

THE EFFICIENCY OF MANDATORY PENSION FUNDS: CASE OF CROATIA

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Abstract

The aim of this paper is to examine performance of pension funds in Croatia, or more precisely, to measure the technical efficiency of mandatory pension funds. The main role of the pension funds is to collect and invest the money contributed by the employer or the employee during working years until retirement. Therefore, development of pension funds as institutional investors is especially important for capital markets as well as for the whole economy. By applying the methodology of data envelopment analysis on a sample of 12 DMUs, i.e. four mandatory pension funds divided into three categories (A, B or C) for 2015-2018 period, we provide further evidence on their efficiency level. The results have shown very small differences among relative inefficient pension funds.

Key words: *mandatory pension funds, technical efficiency, data envelopment analysis, pension system*

JEL classification: *C61; G14; G23; H55*

1. INTRODUCTION

The pension fund industry accumulates a considerable number of financial assets and represents an essential element of the sustainable economic growth in all developed countries. In the course of late 1990's and early 2000's, a number of post-transition European countries enacted parametric reforms of their pension systems because they were incompatible with unfavourable demographic trends, enormous financial pressure and insolvency of public pensions. In addition, most of Central and Eastern European countries (CEE)¹ have implemented systemic pension reforms.

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¹ Bulgaria, Estonia, Croatia, Latvia, Lithuania, Hungary, Poland, Romania and Slovakia opted for mandatory private individual schemes. Contrary to most other CEE countries, Lithuania's second pillar is voluntary, while Slovakia was the latest of the CEE countries to have created a mandatory pillar in 2015.

The Czech Republic and Slovenia are only CEE countries that have not established a funded second pillar. Slovenia introduced mandatory private occupational schemes (instead of mandatory private individual schemes), that are mandatory for certain sectors and voluntary for others (Carone et.al. 2016). The Czech Republic pension system relies on first pillar public pensions and voluntary savings in the third pillar.

The reformed pension systems were based on a three-pillar model consisting of a reduced public PAYG (Pay-as-you-go) scheme and newly formed two pillars. Mandatory second pillar was set up of fully funded individual accounts of the defined contribution (DC) type. The third pillar comprised of voluntary retirement savings, but it still quite underdeveloped.

These new, privately managed financial institutions become an important part of the financial architecture for all of these countries. Their growth has been significantly reduced by the changes in retirement-income systems triggered by the 2008-2009 financial and economic crisis and even more viable with the problems sparked in public finances. Most of the countries reduced the amount of mandatory contributions paid into the pension funds or changed fund participation rules (Bielawska, Chłóń-Domińczak, and Stańko 2017). The most prominent and publicly argued argument that led to the change was a claim about the unsatisfactory level of pension funds' performance.

In Croatia, the systemic reform of the pension system with introduction of mandatory and voluntary pension funds started in 2002 after various parametric reforms of public PAYG system.² It was aimed at diversifying the sources of pension funding, reducing the public and increasing individual retirement benefits and making the system financially viable. Besides reduced PAYG first pillar, the reform resulted in introduction of second and third pillar privately managed mandatory and voluntary pension funds. In the following years, mandatory pension funds turned into most prominent institutional investors in Croatian financial system with 1.94 million members and total assets of HRK 98.1bn at the end of 2018 (HANFA 2018). Therefore, it is not surprising that there is a great public interest for their financial performance and achieved results.

Given that the pension funds are large investors in the domestic economy, by investing their accumulating assets in different securities, they can protect jobs and enhance economic growth. However, they can achieve that only if they are competitive and successful in means of financial performance.

The performance of pension funds is influenced by a number of factors that determine yields. Namely, each pension fund is characterized by its size (measured by number of members, collected contributions, net assets), investment structure, operating costs and investment returns (Vukorepa 2011; Vukorepa 2012).

² The Croatian government implemented parametric reforms of the PAYG system in 1998/1999 and afterwards established three-pillar system with newly formed mandatory and voluntary pension funds that has been in effect since 2002.

Nevertheless, in spite of the great interest of the scientific and professional public, the performance of pension funds in Croatia is a topic that has been envisaged in just a few scientific papers. Bejaković (2019) stated that the structure of the existing Croatian pension system is justified and sustainable with respect to the analysis and comparison of elaborated returns and fees of pension funds. The opposite view on the level of (excessive) operative costs and their justification was explored by Bežovan (2019).

Matek and Radaković (2015) found that active management of mandatory pension funds in Croatia has added on average 77 basis points of return per year during the period from 2005-2014. They identified the main obstacle for the performance assessment of pension funds in lack of publicly available and investible total return benchmark indices for the Croatian market. Novaković (2015) also concluded that Croatian pension funds outperformed the customized external benchmarks on a risk-adjusted basis and for the period from 2002-2013. In the study from 2016 (Matek, Lukač, and Repač) authors found that there are significant differences for the four fund managers investment skills. Nevertheless, all pension funds have achieved a rate of return superior to the risk free-rate and have consequently exhibited positive Sharpe ratios. This is in line with previous studies of Antolin (2008) and Novaković (2015) considering their findings of outperforming the customized external benchmarks on a risk-adjusted basis. These studies used positive Sortino ratios, i.e. a rate of return superior to the inflation rate increased by a margin of 2 percentage points per year. Novaković (2015) also used the Sharpe ratios, the information ratio and the Treynor ratio to rank and compare pension funds portfolio performances. In addition to these generally accepted measures of pension funds performance i.e. investment performance ratios, risk adjusted ratios and artificially constructed benchmarks, the measurement of technical efficiency by Data Envelopment Analysis (DEA) method could be used as an alternative benchmarking tool. Moreover, Rii Zamuee (2015, p. 216) reveals DEA as more reliable and unique compared to traditional measurements based on investment returns.

We choose to measure and evaluate technical efficiency because it is a principal element in economic performance of different business units, either in productive or financial industries. Technical efficiency can be defined as an ability to produce the greatest possible range of outputs with the minimum possible range of inputs. Technically efficient unit is the one that is not able to increase its production without consuming more resources, or reduce the use of at least

one input while maintaining the same level of production (Farrell, 1957).

This paper aims to fill the gap of literature on efficiency of pension funds in Croatia by examining the technical efficiency of four mandatory pension funds³ divided into three categories (A, B or C) by applying DEA. This study is the first analysis of the technical efficiency of Croatian mandatory pension funds to the best of the authors' knowledge.

The authors analyzed the annual data provided by Croatian Financial Services Supervisor Agency (HANFA) for the period 2015-2018. The period before 2015 was not taken into account due to data availability for 12 mandatory pension funds which are being analyzed. Namely, before 2014 there were only four mandatory pension companies operating in the Republic of Croatia managing one mandatory pension fund. In 2014, new legislative framework come into force and enabled a mandatory pension fund belonging to one of the categories A, B or C. Three categories differ with respect to the duration of the fund membership until the retirement of the member, i.e. investment strategies and risk taken.

Hypothesis states that when evaluating the technical efficiency of pension funds it is possible to determine that there are very small differences in performance of analyzed mandatory pension funds in the Republic of Croatia. The contribution of this research lies in the analysis of the performance of all mandatory pension funds divided into categories (A, B or C), in order to investigate the ability of pension industry to preserve contributors saving and add sufficient return as display of strengthening the financial sustainability of pension systems.

The remainder of this paper is organized as follows. The second section briefly reviews literature findings on efficiency of financial institutions, especially for the pension funds. In the third part of the paper, we carry out an analysis of the structure and features of Croatian pension system, with an emphasis to characteristics and performance of mandatory pension funds. The fourth section focuses on describing the data set and used methodology of data envelopment analysis. The fifth section reveals the empirical results while the conclusion provides summarize, limitations and recommendation for further research.

³ Four mandatory pension companies operating in the Republic of Croatia managed one mandatory pension fund belonging to each of the categories A, B or C.

2. EFFICIENCY OF FINANCIAL INSTITUTIONS: A LITERATURE REVIEW

In the literature many studies have been conducted in evaluating efficiency of various financial institutions in the European countries and abroad using DEA methodology (Berger and Humphrey 1997; Emrouznejad and Cabanda 2014; Serrano Cinca, Mar Molinero, and Fuertes Callén 2016). By observing only banking institutions, recent studies are Sherman and Gold (1985), Jemrić and Vujčić (2002), Memić and Škaljić-Memić (2013), Řepková (2014), Tuškan and Stojanović (2016), Bucevska and Hadzi Misheva (2017), Cerović, Suljić Nikolaj and Maradin (2017), Maradin, Oligić Draženović and Benković (2018), Novickytė and Drożdż (2018), and Jurčević and Mihelja Žaja (2013) identified and compared the efficiency measurement results of 30 banks and 19 insurance companies in the period before and after the onset of recent economic crisis (2005-2010) in the Republic of Croatia.

Although lots of studies in evaluating relative efficiency of banking institutions in various countries using DEA methodology have been conducted, only few of them can be found evaluating other financial institutions i.e. insurance companies (Barros, Nektarios, and Assaf 2010; Turkan, Polat, and Gunay 2012; Jarraya and Bouri 2014; Micajkova 2015; Eling and Schaper 2017; Grmanová and Strunz 2017; Eling and Jia 2018) investment funds (Guo, Ma, and Zhou 2012; Basso and Funari 2014; Lulewicz-Sas and Kilon 2014; Gardijan and Krišto 2017; Sánchez-González, Sarto, and Vicente 2017; Allevi et al. 2019) and pension funds.

Research on the efficiency of pension funds are rare; there are just a few scientific articles focused on measuring the efficiency of pension funds, especially for the countries of Central and Eastern Europe. By examining the influence of reforms on Polish pension funds, Kucharski (2016) analyzed 13 open pension funds (OPF) and indicated a strong decrease of efficiency indicators in most OPF caused by the outflow of members and less effective use of transferred contributions. The author also used DEA methodology to examine the efficiency of pension funds in new legal situation in Poland. Therefore, the quarterly change in the number of members and the value of contributions were used as inputs, while for outputs, the mean value of an accounting unit and the financial result of the fund. Rii Zamuee (2015) measured and evaluated the relative financial efficiency of 79 pension funds in Namibia during the period 2010–2014. To obtain empirical results, four inputs (retirement funding contributions, administration costs, investment costs and total fund expenses) and three outputs (fund credits at the end of 5 years, investment returns and average

fund assets) were used as DEA variables. The research findings reveal that most of the pension funds are operating below the efficiency frontier set by the efficient peers. Furthermore, the efficiency results also indicate that funds have relatively low efficiency scores compared to Kenya and Australia. Kurtaran, Karakaya, and Dağlı (2013) analyzed improvement of private pension system in Turkey for the period 2004–2011 by applying DEA methodology. To obtain efficiency scores, two inputs (number of employees representing the labor force and total assets representing capital) and two outputs (total premiums collecting representing the income obtained by company and number of contracts representing the number of participants) were used. Based on efficiency scores, it was concluded that a large-scaled company group had lower efficiency than a small-scaled company group and domestic companies had lower efficiency than foreign companies. The main reason for inefficiency was their inability to operate in optimal scale due to financial crisis. Medeiros Garcia (2010) evaluated and ranked 12 Portuguese pension funds management companies according to their change in total productivity for the period 1994–2007. The inputs (value of pensions paid by the company to the beneficiaries, number of equivalent workers, book value of net assets, contribution received from sponsors and individuals) and outputs (number of funds managed by the company, value of the funds managed by the company, profits earned by the company and number of participants in the funds) were used in DEA methodology. Empirical results encompass several combinations of efficiency change, signifying that pension funds management companies with the poorest performances should change their managerial procedures, and that adjustment have to be based on the improvement of technical efficiency, as well as technological change. Miszczyńska and Miszczyński (2007) examined the technical efficiency of 15 open pension funds in Poland for the period 2004–2006. To evaluate the efficiency of open pension funds the output oriented DEA methodology were applied with selected inputs (number of members, operating costs per capita) and outputs (net assets, result of investments, accounting unit's values). The executed research on efficiency and its changes over time confirms that two funds (Commercial Union and Nationale Nederlanden) remain the leaders in the market of pension funds, and almost all funds operated within the area of increasing returns to scale. Additionally, the efficiency of almost all pension funds increased period by period (growth in efficiency by 1.5-25.3%). Mavlutova, Titova, and Fomins (2016) examined the efficiency of private voluntary pension

schemes in order to provide appropriate pension level in actual financial markets situation. They found that Latvian government is obliged to stimulate Latvian securities market development in order to achieve the Latvian population pension saving investment. Özbek (2015) investigated the performance of 19 private pension companies in Turkey in the period 2010–2014 by applying efficiency analysis technique with output satisficing. In the study, three inputs (number of staff employed, total assets and total shareholders' equity) and two outputs (premium production and pension contracts) were used. According to the analyzed literature, the above mentioned studies applied DEA methodology in analysing efficiency of pension funds and other financial institutions. This is a non-parametric method that allows creation of ranking of decision-making units (DMUs) (in our case mandatory pension funds) indicating the units that could achieve higher outputs at given inputs. If the result of DMUs is equal to 1.0 this means that DMUs is efficient, in other case, when DMUs have efficiency results smaller than 1.0, it is inefficient unit. Technical efficiency measures the ability of DMUs to produce maximal output from a given set of inputs. According to Yannick, Hongzhong, and Thierry (2016) there are two principles of technical efficiency – output oriented and input oriented. The output oriented “measure the ability of a production unit to get the maximum outputs possible with a given combination of inputs and production technology, while the input oriented measures its ability to achieve a given output level with the smallest quantities possible of inputs” (p. 200). Except DEA, stochastic frontier analysis (SFA) also measure efficiency of DMUs. The difference between these two methods are that DEA assumes no errors and deviations from the efficient frontier rather they are entirely assumed to be due to inefficiency, and SFA requires specification of functional form for the frontier and assumption about the distributions of the random error and inefficiency error terms. Based on all above explained, we applied DEA methodology to measure efficiency of four mandatory pension funds divided into three categories in Croatia with most commonly used input and output variables as in mentioned studies. Moreover, a precise conclusion about the efficiency of pension funds can not be drawn, since it depends in the most of the cases on economic development of a country and pension funds.

3. PENSION FUNDS IN CROATIA

Over the past two decades, mandatory pension funds have become the fastest growing financial institutions which have completely changed the landscape of Croatian financial system. The domination of banks is threatened by the rapid and steady growth of pension funds, evolving from newly formed financial institutions in 2002 to the second financial industry in Croatia today. Hence, pension reform was the strongest trigger for the development of non-bank intermediation in Croatia (Olgić Draženović, Prohaska, and Suljić 2015). According to the analysis of HANFA (2018), by the end of 2018, assets of mandatory pension funds stood at HRK 98.1bn which positioned mandatory pension funds as the largest and, with respect to investment potential, the most significant institutions in the financial services sector. The relative importance of mandatory pension funds in the total assets of Croatian financial system amounted to 17% (at the end of the 2018) while banks possess 67% of the total assets.

Pension funds were introduced in Croatia in 2002. Since then, the Croatian pension system exists in a form of a combined «three pillar» system, i.e. the establishment and management of mandatory and voluntary pension funds. Former PAYG public pension system (first pillar) was complemented by privately-managed two pension pillars based on individual capitalized savings. The second pillar involves mandatory “defined contribution” pension funds. Third pillar is a voluntary supplementary scheme including both open-end funds for citizens and closed-end funds sponsored by employers, trade unions or other professional associations (Vukorepa 2012) which are not analyzed in this paper.

All mandatory pension funds are run by one of the four existing management companies which were set up by the few biggest banks and insurance companies in Croatia. Consequently, a rather small number of asset managers operate in a highly interconnected environment. The institutional framework also includes the supervisory authority of HANFA, the depository bank and Central Registry of Affiliates (REGOS) as a public administration institution related to all aspects of pension insurance based on individual capitalized savings. REGOS’s primary task is to collect contributions for members of mandatory pension funds and to keep records of the number and balance of personal retirement accounts.

In the wake of 2008-2009 financial and economic crises, Croatian pension scheme was struggling with insufficient rates of returns and reduced growth in assets consequently with reduced public support. By the amendments to the law, a life-cycle investment

model was introduced in 2014 by the definition of three mandatory pension funds categories of different risk profile, i.e. different investment strategies. The idea is based on premises that riskier investments with high returns are suitable for younger people at the beginning of the accumulation phase while for members that are approaching the retirement age, security of investment is more important than high returns (Kovačević and Latković 2015). Each of the management companies offers three sub-funds to the system participants depending on their investor profile and risk preferences: category A (aggressive), B (balanced) and C (conservative). Category A fund has the highest risk profile, the category C fund may not create exposure to the equity markets and the model B fund can be considered as a fund with a moderately conservative risk profile. Since introduction of three funds categories in 2014, the majority of members still remained in the category B, as presented in Table 1. Less than 1% of total assets relate to category A, while the largest share, as much as 94.4% consists of assets of category B funds. Given that category A and C funds have only been operating five years, it is too early to estimate the yields of OMFs of these categories over a longer period. However, the yield from the start of operations of category A funds is slightly higher (7,04%) than that of category C funds (6%), which reflects their increased risk.

Taking into account pension funds investment policy and given regulatory framework, Croatian funds are very cautious and oriented toward domestic debt market. The 2007 amendments introduced more liberal investment limits in line with the European Union legislation but the portfolio structure remained very similar in the following years. The majority of assets (89% in 2018) is invested in the securities of domestic issuers, whereby the largest component of investment portfolios is domestic public debt (government bonds 69%). Therefore, one can observe that pension funds are too attached to the financial position of the state and overly exposed to the risk of the government bond market. Investment in equities and foreign markets are rather small, because of the lack of specialist experience and the reluctance for greater flexibility and investment dynamics. One of the possible explanation is tacit collusion and conflict of interest (Šonje 2011) Furthermore, corporate debt market in Croatia is dominated by bank-based lending and yields on government bonds are attractively high. Differences in investment strategies across funds are very small and available performance measurements are proven to be inadequate and not transparent enough (Šonje 2011; Novaković 2015; Matek and Radaković 2015).

The main problems of pension funds in Croatia, as

Table 1: Mandatory pension funds in Croatia in period 2015-2018

	2015	2016	2017	2018
Number of funds	12	12	12	12
Number of fund members	1,731,181	1,784,169	1,844,272	1,936,261
Category A	5,094	5,369	5,874	6,273
Category B	1,707,104	1,755,823	1,810,704	1,896,361
Category C	18,983	22,977	27,694	33,627
Total contributions (HRK 000)	56,009,813	61,348,342	67,011,806	73,191,233
Net assets (in HRK 000)	74,004,667	84,179,365	91,924,545	98,126,194
Category A	416,563	506,297	589,546	652,895
Category B	71,351,783	80,624,190	87,374,803	92,633,969
Category C	2,236,322	3,048,878	3,960,196	4,839,330
Return Mirex	7.60%	8.72%	4.57%	1.60%
Category A	9.12%	11.80%	4.57%	0.84%
Category B	6.90%	6.94%	3.06%	1.02%
Category C	6.78%	7.43%	6.08%	2.94%

Source: HANFA 2018

well as in other CEE countries, are as follows (Bakker and Gross 2004; Šonje 2011; Olgjić Draženović, Prohaska, and Suljić 2015, Kovačević and Latković 2015):

- their size related to the shallow and narrow capital market (disproportion between huge demand for “blue chip” securities and available listings),
- ownership and interest relationships between banks and pension fund management companies,
- quantitative regulatory restrictions as the only means of regulating pension funds and lack of funds portfolio diversification,
- high exposure to country risk given prevailing investing in domestic government bonds,
- insufficient competition (to promote maximization of long-run net returns at acceptable level of risk),
- the problem of transparent measurement of pension fund performance (vulnerability to populism and ad hoc policy measures).

The presence of pension funds has undoubtedly had a crucial influence on the development of Croatian capital market. Favorable developments were reflected in the increased orientation to the financing of public debt in the country both in foreign currencies and in Kuna. Also, during the pre-crisis period, the market has emerged corporate and municipal bonds and commercial papers, and also a number of initial public offerings. After 2007, the presence of pension funds was almost the only source of securities demand. Despite these positive influences, the

Croatian capital market can still be assessed as illiquid, shallow and narrow.

4. DATA AND METHODOLOGY

In Croatia, there are only 4 mandatory pension funds (MPF) divided into three categories each A, B, C – PBZ Croatia osiguranje category A (PBZ MPF A), PBZ Croatia osiguranje category B (PBZ MPF B), PBZ Croatia osiguranje category C (PBZ MPF C), Raiffeisen category A (R MPF A), Raiffeisen category B (R MPF B), Raiffeisen category C (R MPF C), AZ category A (AZ MPF A), AZ category B (AZ MPF B), AZ category C (AZ MPF C), Erste Plavi category A (E MPF A), Erste Plavi category B (E MPF B), Erste Plavi category C (E MPF C). Therefore, the analysis is based on 12 DMUs representing 100% of the Croatian mandatory pension funds industry.

DEA is widely used methodology to calculate efficiency of numerous DMUs operating in similar conditions. DEA methodology allows comparison of selected units/entities (DMUs) with the best ones in the sector, i.e., with entities achieving the highest level of efficiency. With this methodology, it is also possible to determine the sources of financial institutions' inefficiency and to have an impact on their elimination. In order to obtain the technical efficiency scores, two inputs and two outputs were applied, as presented in Table 2.

The data were collected from publicly accessible source – HANFA monthly reports based annually, and its statistics are presented in Table 3.

Table 2: Definition of variables

	Variables	Description
Inputs	Entry fees transferred to mandatory pension funds	calculated as a percentage of paid in contributions, calculated and paid to pension funds by Central Office of Insurance (Regos)
	Net pension contributions transferred to mandatory pension funds	based on individual capitalized savings calculated and paid in accordance with the rate determined by law and reduced by a mandatory pension funds entry fee
Outputs	The values of mandatory pension funds units of account	
	Net assets of analysed mandatory pension funds	

Table 3: Statistics of inputs and outputs data in the DEA model for 2015-2018

		Entry fees	Net pension contributions	Values of MPF units of account	Net assets
2015	Max	12,268.87	1,922,205.56	224.19	28,444,271.52
	Min	34.18	4,597.55	107.22	54,602.02
	Average	2,983.99	430,019.94	146.94	6,167,055.57
	SD	4,323.47	649,002.71	49.81	9,366,568.35
2016	Max	12,588.66	1,964,915.94	242.30	31,670,436.02
	Min	38.66	4,793.94	115.08	67,302.22
	Average	3,090.52	444,877.44	159.69	7,014,947.06
	SD	4,427.86	665,011.41	52.23	10,486,096.40
2017	Max	13,225.48	2,054,844.68	254.80	33,646,266.90
	Min	41.29	5,119.94	122.07	79,708.37
	Average	3,283.42	471,955.33	166.80	7,660,378.76
	SD	4,659.44	697,678.18	52.91	11,257,873.83
2018	Max	14,311.41	2,203,531.16	254.56	35,625,951.19
	Min	48.45	6,007.82	126.08	87,927.57
	Average	3,591.41	514,952.25	169.08	8,177,182.80
	SD	5,050.63	752,607.91	52.72	11,892,697.69

Source: Authors' calculation

The approach in this study is to verify empirically the technical efficiency among 12 mandatory pension funds in Croatia. By applying MaxDEA software, Version 7, we calculate the efficiency scores of the input and output variables as well as scale efficiency for the each observed year in the period 2015-2018. Methods of efficiency measurement can be divided into three main categories, such as ratio indicators, parametric and nonparametric methods. In line with economic theory, Data Envelopment Analysis and Free Disposal Hull are nonparametric methods. Farrell (1957) defines and analyzes two concepts of efficiency. *Technical (productive) efficiency* indicates the ability of the company to maximize output from the available

or given level of inputs. The second efficiency concept implies *price (allocative) efficiency*, which indicates the ability of the company to use different inputs in an optimal ratio, given their prices and production technology. If the company is perfectly efficient, or if both technical and price efficiency is satisfied, then *overall (economic) efficiency* is achieved. In this study only the technical efficiency is evaluated, because it is more precisely and prevalent for business performance of the financial institutions to measure and investigate the productive efficiency instead of the price efficiency. In 1957, Farrell laid down the foundations of efficiency, which was later developed by Charnes, Cooper and Rhodes (1978). One of the basic DEA models is the

model of Charnes, Cooper, and Rhodes (CCR) which measure efficiency under the assumption of constant return to scale, which is later extended with Banker, Charnes, and Cooper (BCC) (1984) to allow variable return to scale. This is a nonparametric linear programming method for assessing the relative efficiency of DMUs assuming no random mistakes. Under this method, the DMU is relatively efficient if the input-oriented optimal solution or the output-oriented optimal solution is equal to one. The efficiency curves created units that are relatively efficient compared to other observed units, by maximizing their output variables with specified input variables. It is composed of units that utilize resources in the best possible way in order to achieve outputs. This curve also represents the goal the inefficient units are seeking to achieve. Inefficient units may achieve their efficiency by representing their inputs and outputs values on the curve.

CCR Model

This model implies constant returns-to-scale, which means that output variables increase proportionally with input variables. Therefore, DMUs are operating at optimal scale and allow for estimation of the overall technical efficiency without variations in returns to scale. It is supposed there are n DMUs converting m inputs ($x_i, 1, 2, \dots, m$) into s outputs ($y_r, r=1, 2, \dots, s$). The idea behind the CCR model is to form a virtual input ($v_1x_{1o} + \dots + v_mx_{mo}$) and virtual output ($u_1y_{1o} + \dots + u_sy_{so}$) for each DMU $_j$ included the analysis, using output weights ($u_r, r=1, \dots, s$) and input weights ($v_i, i=1, \dots, m$).

This model is specified as follows:

$$\max \theta_0 = \frac{\sum_{r=1}^s u_r y_{r0}}{\sum_{i=1}^m v_i x_{i0}} \quad (1)$$

Subject to:

$$\frac{\sum_{r=1}^s u_r y_{rj}}{m} \leq 1 \quad (j=1, 2, \dots, n) \quad (2)$$

$$u_1, u_2, \dots, u_s \geq 0; v_1, v_2, \dots, v_m \geq 0 \quad (3)$$

The constraints within this model specify that the ratio of output to input should not exceed 1 for each DMU. In addition, the objective is to get assigned weights by which the ratio is maximized for a particular DMU that is being analyzed. The optimal value is 1 due to the set-up of the actual constraints.

BCC Model

This model is another commonly used DEA model based on the assumption of variable (increasing or decreasing) returns-to-scale. Unlike the CCR model, which is represented by a straight line, this model is represented by a convex efficiency frontier. Therefore, it differs from the CCR model only in that it includes convexity constraints:

$$\sum_{j=1}^n \lambda_j = 1, \lambda_j \geq 0 \quad \forall j \quad (4)$$

In order to determine which DMUs operate at maximum scale or not, scale efficiency has been calculated. Scale efficiency is determined for each DMUs in every model as follows:

$$SE = \frac{TE_{CRS}}{TE_{VRS}} \quad (5)$$

Where:

TE_{CRS} is the technical efficiency of a DMUs under constant returns to scale; and

TE_{VRS} is the technical efficiency of a DMUs under variable returns to scale.

If the value of $SE=1$, then the DMUs is scale efficient, meaning that it operates at maximum scale.

5. EMPIRICAL RESULTS AND DISCUSSION

By providing DEA methodology, technical efficiency among 12 mandatory pension funds in Croatia were estimated. In Table 4, the efficiency scores of CCR model are presented.

Very interesting results of efficiency scores are found by observing each year for each DMU (mandatory pension fund). In the observed period 2015-2018, according to the efficiency scores, the best year was 2015 where five pension funds (PBZ MPF A, R MPF C, AZ MPF C, E MPF A and E MPF C) achieved score 1. The interesting fact is also that among them, two pension funds are from the same fund, i.e. Erste Plavi category A (E MPF A) and Erste Plavi category C (E MPF C). In the

Table 4: Results of CCR Model

	2015	2016	2017	2018
PBZ MPF A	1.000	0.981	0.924	0.946
PBZ MPF B	0.601	0.598	0.557	0.530
PBZ MPF C	0.923	0.927	0.913	0.912
R MPF A	0.800	0.789	0.812	0.802
R MPF B	0.654	0.644	0.619	0.594
R MPF C	1.000	0.985	0.963	0.960
AZ MPF A	0.857	0.881	0.861	0.909
AZ MPF B	0.684	0.672	0.639	0.621
AZ MPF C	1.000	1.000	1.000	1.000
E MPF A	1.000	1.000	1.000	1.000
E MPF B	0.623	0.610	0.579	0.537
E MPF C	1.000	1.000	1.000	1.000

Source: Authors' calculation

Table 5: Results of BCC Model

	2015	2016	2017	2018
PBZ MPF A	1.000	1.000	1.000	1.000
PBZ MPF B	0.931	0.947	0.927	0.935
PBZ MPF C	0.972	0.963	0.956	0.956
R MPF A	0.993	0.947	0.972	0.963
R MPF B	0.986	0.994	1.000	1.000
R MPF C	1.000	1.000	1.000	1.000
AZ MPF A	0.998	0.992	0.980	0.968
AZ MPF B	1.000	1.000	1.000	1.000
AZ MPF C	1.000	1.000	1.000	1.000
E MPF A	1.000	1.000	1.000	1.000
E MPF B	1.000	1.000	1.000	1.000
E MPF C	1.000	1.000	1.000	1.000

Source: Authors' calculation

Table 6: Scores of scale efficiency

	2015	2016	2017	2018
PBZ MPF A	1.000	0.981	0.924	0.946
PBZ MPF B	0.645	0.632	0.601	0.567
PBZ MPF C	0.950	0.962	0.955	0.954
R MPF A	0.806	0.832	0.835	0.833
R MPF B	0.663	0.648	0.619	0.594
R MPF C	1.000	0.985	0.963	0.960
AZ MPF A	0.859	0.888	0.879	0.939
AZ MPF B	0.684	0.672	0.639	0.621
AZ MPF C	1.000	1.000	1.000	1.000
E MPF A	1.000	1.000	1.000	1.000
E MPF B	0.623	0.610	0.579	0.537
E MPF C	1.000	1.000	1.000	1.000

Source: Authors' calculation

later period, only three pension funds achieved efficiency score of 1.

The empirical analysis showed different efficiency scores for BCC Model. The results are presented in Table 5.

In the same time period 2015-2018, among observed pension funds there are only few of them with scores lower than 1, i.e. that are relatively inefficient. These are PBZ MPF B, PBZ MPF C, R MPF A, R MPF B and AZ MPF A in 2015 and 2016, while in 2017 and 2018 the results are the same except that R MPF B is evaluated as relatively efficient.

The mandatory pension funds that operate at maximum score are presented in Table 6.

By observing scale efficiency scores for each year and pension fund, the results displayed that in 2015 there were five pension funds (PBZ MPF A, R MPF C, AZ MPF C, E MPF A, E MPF C) that achieved score 1, and in the later years, only three pension funds (AZ MPF C, E MPF A, E MPF C) had the same score 1. Based on this analysis, we can say that they operated at maximum score for the observed years, i.e. that they operated fully efficient with the observed minimum inputs the maximum outputs are generated.

It is not possible to estimate the performance of the observed pension funds concerning the returns to scale, i.e. constant and variable returns to scale. In that case, it is important to evaluate the relative efficiency with the use of constant (CCR model) and variable (BCC model) returns to scale, as we have already presented in Table 4 and Table 5. The following Table 7 summarizes the above-mentioned.

Table 7 shows the results of the relative efficiency of 12 mandatory pension funds evaluated by the CCR model and the BCC model. There is a significant difference in the number of efficient pension funds assessed with the use of BCC model. For example, there are 166% more efficient funds in the BCC model than in the CCR model in 2017 and 2018. Additionally, the average result of efficiency is higher with variable returns, than with constant returns to scale. This implies that pension funds operated under variable returns to scale.

After defining the variable returns to scale, it is necessary to select the model with respect to orientation. In oriented models the main target of evaluation is either input reduction or output expansion. Input-oriented models aim to reduce input resources to the efficient frontier as far as possible while the output remains at the current level. Output-oriented models maximize output levels in existing input capacities. In this paper,

Table 7: Relative efficiency with the use of constant and variable returns to scale

	2015		2016		2017		2018	
	CCR	BCC	CCR	BCC	CCR	BCC	CCR	BCC
Results of the relative efficiency	CCR	BCC	CCR	BCC	CCR	BCC	CCR	BCC
No. of efficient DMUs	5	7	3	7	3	8	3	8
No. of inefficient DMUs	7	5	9	5	9	4	9	4
Average result of the efficiency	0.845	0.99	0.84	0.987	0.822	0.986	0.818	0.985
Max. result of the efficiency	1	1	1	1	1	1	1	1
Min. result of the efficiency	0.601	0.931	0.598	0.947	0.557	0.927	0.53	0.935

Source: Authors' calculation

Table 8: Projections of relatively inefficient pension funds

DMU	2015		2016		2017		2018	
	Change of the output values of PF units of account	Change of the output net assets	Change of the output values of PF units of account	Change of the output net assets	Change of the output values of PF units of account	Change of the output net assets	Change of the output values of PF units of account	Change of the output net assets
AZ MPF A	0.243%	0.243%	0.759%	0.759%	2.046%	2.046%	3.277%	3.277%
R MPF A	0.664%	0.664%	5.564%	5.564%	2.875%	2.875%	3.847%	3.847%
R MPF B	1.379%	1.379%	0.639%	0.639%	-	-	-	-
PBZ MPF C	2.934%	2.934%	3.821%	3.821%	4.64%	4.64%	4.586%	4.586%
PBZ MPF B	7.391%	7.391%	5.61%	5.61%	7.872%	7.872%	6.916%	6.916%

Source: Authors' calculation

the evaluation of relative efficiency is carried out using the BCC output-oriented model, i.e. holding inputs constant, values of pension funds units of account and net assets as outputs need to be maximized. The output-oriented model is used because it is more appropriate, by the authors opinion, to interpret the research results considering the efficiency of pension funds (by increasing output values while maintaining current inputs).

Besides ensuring the current level of relative efficiency of mandatory pension funds, DEA method can also provide information on how to eliminate relative inefficiency by identifying sources and amounts of inefficiencies. This presents Table 8 with projections or necessary improvements of relatively inefficient pension funds to become efficient.

Table 8 gives an overview of all relatively inefficient pension funds in Croatia and required changes or projections of certain variables in order to achieve a relative full efficiency, i.e., the suggested enhancements of output values. Taken into consideration that the output-oriented model is applied, relative efficiency is achieved by increasing output values while maintaining current inputs. This means that the lowest rated pension fund PBZ MPF B, to become relatively efficient, should increase output amounts, i.e., output

values of pension funds units of account and output net assets, each by 6.916% for the latest observed year. It is necessary to point out that the pension fund R MPF B was relatively efficient in 2017 and 2018, unlike in 2015 and 2016.

Although the research has shown that there are differences in relative efficiency of pension funds, and that four pension funds (2017 and 2018) and five pension funds (2015 and 2016) are evaluated as relatively inefficient, it can be concluded that those differences are very small. Furthermore, for 2015 and 2016, most of the pension funds (58%) are doing business within the efficiency frontier. In 2017 and 2018, over 66% of pension funds are efficient. All the above shows that the market is very homogeneous and that pension funds have the stable membership within the similar investment strategy and opportunistic behavior. Due to the fact that members are not interested in transferring to another pension fund, they may be perceived as passive. This kind of behavior further emphasizes the lack of pension market competitiveness.

According to Markovič Hribernik and Jakopanec (2012), the preference of pension funds towards a more conservative investment approach is explained with the rule of a minimum guaranteed return. Based on The mandatory pension fund Act (2014), pension

companies have to set aside a guarantee deposit that would be activated if the average annual yield of the pension fund through the period of three calendar years is smaller than the guaranteed yield. Matek and Galić (2017) considered that as the evidence of herding behavior between fund managers as pension fund management companies could further reduce the risk of activation of the guarantee scheme by aligning their portfolios with competitors. Therefore, pension funds in Croatia can be marked as highly interconnected group of institutional investors.

6. CONCLUSION

The efficiency of pension systems in the world, and also in Croatia has significant impact on economic growth and social cohesion. The aim is to improve the welfare of people during retirement by stimulating them to make long-term savings. Investment system and individual retirement savings help government to create new jobs and to ensure social security, to promote individual financial responsibility and to boost economic growth.

The activity and performance of pension funds in Croatia is in the focus of public interest, especially in terms of achieved results and performance in given terms. Particularity that is the case for the annual returns and costs of the mandatory pension funds.

Based on the observed results, we can conclude that among 12 mandatory pension funds, only five pension funds (PBZ MPF A, R MPF C, AZ MPF C, E MPF A, E MPF C) achieved scale efficiency for the period from 2015 to 2018, meaning that they operated at maximum score in 2015. By analysing CCR and BCC model, we found that there are 166% more efficient funds in the BCC model than in the CCR model in 2017 and 2018. Results reveal that mandatory pension funds tend to act similarly due to legal investment restrictions, herding behaviour and pension funds interconnection, prescribed minimum guaranteed return and lack of pension market competitiveness in Croatia. The limitations of this research are in limited number of mandatory pension funds, where we were not able to use more input and output variables in empirical analysis due to DEA limitations. Moreover, taking into account the different classification of funds by the law amendments in 2014, the number of funds has increased from 4 to 12. Our recommendation for further research will be to examine efficiency of all pension funds in Croatia (mandatory and voluntary) and compare it with selected European countries, especially those countries that implemented systemic three-pillar pension reform.

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