Cummins & Weiss (2013) insurance companies use the following inputs: labour, business services and materials, and capital. Considering the labour,

since the data on the quantity of labour are usually not available, in the existing empirical studies, researchers usually apply total labour costs divided by wage rate. The same is applied for business services, using the price indices. The capital employed in insurance business is consisted of physical, equity and debt capital. According to previously mentioned authors, physical capital is often encompassed in the category of business services and materials input. However, most of the empirical studies apply labour and capital as inputs.

Considering the choice of outputs, there are three approaches for measuring output of companies in financial service industry: intermediation (assets) approach, the user-cost approach and the value-added (production) approach (Berger & Humphrey, 1992). According to Cummins & Weiss (2013) the last approach is the most appropriate for analysing efficiency of insurance companies and it is the most used approach in the existing empirical studies. The outputs are important if they create added value, estimated on operating cost allocations. In the line with this method of measuring output, insurance companies provide three main services: risk-pooling and risk-bearing, "real" financial services related to insured losses and intermediation service. The first service is related to organizing a risk pool that results in risk reduction, collecting premiums from policyholders and redistributing the collected money to those who suffer losses. The real services that add value to policyholders are related to loss prevention services, designing of coverage programs and recommendation on deductibles and policy limits (non-life insurance) as well as financial planning (life insurance). The third service consists of financial intermediation functions. Insurance companies create value by issuing financial instruments and investing the collected funds to financial markets. For all three services, the output proxies have to be defined. When considering proxy for the first service, there is debate among researchers between premiums and present value of losses (non-life insurance) or incurred benefits (life insurance). According to Eling & Luhnen (2010b) a number of existing studies that apply claims/present value of claims is higher in comparison to those that use premiums as proxy for the insurance companies' services related to risk-pooling and risk-bearing. However, since data on claims/benefits are not publicly available for some countries, the researchers often use premiums as the proxy. Intermediation function is usually measured by additions to reserves or investment assets. The proxies for the two above mentioned services are also related to the "real" financial service.

There are two main approaches in the efficiency measurement: the econometric (parametric) and the mathematical programming (non-parametric) approach. The most used method is DEA that belongs to the mathematical programming approaches. It analyses the relationship between outputs and inputs using linear programming. The results of the optimization process are the efficiency scores. There are two DEA models. The first one assumes constant returns to scale and the second one variable returns to scale (Eling & Luhnen, 2010b, p. 224).

Taking into consideration the field of application of the frontier efficiency methodology, Eling & Luhnen (2010b) categorize the research into ten fields. They encompass: financial and risk management and capital utilization, distribution systems, level of efficiency as well as its evolution over time, cross-country comparisons, market structure, merger activities, methodology issues and comparison of various techniques or assumptions, changes in regulation, organisational form and corporate governance issues, scale and scope economics. Due to the focus of our study, we review the papers in the field of the effect of regulation change with the special emphasis on the integration to the EU on efficiency of insurance companies.

Rees & Kessner (1999) analyse effect of deregulation related to removing the obstacles to competition within and between insurance industries of the members of the EU, on the efficiency of U.K. and German life insurance companies. They find modest improvements of the efficiency in the period from 1992 to 1994. Ryan & Schellhorn (2000) study the impact of the risk-based capital (RBC) requirements on cost efficiency of US life insurance companies in the period 1990-1995. According to the results, X-efficiency did not change, implying that the new capital requirements did not adversely affect the efficiency. Mahlberg & Url (2003) research the effect of the single market on efficiency of Austrian insurance companies in the period 1992-1999. The single market reduced the dispersion of efficiency scores over time. However, insurance companies in Austria have significant inefficiencies. On the other hand, Ennsfellner, Lewis & Anderson (2004) find positive impact of deregulation on production efficiency of Austrian insurance companies over the period from 1994 to 1999. The authors state that if the experience of insurance companies in Austria is representative, similar benefits from the accession to the EU may be expected for Central and Eastern countries that prepare for the membership. However, the differences among countries should be taken into account (Ennsfellner, Lewis & Anderson, 2004). Turchetti & Daraio (2004) study the impact of deregulation on efficiency of Italian motor insurers during the period 1982–2000 and find that cost efficiency increased, especially in the second half of 1990s, while the pure technical and scale efficiency stayed at high levels during the whole period. Cummins & Rubio-Misas (2006) analyse the effect of deregulation and consolidation on Spanish insurance industry for the period of 1989-1998. Deregulation resulted in reduction of number of insurance companies, significant increase of average size of the companies, decline of unit prices and in increased efficiency. Motivated by liberalisation of European insurance markets, Fenn, Vencappa, Diacon, Klumpes & O'Brien (2008) estimate cost and profit efficiency of life, non-life and composite insurance companies, operated in 14 countries for the period 1995-2001. Most of the insurance companies operate under condition of decreasing costs. Company size and market share significantly determine X-inefficiency with respect to cost as well as profits. The single insurance market at the European level is not yet a full reality. Smaller companies have relatively higher level of cost efficiency. The largest insurers are the

most profit-efficient implying that the market power at the European level can be effective. The study of impact of deregulation and liberalisation on efficiency of Taiwanese life insurers from 1981 to 2004, performed by Jeng & Lai (2008), evidences that the changes did not adversely affect the technical, cost and revenue efficiency of the existing domestic insurers in the long-run. For the new companies it is easier to become technically efficient in the short period after entering the market, while getting cost and revenue efficiency is more difficult. The findings of the study of Mahlberg & Url (2010) on the effect of the European single market on productivity of German insurance groups over the period 1991 through 2006, show increase of total factor productivity but the improvements in pure technical efficiency are small. Additionally, the most inefficient insurers did not improve their position relative to the benchmark insurance companies.

Most of the existing empirical studies of insurance companies' efficiency, especially those initial, focus on specific insurance market and usually encompass developed countries. However, in the last decades the number of studies in the field of insurance business efficiency at cross-country level (e.g. Diacon, Starkey & O'Brien, 2002; Fenn, Vencappa, Diacon, Klumpes & O'Brien, 2008; Eling & Luhnen, 2010a; Škrinjarić, 2016) as well as in emerging markets are growing, too. Besides research based on insurance companies operating in Asian and Latin American emerging markets (e.g. Tone & Sahoo, 2005; Hu, Zhang, Hu, & Zhu, 2009; Eling & Luhnen, 2010a; Wanke & Barros, 2016) there are studies focused on efficiency of insurance companies in Central and Eastern Europe. They encompass research of efficiency of insurance business in North Macedonia (Mijackova, 2015), Slovakia (Grmanová & Strunz, 2017), Czech Republic and Poland (Grmanová & Pukala, 2018) and Serbia (Knežević, Marković & Brown, 2015; Mandić, Delibašić, Knežević & Benković, 2017; Lukic, Sokic, & Vojteski Kljenak, 2018). Despite of growing number of studies in the field of insurance efficiency, Croatian insurance companies have been subject of a very few studies. Moreover, neither study analyses the impact of accession to the EU on the efficiency of insurance business in Croatia.

The first study that encompasses efficiency of Croatian insurance companies refers to the research of Medved & Kavčič (2012). The authors analyse efficiency of insurance companies in Slovenia and Croatia, applying DEA. The sample consists of 24 life and non-life insurance companies operating in Croatia and 15 that operated in Slovenia in the period 2006-2010. Operational costs divided by average monthly gross wage rate are used as a proxy for labour while averages of yearly rates of stock market indexes are used as a proxy for capital. Output is measured by gross written premiums, separating between life and non-life business. The analysis is based on the assumptions of constant returns to scale technology and input orientation. According to the measures of intra efficiency, average insurers in Croatia operate more efficiently in comparison to the insurers in Slovenia. Average insurance company in Croatia could reduce the cost by 34%. Companies that are specialized in non-life insurance

business are the most cost efficient in average while those performing life insurance only are the least cost efficient. However, the inter-industry analysis shows that insurance industry in Slovenia is more efficient in terms of cost and technical efficiency than Croatian insurance industry. In order to get higher level of efficiency, the authors suggest more investment in technology and research and development.

Jurčević & Mihelja Žaja (2013), besides relative efficiency of banks, compare relative efficiency of 19 insurance companies that operated in Croatian insurance market in the period 2005-2010. The authors use DEA, including both CCR and BCC output-oriented models and accounting indicators before and after the financial crisis. The inputs are net operating expenses, investment costs, claims incurred, while the outputs are consisted of earned premiums and investment income. The DEA efficiency scores are compared with ROA and ROE. The average efficiency scores were 0.833 and 0.934 for CCR and BCR model, respectively. The scores reached the lowest values in 2007 and the highest level in 2009. Considering the accounting ratios, ROA and ROE had the lowest value in 2009 due to deteriorated market conditions and the business policy that was more reserved.

Croatia is encompassed in the cross-country analysis of 29 European insurance industries' efficiency in the period from 2004 to 2013 done by Škrinjarić (2016). The following inputs are used: the share of number of employees in the total number of employees in the country, premiums, number of subsidiaries. The output encompasses earned premiums, investments and the share of earned premiums in GDP. The analysis is performed for BCC and CCR models for both input and output orientation. According to the results, Croatian insurance industry belonged to the group of five the most inefficient European insurance industries. In order to achieve higher level of efficiency, the author suggests reduction of the share of the insurance industry's employees in total number of employees and the number of subsidiaries as well as the increase of the insurance penetration and investments.

Considering the research of efficiency of Croatian insurance industry, the existing studies did not completely separate between life and non-life business. Precisely, only Medved & Kavčič (2012) distinct between life and non-life premiums, but they did not make the difference between life and non-life business's inputs. Taking into consideration the difference between life and non-life products, this work analyses efficiency based on separate data for life and non-life insurance for all inputs and outputs. Additionally, existing studies did not analyse the effect the accession of Croatia to the EU has on the efficiency of Croatian insurance industry. Yet, the results of those studies that research the effect of deregulation and the single European insurance market on the efficiency of insurance companies, are mixed. Thus, the focus of this study is the comparison of efficiency of insurance companies in Croatia in the periods before and after the accession to the EU.

Methodology and variable selection

Methodology

DEA is a non-parametric methodology, based on linear programming, with the main objective to evaluate relative efficiency of decision-making units (DMUs) which are homogenous in their nature. Initial version of DEA, developed by Charnes, Cooper & Rhodes (1978) and named after their authors – CCR model, was based on the assumption of constant returns to scale (CRS). However, in the real economic world it is not always to expect that all inputs/outputs will change in a proportional way. Therefore, Banker, Charnes & Cooper (1984) developed BCC model, a more flexible model with an assumption of variable returns to scale (VRS). While the CCR model implicitly assumes that there is no significant relationship between efficiency and scales of operation i.e. this model evaluates overall technical efficiency (OTE) of DMUs, the BCC model calculates pure technical efficiency (PTE), allowing the analyst to measure inefficiencies arising from inappropriate DMSs' size as well as that generated from the inappropriate input/output configuration. In other words, application of the BCC model allows a decomposition of OTE into PTE and scale efficiency (SE).

Aside from being categorized by the type of returns to scale (CCR and BCC model), DEA models can be also considered in accordance with the model orientation (input and output oriented model). Input oriented models are focused on input minimization though keeping output constant, while output oriented models tend to maximize output with the given inputs. Regardless of model orientation and type of returns, application of DEA analysis allows a separation of efficient DMUs (with efficiency scores of 1.0 or 100%) from those inefficient (efficiency score less than 1.0 or 100%). Efficient DMUs form efficient frontier against which efficiency measures for each DMU relative to that of all other DMUs are computed.

DEA analysis was chosen in this research for several reasons. It can measure relative efficiencies of DMUs with multiple inputs and multiple outputs. As a non-parametric method, it does not require specific functional form to be defined in advance. Additionally, it can decompose overall technical efficiency into pure technical efficiency and scale efficiency. Finally, unlike parametric methods, it can deal with the small sample size (Taib, Ashraf & Razimi, 2018; Iqbal & Awan, 2015; Medved & Kavčič, 2012). A comparison of nonparametric and parametric methods can be found in Jarzębowski S. (2013). Since in this research cannot be assumed that economies of scale do not change as size of insurers increases, an application of BCC model is more appropriate for the analysis of insurance companies' efficiency. In addition, as input orientation assumes that insurers have more influence on the inputs than outputs, an input oriented model is applied. Same model orientation and return to scale assumption can be found in many insurance studies (e.g. Cummins &Xie, 2013; Medved & Kavčič, 2012; Eling & Luhnen, 2010). Additionally, in the study of Cummins &

Weiss (2013), the authors stress that the majority of analyses in insurance industries dealing with efficiency are input-oriented.

According to Cooper, Seiford & Tone (2007) and Paradi, Sherman & Tam (2018), mathematical formulation of the input-oriented BCC model evaluating the efficiency of DMU_o (o=1,…,n) by solving the linear program, can be presented in following way:

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

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

$$Y\lambda \geq y_0$$

$$e_n\lambda = 1$$

$$\lambda \geq 0$$

Where:

x_o denotes column vectors of inputs for DMU_o,

y_o denotes column vectors of outputs for DMU_o,

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 DMU_o's inputs,

e is a row vector of n,

n is a number of DMUs.

Selection of inputs and outputs

All inputs and outputs were selected in accordance with theoretical and empirical literature, while taking into consideration researchers' recommendation regarding the number of inputs and outputs appropriate for the particular number of decision-making units i.e. insurers. According to Golany & Roll (1989) the minimal number of DMUs should be at least twice the number of inputs and outputs used in the analysis. However, some authors recommend more restricted rule of thumb according to which the number of DMUs should be at least three times the number of inputs and outputs (Bowling, 1998).

This analysis comprised all insurers that were operating in at least three consecutive years. Moreover, after adjusting the sample for companies with incomplete data, the final number of investigated Croatian non-life, life and composite insurers during the analysed period varies from 6 to 10, from 3 to 6 and from 8 to 9, respectively, representing more than 90% of Croatian insurance industry. In order to expand the number of predefined non-life and life insurance companies, we decided to separate non-life and life operations of composite insurance companies and added each part of its non-life and life business to the related non-life and life insurance industry segment.

All necessary data for inputs and outputs (except for one variable – number of employees) were already provided separately for (non)life segment for each insurer. Yet, for this variable, the separation was done based on the share of (non)life net earned premiums into total premiums. Validation of this approach was verified through significantly high value of correlation coefficients recorded between number of non(life) employees based on net premium and number of non(life) employees based on operating expenses. Specifically, the correlation coefficient for non-life and life segment amounted 0.994 and 0.957 respectively.

Final number of non-life and life insurers during the analysed period varies from 13 to 18, and from 13 to 15. Thus, in accordance with the literature recommendation, the number of inputs and outputs should not exceed 4. In accessing efficiency scores, a Performance Improvement Management Software (PIM-DEA) is applied.

Determining adequate inputs and outputs is a crucial step in each efficiency analysis. Therefore, it is of great importance to identify services offered by insurers. The insurance efficiency literature broadly accepts the value-added approach that is also considered as the most adequate approach when analysing insurance industry efficiency (Cummins &Weiss, 2013). The same authors as well as e.g. Cummins, Tennyson & Weiss (1999), Cummins & Rubio-Misas (2006), Shim (2011) and Biener, Eling & Wirfs (2015), to name a few, identify "three main services provided by insurers as outputs: risk-pooling/bearing services, intermediation and financial services" that we have taken into account while identifying output variables.

Having in mind that through risk-pooling/bearing insurers create value added by managing a risk pool, raising premiums from the insured and reallocating them to the policyholders in case the insured risks occur (Eling & Luhnen, 2010b), we have opted for net premiums as an output that proxies this insurers' service. Specifically, we applied Huang & Eling (2013) approach and as a proxy for risk-pooling/bearing services, the authors apply net earned premiums. Though, some authors (e.g. Cummins & Zi, 1998; Eling & Luhnen, 2010b; Biener, Eling & Wirfs, 2015) argue whether the use of premiums is appropriate proxy since premium not only represents just output but rather price as well as the quantity of the output. Cummins & Zi (1998), citing Yuengert (1993), note that premiums, in fact, represent revenues. Therefore, these authors suggest the use of incurred claims instead. However, we agree with Kader, Adams & Hardwick (2010) who opted for the use of premiums instead of losses, as premiums are probable to be correlated with an insurer's expected losses.

Another output variable employed in the analysis, which is a proxy for intermediation function of the insurers, are total investments since the function of financial intermediation implicates collecting funds by issuing insurance policies and investing these funds in different types of assets (Cummins & Xie, 2013). As explained by Cummins & Weiss (2013), insurance companies issue insurance policies as well annuities while the collected funds are invested until they become due or until the claims need to be paid. Total investments were also employed as output in efficien-

cy analysis by e.g. Eling & Luhnen (2010a), Biener & Eling (2012), Huang & Eling (2013) and Biener, Eling & Wirfs (2015).

Besides risk-pooling/bearing services and intermediation function that are proxied by net premiums and total investments, financial services function of insurers is not separately employed in the analysis as suggested by Huang & Eling (2013), since premiums and investments are to a large extent correlated with financial services function.

Moreover, two input variables were identified following the recent literature dealing with insurance efficiency, i.e. labour and capital. Labour input is presented by the number of employees per insurer, unlike many other studies that proxy labour input with operating expenses (e.g. Cummins & Rubio-Misas, 2006; Eling & Luhnen, 2010a; Biener & Eling, 2012; Medved & Kavčič, 2012; Huang & Eling, 2013), since these data are publicly available for Croatian insurers. For instance, Noreen & Ahmad (2016) have employed number of employees as labour input when analysing cost efficiency in Pakistani insurance sector as well as Barros & Garcia (2006) while evaluating performance of Portuguese pension funds management companies.

Another important input is capital since, according to Cummins & Rubio-Misas (2006) insurance companies need to possess adequate levels of equity in order to ensure that the policyholders will be reimbursed in case that the insured risk occurs. Moreover, an adequate level of equity is needed in order to meet regulatory compliance as well as against unexpected losses (Shim, 2011). This input is presented by paid in capital following modified approach employed by Huang & Eling (2013).

All variables used in the research are presented in table 1 containing the main explanation of the variable, its abbreviation as well as its classification as input or output.

Table 1: Variable description

Variable	**Measure**	**Abbreviation**	**Type of variable (input/output)**
Capital	Paid in capital	CAP	Input
Labour	Number of employees	EMP	Input
Risk-pooling/bearing services	Net earned premiums	NP	Output
Intermediation function	Total investments	INV	Output

Source: Authors' calculation.

Data for all outputs employed in the analysis, i.e. net earned premiums and investments as well as for the input relating to paid in capital were obtained from annual reports publicly available on website of Croatian Financial Agency (FINA) or from corporate web pages of a particular insurer. The total number of employees, however, has been retrieved from various issues of Croatian Insurance Market published annually by Croatian Insurance Bureau.

Results and discussion

After choosing inputs and outputs that on the most suitable way reflect the functioning of insurance companies, the following step was to examine the correlation among chosen inputs and outputs. The results of the correlation analysis are presented in table 2, from which can be perceived a fairly strong positive (values of all correlation coefficients are higher than 0.8) and statistically significant relationship among variables related to non-life insurers. On the other hand, correlation coefficients of variables related to life insurers range between low and moderate. Though the capital indicates positive, but no significant relation to the net earned premiums, due to its association with the investments (as one of chosen output) we have decided to keep it in the model. Moreover, since the coefficients for all analysed variables (life and non-life) are positive, i.e. the output increases when input increases, the data satisfy isotonicity (Wang, 2015; Lo, Chien, & Lin, 2001; Charnes, Clark, Cooper, & Golany, 1985) meaning that the analysis can be performed with the application of DEA methodology.

Table 2: Correlation analysis for insurers operating in non-life and life insurance industry segments

	Non-life				Life			
	CAP	EMP	NP	INV	CAP	EMP	NP	INV
CAP	1				1			
EMP	0.813**	1			0.255**			
NP	0.803**	0.959**	1		0.131	0.788**	1	
INV	0.837**	0.929**	0.930**	1	0.250**	0.754**	0.877**	1

**. Correlation is significant at the 0.01 level (2-tailed).

Source: Authors' calculation.

Descriptive statistics for inputs and outputs of Croatian insurance companies (for the whole period) are presented in table 3. The data show a perceptible variation in the analysed inputs and outputs across the (non)life insurers, so besides an average value, a median as a central tendency measure is also presented. The average amount of paid in capital, number of employees and net earned premiums for non-life insurers were almost twice as large as those recorded for life insurance companies. The opposite is true for the investments, which value for the life segment is nearly double of that noted in the non-life segment. In terms of numbers, during the years, non-life insurers, on average, had 74 mill. HRK (10 mill. euro) of paid in capital, 406 employees, earned 313 mill. HRK (41.7 mill. euro) of net premiums and invested almost 620 mill. HRK (82.6 mill. euro).

Table 3: Descriptive statistics of the inputs and outputs for the non-life and life insurance companies

Non-life						
	N	Minimum	Maximum	Mean	Std. Deviation	Median
CAP	164	37,500	557,287,080	76,448,235	108,307,217	40,726,100
EMP	164	4	2,522	407	531	219
NP	164	31,267	2,294,843,040	313,200,897	469,797,564	142,910,922
INV	164	3,055,000	4,833,920,055	620,035,719	988,795,843	235,982,642
Life						
	N	Minimum	Maximum	Mean	Std. Deviation	Median
CAP	130	2,887,500	134,303,825	43,990,245	25,792,693	40,900,000
EMP	130	4	786	239	196	205
NP	130	752,514	564,701,246	178,510,470	152,427,700	184,163,721
INV	130	25,128,412	3,227,222,082	1,148,911,849	1,032,911,030	814,071,504

Note. All values (paid in capital, net earned premiums and investments) are presented in Croatian kunas (HRK).

Source: Authors' calculation.

Table 4 presents yearly-based pure technical efficiency (PTE) scores obtained from the input oriented BCC model, which was applied on 18 non-life insurance companies that were operating during the 2009-2018 period. Given the scale size, these efficiency scores indicate the segment of overall technical efficiency (OTE) that is attributed to the efficient transformation of inputs into outputs. All empty cells denote that particular DMU i.e. insurer, in the analysed year was not operating, either because it has not yet started to operate (like DMU12 or DMU21) or because it was involved in merger activities in some later period (like DMU19 or DMU22).

Table 4: Pure technical efficiency scores of non-life insurers (BCC – input oriented model)

BCC	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
DMU1	90.23	86.72	88.82	90.1	91.51	95.69	93.06	93.43	100	100
DMU10	100	74.52	100	100	100	100	100	100	100	100
DMU11	100	100	100	100	100	100	100	100	100	
DMU12			56.25	56.25	72.39	71.6	75.1	76.11	75.65	75.55
DMU13	100	100	100	100	94.08	100	100	100	100	100
DMU15	38.92	100	58.6	53.94	34.3	91.18	50.3	33.9	28.96	27.97
DMU16	99.17	39.34	99.17	63.77	86.66	100	100	98.64	98.77	99.96
DMU17	53.13	47.68	44.18	41.13	49.3	63.53	63.12	50.51	47.82	55.17
DMU19	34.09	23.39	25.55	81.78	63.98	62.93	63.7			
DMU21			60	77.53	100	100	100	100	100	100
DMU22	100	100	92.23	86.93	97.95	89.78				
DMU23	70.18	71.17	66.11	65.6	67.43	78.79	100	100		
DMU3	67.6	68.07	61.59	65.38	58.47	86.11	100	100	100	100
DMU4	100	100	100	100	100	100	100	100	100	100
DMU5	100	100	100	100	100	100	100	100	100	100
DMU7	100	100	100	100	100	100	100	100		
DMU8	58.71	49.82	66.77	57.85	100	80.1	90.42	88.17	86.28	90.63
DMU9	66.11	57.51	67.18	65.4	80.34	83.54	81.16	87.59	91.82	97.03
Average	**79.88**	**76.14**	**77.03**	**78.09**	**83.13**	**89.07**	**89.23**	**89.27**	**87.81**	**88.18**

Source: Authors' calculation.

The results from the table 4 (last row) indicate a continuous growth in the pure technical efficiency scores in the non-life insurance sector during the period from 2010 to 2016. A slight decrease of the efficiency (-1.5%) was recorded in 2017, but it rose again in the following year. The average efficiency in 2018 (the last year covered by the analysis) was 88.18% indicating that giving the scale of operation, on average, non-life insurers can reduce their inputs by 11.82% in order to become pure technical efficient. It is also evident that out of 13 non-life insurers, seven (53.8%) insurers were pure technically efficient (efficiency score of 100%) in 2018 and thus they formed the efficiency frontier in that year. The efficiency scores of the remaining insurers were less than 100% suggesting that these six insurers were inefficient. Insurance companies situated on the efficiency frontier form the "reference set" or benchmarks for those inefficient. In other words, efficient insurance companies can be seen as an example of good operating practice that those inefficient need to catch up to. Clearly, efficient insurers are their own benchmarks. For instance, benchmark for non-life insurer marked as DMU1 is DMU1, for DMU3 is DMU3 and so on. A reference set for the least efficient non-life insurance company, DMU15, are DMU3, DMU10 and DMU13 (see table A1 in the Appendix). More precisely, in order to become efficient, DMU15 should use a combination from DMU3, DMU10 and DMU13 (a virtual insurer) and in doing so it will attempt to become more like DMU13 than DMU3 or

DMU10. The data in table 4 also indicate that four non-life insurers (DMU4, DMU5, DMU7 and DMU11) were pure technically efficient during the all 10-year period, two additional insurers (DMU10 and DMU13) were efficient in all analysed years except one, while several insurers (DMU1, DMU3, DMU21 and DMU23) achieved their efficiency in later years of their business operation.

Considering the most efficient insurance companies in *non-life* insurance business, besides an increase in the value of investments for DMU4 and DMU7, decrease in number of employees added to the efficiency of DMU4 as well (the number of employees at the end of the period was reduced by 30 per cent in comparison to the number in the first year of the analysed period). Although the third most efficient insurer (DMU5) had experienced volatility both in the volume of premium and investments, since 2015 these outputs were increasing until the end of the analysed period, contributing to the efficiency of the company. One out of four the most efficient non-life insurers (DMU11) went through the internal restructuring within the existing insurance group. When analysing the worst performer (DMU19), the average ratio of net earned non-life insurance premiums to the average number of employees in the period covered by the analysis was 228,393 HRK (30,452 EUR). The same ratio for the most efficient companies amounted 864,771 HKR (115,303 EUR), 854,598 HRK (113,946 EUR), and 355,530 HRK (47,404 EUR).

Variations in obtained pure technical efficiency scores for the Croatian life insurance sector during the period covered with the analysis (Table 5) is not as clear as that one in the non-life sector for which an upward trend of efficiency scores was noticeable.

Table 5: Pure technical efficiency scores of life insurers (BCC – input oriented model)

Years	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
DMU13	100	100	100	85.8	100	100	100	83.56	83.62	82.02
DMU14	55.01	74.65	100	100	100	100	100	100	100	100
DMU15	99.57	99.57	99.57	99.57	100	92.25	93.31	93.61	93.31	93.31
DMU16	99.17	99.17	99.17	85.51	98.21	100	100	100	100	100
DMU17	48.67	51.36	29.94	30.8	38.32	38.4	42.45	32.95	31.03	42.78
DMU18				100	100	81.32	100	100	100	100
DMU2	100	100	100	100	100	100	100	100	100	100
DMU20	34.09	34.09	34.09	85.23	65.45	15.76	68.07			
DMU24	55.52	55.52	50.76	50.76	55.14	23.95				
DMU3	100	100	100	100	100	100	100	100	100	100
DMU4	100	100	100	100	100	90.96	87.83	67.72	100	100
DMU6	100	100	100	100	100	100	99.95	100	100	100
DMU8	56.96	56.96	63.25	78.74	100	49.88	75.58	73.72	73.8	74.33
DMU9	86.19	100	100	100	100	86.72	73.03	61.79	59.22	59.87
Average	**79.63**	**82.41**	**82.83**	**86.89**	**89.79**	**77.09**	**87.71**	**84.45**	**86.75**	**87.69**

Source: Authors' calculation.

After the initial growth of efficiency scores in life sector, in 2014 a decline in efficiency scores occurred and this was repeated again in 2016. In-depth analysis showed that decline in 2014 was mainly due to high inefficiency recorded in two companies, DMU24 and DMU20, both of which were acquired in the next period. Life insurance industry in the last analysed year, 2018, recorded a slightly lower efficiency score (87.69%) when compared to the non-life insurance sector (88.18%). Out of 12 life insurers, seven of them (58.3%) were pure technically efficient (DMU2, DMU3, DMU4, DMU6, DMU14, DMU16 and DMU18), while the rest of them were inefficient. The insurer DMU17 was the most inefficient insurer since its pure technical efficiency was found to be 42.78%. Among the inefficient insurers, two of them DMU13 and DMU15 have the efficiency score above average. On a yearly basis, during a 10-years period, the number of efficient life insurers varies from five (in 2009) to ten (in 2013), however, two insurers (DMU2 and DMU3) were pure technically efficient during the whole observed period meaning that managers of these insurance companies were successful in input utilization. These insurers can serve as benchmarks for those inefficient. In other words, inefficient insures could improve their input utilization by following the best practice of efficient insurers.

In the *life* insurance business, there were two best performers (DMU2 and DMU3). The important effect on the efficiency of the both companies came from good investment management. Additionally, efficiency of DMU2 was affected by the growth of premiums in the last years of the analysed period, while DMU3 significantly reduced the number of employees (the number of employees in the last year was less than half of the number of the employees in the first year of the analysed period). The worst performer in the life insurance business (DMU17) earned 550,557 HRK (73,408 EUR) net life premium per employee. The same ratio for the most efficient insurers was 2,048,214 HRK (273,095 EUR) and 874,966 HRK (116,662 EUR), respectively.

In order to analyse whether the Croatia's accession to the EU in 2013 has impacted the level of achieved insurers' pure technical efficiency, the sample of non-life and life insurers is further divided into two sub-periods, one comprising period before Croatia's accession to the EU (2009-2012) and the second one covering the period after Croatia's EU accession (2013-2018). Average pure technical efficiency scores for the non-life and life insurance industry during the two observed sub-periods are presented in table 6. Confronting the period prior to and after Croatia's EU accession, it is noticeable that the average pure efficiency score for the non-life insurance industry grew by 10.67% (from 76.92% to 87.59%), suggesting more efficient input utilization. At the same time, the pure technical efficiency score for the life insurance industry slightly decreased by 1.89%. However, in order to test whether these changes in pure technical efficiency were statistically significant, Wilcoxon signed ranks test was conducted. The results are presented in table 7.

Table 6: Average pure technical efficiency scores before and after Croatia's accession to EU

Non-life			Life		
DMU's label	**average 2009-12**	**average 2013-18**	**DMU's label**	**average 2009-12**	**average 2013-18**
DMU1	88.968	95.615	DMU13	96.45	91.533
DMU10	93.63	100	DMU14	82.415	100
DMU11	100	100	DMU15	99.57	94.298
DMU12	56.25	74.4	DMU16	95.755	99.701
DMU13	100	99.013	DMU17	40.192	37.655
DMU15	62.865	44.435	DMU18	100	96.886
DMU16	75.362	97.338	DMU2	100	100
DMU17	46.53	54.908	DMU20	46.875	49.76
DMU19	41.203	63.537	DMU24	53.14	39.545
DMU21	68.765	100	DMU3	100	100
DMU22	94.79	93.865	DMU4	100	91.085
DMU23	68.265	86.555	DMU6	100	99.991
DMU3	65.66	90.7633	DMU8	63.977	74.551
DMU4	100	100	DMU9	96.547	73.438
DMU5	100	100	**Average**	**83.92**	**82.03**
DMU7	100	100			
DMU8	58.288	89.267			
DMU9	64.05	86.913			
Average	**76.92**	**87.59**			

Source: Authors' calculation.

Table 7: Wilcoxon signed ranks test for non-life and life insurance industry

Non-life						
Ranks					**Test Statistics[a]**	
		N	Mean Rank	Sum of Ranks	BCCaverage 2013-18 - BCCaverage 2009-12	
BCCaverage 2013-18 – BCCaverage 2009-12	Negative Ranks	3[a]	3.67	11.00	Z	-2.605[b]
	Positive Ranks	11[b]	8.55	94.00	Asymp. Sig. (2-tailed).	009
	Ties	4[c]				
	Total	18				
a. BCCaverage 2013-18 < BCCaverage 2009-12 b. BCCaverage 2013-18 > BCCaverage 2009-12 c. BCCaverage 2013-18 = BCCaverage 2009-12					a. Wilcoxon Signed Ranks Test b. Based on negative ranks.	
Life						
Ranks					**Test Statistics[a]**	
		N	Mean Rank	Sum of Ranks	BCC_average 2013-18 – BCC_average 2009-12	
BCCaverage 2013-18 – BCCaverage 2009-12	Negative Ranks	8[a]	6.25	50.00	Z	-.863[b]
	Positive Ranks	4[b]	7.00	28.00	Asymp. Sig. (2-tailed)	.388
	Ties	2[c]				
	Total	14				
a. BCCaverage 2013-18 < BCCaverage 2009-12 b. BCCaverage 2013-18 > BCCaverage 2009-12 c. BCCaverage 2013-18 = BCCaverage 2009-12					a. Wilcoxon Signed Ranks Test b. Based on negative ranks.	

Source: Authors' calculation.

Results evidenced in table 7 undoubtedly indicate that the pure technical efficiency in the non-life insurance industry grew after Croatia's accession to the EU and this growth was statistically significant. Contrary to that, slight change (decrease) in pure technical efficiency in life insurance industry was not found to be statistically significant. More detailed analysis showed that after Croatian accession to the EU, the growth of pure technical efficiency in non-life insurance industry was mainly due to better manager practices and decrease of costs through rationalization of number of employees, whose number on average dropped by almost 12% when compared to the period prior to the accession to the EU. Additionally, non-life insurers' investments also showed significant increase, by almost 25%. In those circumstances, the growth of PTE in non-life insurance companies was in accordance with our expectation. On the other hand, life insurers did not succeed to improve their pure technical efficiency in period after Croatian accession to the EU primarily because they did not find successful way to reduce inputs used in achieving the desirable level of outputs. Moreover, both of the analysed inputs, paid in capital and the number of employees, showed average growth of 12% and 15% respectively. Even the comparison of average efficiency in period before (2009-2012) and after (2013-2018) Croatia accessed to the EU showed slight decrease in life insurance industry, it must be pointed out that

for the last three analysed years (2016-2018), PTE shows continuous growth and in 2018 it amounted to 87.69%. The level of this score is encouraging since its value is higher than any other PTE score recorded in years prior to the EU accession.

The new regulatory and market environments encouraged insurers on consolidation and more efficient usage of inputs. Number of insurance companies decreased from 27 in 2012 and 26 in 2013 (i.e. years before EU accession) to 18 in 2018. With the accession to the EU, insurance companies from other EU member states are allowed to provide insurance services directly or through a branch in Croatia (the same is true for Croatian insurance companies in providing services in other EU member states). Capital requirements for insurance companies increased while the number of employees in the insurance industry was reduced. There were 11,616 employees in 2012; 11,533 in 2013 and 8,238 in 2018 (HUO, 2019, p. 24). Some insurers externalized their sales force while there are those that engaged part of their back office employees to sell insurance. This especially contributed to the efficiency of the non-life insurance business. Namely, although both life and non-life insurance industry in Croatia are less developed in comparison to the EU average, Croatian non-life insurance industry has significantly higher importance in comparison to the life insurance sector. The share of non-life insurance premiums in total premiums in 2018 was 68.2% (Croatian Insurance Bureau, 2019 p. 15). The third party motor vehicle liability insurance, which is obligatory, is the most important non-life insurance line. Thus, the highest competition among the insurers is in this segment of the insurance industry and it especially increased after the accession to the EU. Although the liberalization of the third party motor vehicle liability insurance was allowed in 2008, the real liberalization started with the accession to the EU. With market premium determination, average premium per motor vehicle decreased. In 2016 new solvency regulation, Solvency II came into effect with additional regulatory requirements that increased the costs for insurance companies. As a result, mergers and acquisitions continued. All these changes affected efficiency of insurance companies. Additional reasons for their (in)efficiency might be found in challenging environment in which insurers operate, in higher competition from other financial institutions offering complement services or in some other hardly measured institutional factors.

In order to examine whether inefficiency of analysed (non)life insurers was due to inefficient production operation or due to the size of the insurers, we followed Cooper, Seiford & Tone (2007) and Özcan (2008) who stated that scale efficiency can be calculated by the ratio of CCR and BCC optimal efficiency scores. This approach was adopted by numerous researchers (e.g. Taib, Ashraf & Razimi, 2018; Kordić & Šimundić, 2017; Micajkova, 2015; Iqbal & Awan, 2015; Mogha & Yadav, 2014). In line with stated, a further step was to calculate efficiency scores for non-life and life insurers under the assumption of constant returns – CCR model. Obtained overall technical efficiency scores for (non)life insurers under the CCR model are presented in Appendix – table A2 and A3, while those ones referring to scale efficiency are

shown in table A4 and table A5. In short, the values of OTE for both, non-life and life insurance companies, were fluctuated during the observed years. However, when comparing the averages of their value before and after Croatian accession to the EU, one can notice an increase of 3.5% in overall technical efficiency (from 60.5% to 64% for non-life insurance segment and from 59.5% to 63% for life insurance segment) indicating an increasing efficiency in the insurance industry. Still, Wilcoxon signed ranks test showed that this increase was not statistically significant. On a yearly-basis, number of efficient insurers was mainly two or three for non-life and four or five for life insurance industry. Average values of scale efficiency scores together with the returns to scale specification before and after Croatia's accession to the EU are evidenced in table 8.

Table 8: Scale efficiency (SE) scores and returns to scale specification (RTS) before (2009-2012) and after (2013-2019) Croatian accession to the EU

Non-life					Life				
DMU's label	**SE (average 2009-2012)**	**RTS**	**SE (average 2013-2019)**	**RTS**	**DMU's label**	**SE (average 2009-2012)**	**RTS**	**SE (average 2013-2019)**	**RTS**
DMU1	96.2825	IRS	93.75	IRS	DMU13	99.39	IRS	99.2517	DRS
DMU10	72.7675	IRS	63.815	IRS	DMU14	74.0375	IRS	96.6533	IRS
DMU11	84.2825	IRS	100	CRS	DMU15	44.07	IRS	47.0733	IRS
DMU12	27.445	IRS	27.82	IRS	DMU16	46.4825	IRS	85.2067	IRS
DMU13	62.3825	IRS	58.04	IRS	DMU17	86.5475	IRS	98.5983	DRS
DMU15	90.1075	DRS	90.6667	DRS	DMU18	22.21	IRS	69.325	IRS
DMU16	50.5025	IRS	69.7233	IRS	DMU2	100	CRS	100	CRS
DMU17	95.7325	DRS	89.925	DRS	DMU20	8.075	IRS	31.9733	IRS
DMU19	52.4975	IRS	33.8267	IRS	DMU24	14.2925	IRS	30.735	IRS
DMU21	43.525	IRS	53.0667	IRS	DMU3	100	CRS	100	CRS
DMU22	99.0375	DRS	96.375	DRS	DMU4	97.5475	DRS	90.2433	DRS
DMU23	91.5775	IRS	82.08	IRS	DMU6	91.43	IRS	29.515	IRS
DMU3	99.21	IRS	97.5967	DRS	DMU8	62.1225	IRS	76.8967	IRS
DMU4	79.53	DRS	69.475	DRS	DMU9	92.4125	DRS	97.3967	CRS
DMU5	90.1625	IRS	29.725	IRS					
DMU7	100	CRS	100	CRS					
DMU8	74.12	IRS	81.135	IRS					
DMU9	85.7375	IRS	72.8167	IRS					

Source: Authors' calculation.

During the 2009-2012 period (before Croatia's accession to the EU), only one non-life insurance company (DMU7) had continuously scale efficiency score of 100%, implying it was the only insurer at the optimal size for its particular input-output combination. The remaining non-life insurers were scale inefficient (SE scores less than 100%). However, after Croatia accessed to the EU, besides DMU7, one additional non-life insurer (DMU11) became scale efficient. As scale efficiency scores measure the influence of scale size on the efficiency of an insurer, it can be stated that, on average, for period 2013-2019, scale efficiency score was 72.77% (4.7% lower than in period 2009-2012) indicating that scale inefficient non-life insurers can reduce their size by 27.23% while retaining their current output at the same level. Moreover, in 2018, overall technical inefficiency of non-life insurers marked as DMU4, DMU5, DMU10, DMU13 and DMU21 was completely attributed to scale inefficiency.

As regards returns to scale, the results revealed that when the insurers increase their inputs by a given proportion before (after) EU accession, it would lead to:

(1) increasing returns to scale (IRS) for 13 (11) insurers, indicating that their output would increase by a larger proportion and therefore insurers need to increase their size in order to obtain optimal scale.
(2) constant returns to scale (CRS) for one (two) insurers, denoting that their output would increase by the same proportion and hence these insurers are operating at their most productive scale size.
(3) decreasing returns to scale (DRS) for four (five) insurers, meaning that their output would increase by a smaller proportion and thus insurers need to reduce their size if they want to attain optimal scale. However, it must be noted that four out of five insurers are close to the edge of operating under CRS.

Considering life insurance sector, number of scale efficient insurers before and after Croatian accession to the EU remained the same, at the level of two (DMU2 and DMU3). Remaining 12 insurers were scale inefficient. During the period before and after Croatian accession to the EU, the average value of the scale efficiency score for life insurers increased by 8.16%, to the level of 75.2%, accordingly, scale inefficient insurers could decrease their size by 24.8% while holding their current output at the same level. As average pure technical efficiency for life insurers, during the period before and after EU accession, was greater than scale efficiency, the inefficiency of these companies was mainly due to scale inefficiency. On the other hand, regarding the non-life insurers, it can be perceived that average pure technical efficiency during the period before EU accession was lower (although slightly) than the average of scale efficiency, pointing to the manager inefficiency as a source of insurers inefficiency. However, after the EU accession, a main reason for non-life insurers' inefficiency was attributed to scale inefficiency. Overall, on average, both non-life and life insurance companies/business segments need to increase their size if they want to achieve optimal scale.

Our results are mixed, as are those of other studies of the effect of deregulation and the single market on the technical efficiency of European insurance companies, which opened domestic insurance market to the competition of the insurers from other countries that are members of the EU. Mahlberg & Url (2003) analyse the impact of the single market on the efficiency of the Austrian insurers and find that there is a reduction of the dispersion of efficiency over time. However, there is still a significant inefficiency. Like in Croatian insurance industry, there is potential for reduction of the costs by both increasing the technical efficiency and adjusting the size of the companies. Analysing the effect of deregulation on the efficiency of Italian motor insurance industry, Turchetti & Doraio (2004) find that pure technical efficiency and scale efficiency were at very high level before and after the deregulation. The efficiency scores are higher in comparison to those in Croatian non-life insurance industry. The research of Spanish insurers confirms that in the analysed period that covers the deregulation of the EU insurance market, pure technical efficiency of the insurance companies increased (Cummins & Rubio-Misas, 2006), as it was the case in Croatian non-life insurance business. Moreover, the consolidation contributed to the increase of average scale efficiency, as in life insurance industry in Croatia. Considering the effect of the single market on efficiency of German insurance groups, Mahlberg & Url (2010) find only small progress in pure technical efficiency.

Robustness check

In order to validate the obtained results of the analysis, the authors have performed robustness test. For this purpose, instead of using net earned premium as output variable, variable claims has been introduced in the analysis. Specifically, besides premiums, claims have often been used as proxy for measuring risk-bearing and risk-pooling function of insurers (e.g. Mahlberg & Url, 2003; Klumpes, 2004; Barros, Barroso & Borges, 2005; Hussels & Ward, 2007). Furthermore, Eling & Luhnen (2010b) provided an overview survey dealing with efficiency studies in an insurance industry stating that out of the 80 papers, 46 of them employ output as either claims/present value of claims in non-life insurance sector or benefits/net incurred benefits in life insurance sector.

The estimated average pure technical efficiency scores before and after Croatia's accession to the EU as well as Wilcoxon signed ranks test for non-life and life insurance industry are presented with tables 9 and 10.

Table 9: Average pure technical efficiency scores before and after Croatia's accession to EU (in which claims were used instead of net premiums)

DMU's label	**NL-Average 2009-2012**	**NL-Average 2013-2018**	**DMU's label**	**Life-Average 2009-2012**	**Life-Average 2013-2018**
DMU1	84.64	96.30	DMU13	100.00	91.53
DMU10	88.53	100.00	DMU14	82.79	98.88
DMU11	100.00	100.00	DMU15	99.57	82.91
DMU12	56.25	74.65	DMU16	95.76	99.70
DMU13	96.70	99.22	DMU17	40.19	40.54
DMU15	58.72	55.15	DMU18	100.00	95.55
DMU16	73.93	97.59	DMU2	100.00	99.24
DMU17	44.33	56.83	DMU20	46.88	47.33
DMU19	41.36	63.59	DMU24	53.14	36.59
DMU21	70.70	100.00	DMU3	100.00	100.00
DMU22	93.58	100.00	DMU4	100.00	85.04
DMU23	58.06	100.00	DMU6	100.00	100.00
DMU3	61.10	96.99	DMU8	63.98	72.53
DMU4	100.00	100.00	DMU9	96.55	75.65
DMU5	100.00	100.00	**Average**	**84.20**	**80.39**
DMU7	100.00	100.00			
DMU8	55.62	87.00			
DMU9	65.44	87.27			
Average	**74.94**	**89.70**			

Source: Authors' calculation.

Tables 10: Wilcoxon signed ranks test for non-life and life insurance industry (in which claims were used instead of net premiums)

Non-life						
Ranks					**Test Statistics[a]**	
		N	Mean Rank	Sum of Ranks	NL-Average 2013-2018 – NL-Average 2009-2012	
NL-Average 2013-2018 – NL-Average 2009-2012	Negative Ranks	1[a]	2.00	2.00	Z	-3.294[b]
	Positive Ranks	14[b]	8.43	118.00	Asymp. Sig. (2-tailed)	.001
	Ties	4[c]				
	Total	19				
a. NL-Average 2013-2018 < NL-Average 2009-2012 b. NL-Average 2013-2018 > NL-Average 2009-2012 c. NL-Average 2013-2018 = NL-Average 2009-2012					a. Wilcoxon Signed Ranks Test b. Based on negative ranks.	
Life						
Ranks					**Test Statistics[a]**	
		N	Mean Rank	Sum of Ranks	Life_Average 2013-2018 – Life-Average 2009-2012	
Life_Average 2013-2018 – Life-Average 2009-2012	Negative Ranks	8[a]	8.13	65.00	Z	-1.363[b]
	Positive Ranks	5[b]	5.20	26.00	Asymp. Sig. (2-tailed)	.173
	Ties	2[c]				
	Total	15				
a. Life_Average 2013-2018 < Life-Average 2009-2012 b. Life_Average 2013-2018 > Life-Average 2009-2012 c. Life_Average 2013-2018 = Life-Average 2009-2012					a. Wilcoxon Signed Ranks Test b. Based on negative ranks.	

Source: Authors' calculation.

The estimated average pure technical efficiency scores before and after Croatia's accession to the EU as well as Wilcoxon signed ranks test for non-life and life insurance industry suggest that the alternative measure of output generates the same results making the results robust. Specifically, average pure technical efficiency scores are substantially higher after Croatia's accession to the EU in non-life segment whereas life insurance segment registers slight decrease in efficiency. Moreover, this difference is statistically significant regarding non-life insurance segment while it remains insignificant in life insurance. It is worth noting that Hussels & Ward (2007) have obtained similar results regarding efficiency on the sample of German insurance market whether premiums or claims have been used as outputs.

Conclusion

The aim of this research was primarily to evaluate pure technical and scale efficiency of the non-life and life insurers operating in Croatia before and after its accession to

the EU. In doing so, an overall technical efficiency was also evaluated. Aiming to obtain efficiency scores, a DEA analysis, including both BCC and CCR input oriented models were applied.

The results showed that overall technical efficiency (OTE) before and after Croatia's accession to the EU increased. However, this increase was not statistically significant. Nevertheless, the results implied that on average, after Croatian accession to the EU, more than one third of technical potential of Croatian insurers operating in non-life (life) industry was not in use. As a regard of pure technical efficiency (PTE), the results showed statistically significant increase for non-life, and statistically insignificant slight decreased for life insurers. The new regulatory and market environments encouraged insurers on consolidation and more efficient usage of inputs, especially in non-life insurance business. The competition encouraged the insurance product innovations and enhanced the choice for policyholders. Although the price deregulation in the motor third party liability insurance had been allowed prior to the Croatian accession to the EU, it increased competition among insurance companies just after the accession, when direct cross-border selling of insurance was allowed. The average premium of the motor third party liability insurance decreased. Since the risk premium should be proportional to the risk, the insurance companies could compete with the reduction of the costs. Thus, the increased competition that resulted from the accession to the EU, encouraged less efficient insurance companies that operate in the motor third party insurance market to take additional effort to get closer to the benchmark companies. Contrary, the efficiency of life insurers was not significantly affected by the accession to the EU. However, the level of life insurers' efficiency before the accession was higher in comparison to the non-life insurance companies' efficiency.

Examination of scale efficiency and returns to scale before and after Croatian accession to the EU showed that after accession to the EU, scale efficiency score increased in life and decreased in non-life insurance industry. The obtained scores demonstrated that scale inefficient life (non-life) insurance companies/segments could reduce their size while retaining their current output at the same level. Most of the (non)life insurance companies/segments were scale inefficient as they were operating at increasing returns to scale during the almost whole period covered with the analysis. Since these insurance companies/segments were mainly operating at the sub-optimal scale size, they need to make necessary adjustments in their scale-size (enlarge their business by internal or external growth) if they want to obtain optimal size.

Due to the overall increase in the use of information technology in financial services industry and its importance for the improvements of efficiency, the insurance companies should increase their investment in information technology. This especially refers to the distribution channels, products, underwriting and claim adjusting. In this way, insurance companies will be able to additionally reduce the number of employees that could contribute to the efficiency. A way towards digitalisation of insurance business has additionally accelerated by the coronavirus pandemic.

Besides the above mentioned, the company-level activities for the improvements of the efficiency, policy makers at macro level could also contribute to the efficiency of the insurance companies. Positive effect of the price deregulation in the motor third party liability insurance confirms the importance of this policy for non-life insurance business. Since both insurance businesses, but especially life insurance, are less developed in comparison to the EU average and having in mind that the efficiency of the insurance companies depends on the output size while the level of insurance premiums is also affected by external factors, policy makers should assure favourable economic and institutional environments for further increase of demand for insurance products.

The study has some limitations that are related to data. Number of insurance companies that operate in the Croatian market is relatively small and therefore the results should be treated with caution. By expanding the sample of predetermined number of insurers and by separating non-life and life operations of composite insurers, the effects of economies of scope might have not been encompassed by the analysis. Additionally, the number of employees applied as an input does not include the number of agents since this data is not publicly available at the company level.

This research could be extended in several ways. The suggestion for future research might be to encompass other European insurance markets with the similar level of development with the aim of comparing their levels of efficiency. Furthermore, an investigation of factors that determine efficiency, including among others M&A activities, might also be incorporated in future research as well as the level of productivity measured with Malmquist index.

Appendix

Table A1: Reference set for non-life insurers in 2018.

DMU	DMU1	DMU10	DMU13	DMU21	DMU3	DMU4	DMU5
DMU1	1	0	0	0	0	0	0
DMU10	0	1	0	0	0	0	0
DMU12	0	0	0.63	0	0	0	0.37
DMU13	0	0	1	0	0	0	0
DMU15	0	0.01	0.52	0	0.47	0	0
DMU16	0.19	0.6	0.21	0	0	0	0
DMU17	0	0	0	0.48	0.52	0	0
DMU21	0	0	0	1	0	0	0
DMU3	0	0	0	0	1	0	0
DMU4	0	0	0	0	0	1	0
DMU5	0	0	0	0	0	0	1
DMU8	0	0.79	0.02	0	0.19	0	0
DMU9	0.17	0	0.72	0	0.11	0	0

Source: Authors' calculation.

Table A2: Efficiency score for non-life insurers – CCR model

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Average
DMU1	86.09	86.28	84.35	85.81	77.66	90.37	85.81	85.02	100	100	88.14
DMU10	62.5	70.57	67.57	66.29	49.19	65.5	70.12	64.02	67.76	66.3	64.98
DMU11	100	37.13	100	100	100	100	100	100	100		93.01
DMU12			14.02	16.86	18.18	20.97	27.78	21.86	17.76	17.63	19.38
DMU13	70.57	100	41.98	36.98	44.16	44.43	47.46	67.72	73.81	67.88	59.50
DMU15	34.06	100	50.58	46.72	31.5	74.88	41.14	33.43	27.71	26.28	46.63
DMU16	33.01	32.73	34.46	32.39	39.85	87.54	92.47	58.54	66.08	66.08	54.32
DMU17	51.6	47.37	41.32	38.23	44.52	53.27	54.86	48.61	40.23	54.13	47.41
DMU19	12.13	19.87	15.59	23.21	18.4	25.78	20.22				19.31
DMU21			12.6	51.21	51.31	48.32	52.26	54.35	43.63	68.53	47.78
DMU22	100	100	89.59	86.07	91.1	89.55					92.72
DMU23	65.07	70.83	58.49	56.15	34.81	67.94	98.76	91.7			67.97
DMU3	67.29	68.04	60.48	64.84	51.17	84.44	100	100	100	100	79.63
DMU4	81.1	80.43	80.39	76.2	68.4	74.57	75.41	66.18	66.81	65.48	73.50
DMU5	100	100	100	60.65	55.01	2.36	24.7	22.62	34.04	39.62	53.90
DMU7	100	100	100	100	100	100	100	100			100.00
DMU8	38.38	47.32	56.9	29.45	100	61.07	76.84	64.61	66.1	68.6	60.93
DMU9	55.48	56.13	59.46	47.7	57.68	63.36	64.86	63.24	61.42	68.16	59.75

Source: Authors' calculation.

Table A3: Efficiency score for life insurers – CCR model

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Average
DMU13	100	100	100	83.71	100	100	100	82.02	82.43	81.02	92.92
DMU14	34.88	50.09	65.66	100	100	100	100	95.39	97.89	86.64	83.06
DMU15	33.3	40.11	47.83	54.29	29.6	90.24	45.66	32.9	32.79	33.43	44.02
DMU16	38.54	38.63	47.67	51.35	59.9	100	100	90.93	81.27	78.05	68.63
DMU17	42.38	45.65	25.54	26.16	37.77	38.4	42	32.93	30.81	40.58	36.22
DMU18				22.21	29.1	50.94	76.7	100	77.52	69.99	60.92
DMU2	100	100	100	100	100	100	100	100	100	100	100.00
DMU20	2.66	3.13	2.71	6.29	8.13	9.52	15.75				6.88
DMU24	3.26	5.06	7.52	13.89	8.26	11.14					8.19
DMU3	100	100	100	100	100	100	100	100	100	100	100.00
DMU4	92.13	98.06	100	100	100	90.94	86.32	67.46	68.6	74.98	87.85
DMU6	100	100	100	65.72	36.88	51.15	31.7	21.77	19.89	15.68	54.28
DMU8	27.61	34.33	47.11	51.39	100	46.4	70.92	42.01	37.77	49.33	50.69
DMU9	76.56	85.97	100	94.85	98.26	82.41	72.61	61.31	55.48	59.13	78.66

Source: Authors' calculation.

Table A4: Scale efficiency scores (SE) for non-life insurers

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Average
DMU1	95.42	99.5	94.97	95.24	84.86	94.44	92.21	90.99	100	100	94.76
DMU10	62.5	94.71	67.57	66.29	49.19	65.5	70.12	64.02	67.76	66.3	67.40
DMU11	100	37.13	100	100	100	100	100	100	100		93.01
DMU12			24.92	29.97	25.11	29.29	36.99	28.72	23.48	23.33	27.73
DMU13	70.57	100	41.98	36.98	46.94	44.43	47.46	67.72	73.81	67.88	59.78
DMU15	87.5	100	86.31	86.62	91.82	82.13	81.79	98.61	95.7	93.95	90.44
DMU16	33.28	83.19	34.75	50.79	45.98	87.54	92.47	59.35	66.9	66.1	62.04
DMU17	97.11	99.36	93.52	92.94	90.31	83.85	86.9	96.24	84.13	98.12	92.25
DMU19	35.59	84.99	61.02	28.39	28.76	40.97	31.75				44.50
DMU21			21	66.05	51.31	48.32	52.26	54.35	43.63	68.53	50.68
DMU22	100	100	97.14	99.01	93.01	99.74					98.15
DMU23	92.72	99.52	88.48	85.59	51.62	86.24	98.76	91.7			86.83
DMU3	99.53	99.94	98.2	99.17	87.52	98.06	100	100	100	100	98.24
DMU4	81.1	80.43	80.39	76.2	68.4	74.57	75.41	66.18	66.81	65.48	73.50
DMU5	100	100	100	60.65	55.01	2.36	24.7	22.62	34.04	39.62	53.90
DMU7	100	100	100	100	100	100	100	100			100.00
DMU8	65.37	94.97	85.23	50.91	100	76.24	84.99	73.28	76.61	75.69	78.33
DMU9	83.91	97.6	88.51	72.93	71.8	75.84	79.91	72.21	66.89	70.25	77.99

Source: Authors' calculation.

Table A5: Scale efficiency scores (SE) for life insurers

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Average
DMU13	100	100	100	97.56	100	100	100	98.15	98.58	98.78	99.31
DMU14	63.4	67.09	65.66	100	100	100	100	95.39	97.89	86.64	87.61
DMU15	33.44	40.29	48.03	54.52	29.6	97.81	48.94	35.14	35.13	35.82	45.87
DMU16	38.86	38.95	48.07	60.05	60.99	100	100	90.93	81.27	78.05	69.72
DMU17	87.08	88.89	85.31	84.91	98.54	100	98.95	99.94	99.29	94.87	93.78
DMU18				22.21	29.1	62.64	76.7	100	77.52	69.99	62.59
DMU2	100	100	100	100	100	100	100	100	100	100	100.00
DMU20	7.81	9.17	7.94	7.38	12.42	60.37	23.13				18.32
DMU24	5.87	9.11	14.82	27.37	14.97	46.5					19.77
DMU3	100	100	100	100	100	100	100	100	100	100	100.00
DMU4	92.13	98.06	100	100	100	99.98	98.28	99.62	68.6	74.98	93.17
DMU6	100	100	100	65.72	36.88	51.15	31.72	21.77	19.89	15.68	54.28
DMU8	48.47	60.27	74.48	65.27	100	93.01	93.84	56.98	51.18	66.37	70.99
DMU9	88.83	85.97	100	94.85	98.26	95.03	99.42	99.22	93.68	98.77	95.40

Source: Authors' calculation.

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