UDK:528.88:303.22:616-036.8:517.988:368.031.9(497.11)
DOI: 10.5937/tokosig2103009F

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APPLICATION OF ARAS METHOD IN ASSESSING EFFICIENCY OF INSURANCE COMPANIES IN SERBIA

SCIENTIFIC PAPER

Abstract

The issue of assessment of the efficiency of insurance companies based on multi-criteria analysis has become increasingly pressing, complex and significant. It provides the grounds for the achievement of future improved efficiency of insurance companies by using adequate measures. With this in view, the paper analyses the efficiency of insurance companies in Serbia based on ARAS (Additive Ratio Assessment) method. The results obtained from the empirical research of the efficiency of insurance companies in Serbia by ARAS method show that the year 2020 was the most efficient. Lately, the efficiency of insurance companies in Serbia has continuously increased, positively triggered by a number of factors such as the economic climate, standard of living, employment, modern cost management concepts, revenues and profit, electronic sale of insurance services, digitization of overall business. The negative impact of the Corona virus pandemic in Serbia is negligible (compared to the other industries) and partially compensated for by the increased online sale of the insurance services and/or the growth in insurance of infrastructure (property) on the one hand and the raised awareness of the need to be covered by insurance against potential risks of all kinds, on the other hand.

Key words: *efficiency, insurance, ARAS method*
JEL Classification: C2, C6, G1, G2, G22

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Paper received on: 10 july 2021
Paper accepted on: 28 july 2021

I. Introduction

The evaluation of the efficiency of insurance companies based on multi-criteria analysis (Beiragh, 2020) is becoming increasingly significant. Starting from this, the subject of the research in the paper comprises an efficiency analysis of insurance companies in Serbia based on the ARAS method. The aim and purpose is to treat this issue with a greater complexity in terms of quality and, especially, the quantity in order to get to know what is the real efficiency of insurance companies in Serbia, as a starting point for improving the efficiency in future by taking adequate steps. This, among other things, reflects the scientific and professional contribution of this paper.

Recently, an increasingly rich literature has been dedicated to assessing the efficiency of all companies, including the insurance companies, based on multi-criteria analysis (Saaty, 2008; Chatterjee, 2013; Isseveroglu, 2015; Ersoy, 2017; Lukic, 2018, 2019, 2020a, b, c , 2021a, b, c; Beiragh, 2020; Tsolas, Ioannis, 2020; Tsvetkova, 2021). In this context, the role and importance of the ARAS method is growing (Thakkar, 2021). In the relevant literature, as far as we know, there is no completed paper dedicated to evaluating the efficiency of insurance companies in Serbia using the ARAS method (Kočović, 2010; Lukić, 2010, 2016; Mandić, 2017; Rakonjac Antić, 2018). This paper is intended to fill the gap to some extent, which reflects, *inter alia,* its scientific and professional contribution.

The standard research hypothesis of the issue processed in this paper relies upon the fact that a continuous analysis and control of the factors of influence is a prerequisite for improving the efficiency of insurance companies in the future by taking the adequate steps. Here, the application of ARAS method also plays a significant role.

The research methodology of the given hypothesis relies upon the application of AHP and ARAS methods. To some extent, we used a statistical analysis for the most complex quantitative analysis of the problem treated in this paper.

For the purposes of researching the problem dealt with in this paper by using the presented methodology, we collected the empirical data from the Serbian Business Registers Agency. These data were produced in accordance with the relevant international standards, so that no restrictions are imposed on the international-scope comparison.

II. ARAS Method

ARAS (*Additive Ratio Assessment*) method is one of the multi-criteria analysis technique. It was developed by Zavadskas and Turskis (Zavadskas and Turskis, 2010). Unlike other methods of multi-criteria decision-making, the ranking of alternatives is based on the value of the utility function (Chatterjee and Chakraborty, 2013; Sliogene et al. 2013; Rostamzadeh, 2017; Koc, 2017; Dahooie, 2019; Jovčić, 2020). The ARAS method procedure consists of several steps (Zavadskas et. Al., 2010):

Step 1: Formulate a decision matrix.

The decision matrix (DMM) is formulated as follows:

$$X = \begin{bmatrix} x_{01} & \cdots & x_{0j} & \cdots & x_{0n} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ x_{i1} & \cdots & x_{ij} & \cdots & x_{in} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mj} & \cdots & x_{mn} \end{bmatrix}; i = \overline{0,m}; j = \overline{1,n} \quad (1)$$

where *m* – the number of alternatives, *n* – the number of criteria describing each alternative, x_{ij} – the performance value *i*-th alternatives in relation to *j*-th criterion, x_{01} – optimum value of *j*-th criterion.

If the optimum value of the j-th criterion is unknown, than

$$x_{0j} = \max_i x_{ij}, ako\ je\ \max_i x_{ij}\ poželjno;$$

$$x_{0j} = \min_i x_{ij}^*, ako\ je\ \min_i x_{ij}^*\ poželjno \quad (2)$$

Step 2: Normalization of the criterion value

In this stage, the initial criterion values are normalized – by defining value $\bar{x}_{ij}$ normalized decision matrices - $\bar{X}$.

$$\bar{X} = \begin{bmatrix} \bar{x}_{01} & \cdots & \bar{x}_{0j} & \cdots & \bar{x}_{0n} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ \bar{x}_{i1} & \cdots & \bar{x}_{ij} & \cdots & \bar{x}_{in} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ \bar{x}_{m1} & \cdots & \bar{x}_{mj} & \cdots & \bar{x}_{mn} \end{bmatrix}; i = \overline{0,m}; j = \overline{1,n} \quad (3)$$

If maximum value is suggested, the normalization is as follows:

$$\bar{x}_{ij} = \frac{x_{ij}}{\sum_{i=0}^{m} x_{ij}} \quad (4)$$

If minimum value is suggested, the procedure comprises two stages:

$$x_{ij} = \frac{1}{x_{ij}^*}; \quad \bar{x}_{ij} = \frac{x_{ij}}{\sum_{i=0}^{m} x_{ij}} \tag{5}$$

Step 3: determining the weight normalized matrix - $\hat{X}$

The weight coefficients are most often determined by the method of professional grade. Only well-founded weight coefficients should be used, in any case, because they are always subjective in nature and affect the outcome. The sum of weight coefficients is limited (i.e. it equals 1):

$$\sum_{j=1}^{n} w_j = 1 \tag{6}$$

$$\hat{X} = \begin{bmatrix} \hat{x}_{01} & \cdots & \hat{x}x_{0j} & \cdots & \hat{x}_{0n} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ \hat{x}_{i1} & \cdots & \hat{x}_{ij} & \cdots & \hat{x}_{in} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ \hat{x}x_{m1} & \cdots & \hat{x}_{mj} & \cdots & \hat{x}_{mn} \end{bmatrix}; i = \overline{0, m}; j = \overline{1, n} \tag{7}$$

The weight-normalized value of the criterion is defined as shown below:

$$\hat{x}_{ij} = \bar{x}_{ij} w_j; i = \overline{0, m} \tag{8}$$

Where w_j is the weight (relevance) of the *j*-th criterion and $\bar{x}_{ij}$ is normalized grade of the *j*-th criterion.

The function of optimal value is defined as shown below:

$$S_i = \sum_{j=1}^{n} \hat{x}_{ij}; \; i = \overline{0, m} \tag{9}$$

Where S_i is the function of the optimal value of the *i*-th alternative. If S_i is biggest, the criterion is the best.

Utility degree calculation (K_i) of the alternative a_i is done (by using the previous equation) as shown below:

$$K_i = \frac{S_i}{S_0}, \qquad i = \overline{0, m} \tag{10}$$

Where S_i and S_0 are optimum criterion values.

Value K_i is within the range . Relative efficiency (position, ranking) of the alternative is defined as per value of the utility function. The best one has the highest value.

III. Method of Analytic Hierarchy Process (AHP)

Having in mind that the weight coefficient of the criteria in the application of the ARAS method is defined by using the AHP method, we shall make a short review of its theoretical and methodological features.

Method of analytic hierarchy process (AHP) (Analytic Hierarchy Process - AHP) is implemented through the below steps (Saaty, 2008):

Step 1: Formation of the comparison pair matrix

$$A = [a_{ij}] = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ 1/a_{12} & 1 & \cdots & a_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ 1/a_{1n} & 1/a_{2n} & \cdots & 1 \end{bmatrix} \tag{11}$$

Step 2: Normalization of the comparison pairs matrix

$$a_{ij}^* = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}}, i, j = 1, \dots, n \tag{12}$$

Step 3: Defining relative significance, i.e. the weight vector

$$w_i = \frac{\sum_{i=1}^{n} a_{ij}^*}{n}, i, j = 1, \dots, n \tag{13}$$

Consistency index – CI represents a measure of deviation *n* from λ_{max} and may be represented by the following formula:

$$CI = \frac{\lambda_{max} - n}{n} \quad (14)$$

If CI < 0,1 the estimated coefficient values of a_{ij} are consistent and the deviation $\lambda_{max\ from}$ *n* is negligible. In other words, this means that the AHP method accepts the inconsistency less than 10%.

By the help of the consistency index, we can calculate the consistency ratio CR = CI/RI, whereby the RI is a random index.

IV. Efficiency Measurement of Insurance Companies in Serbia Based on AHP-ARAS Method: Results and Discussion

When measuring the efficiency of insurance companies in Serbia based on ARAS method, the applied criteria include C1 – number of employees, C2 – assets, C3 – equity, C4 – operating (functional) income, C5 – net profit. The alternatives represent the years observed A1 – 2013, A2 – 2014, A3 – 2015, A4 – 2016, A5 – 2017, A6 – 2018, A7 – 2019 and A8 – 2020. (The calculation was made by applying the ARAS Software-Excel software program and the obtained results are displayed in the tables below as well as in the graphs)

The Table 1 shows the initial data for efficiency measurement of insurance companies in Serbia for the period 2013–2020.

Table 1 Initial data for efficiency measurement of insurance companies in Serbia

	Number of employees	Assets	Equity	Operating (functional) income	Net profit
2013	10918	138052	28617	55424	2009
2014	11295	167768	35177	58747	2900
2015	11252	191796	44795	70572	4625
2016	11043	215589	50816	79017	6009
2017	10894	232968	53981	82209	6634
2018	10649	279227	61703	86850	9072
2019	10917	299739	72147	92194	11680
2020	11164	314197	76871	95274	13003

Note: Data are declared in million dinars. The number of employees is shown as an integral number.
Source: Serbian Business Registers Agency

The Table 2 shows the initial data statistics

Table 2 Statistics

Statistics						
		Number of employees	Assets	Equity	Operating (functional) income	Net profit
N	Valid	8	8	8	8	8
	Missing	0	0	0	0	0
Median		10980.5000	224278.5000	52398.5000	80613.0000	6321.5000
Std. Deviation		215.52129	63672.36835	16892.16762	14787.73070	3976.85730
Minimum		10649.00	138052.00	28617.00	55424.00	2009.00
Maximum		11295.00	314197.00	76871.00	95274.00	13003.00
NPar Tests						
Friedman test						
Ranks						
Mean Rank		1.75	5.00	3.00	4.00	1.25
Test Statistics[a]						
N		8				
Chi-Square		30.800				
df		4				
Asymp. Sig.		.000				
a. Friedman Test						

Note: Author's calculation by the use of a software program SPSS

The data in the given table show that the values of all observed variables since 2016 were above average. This had a positive effect on the efficiency of insurance companies in Serbia. Since the Asimp. Sig. = .000 <.05, the hypothesis that the differences between the variables (measurements) equal zero is rejected, i.e. the hypothesis that the differences between them are statistically significant is accepted.

The Table 3 shows the correlation matrix of the initial data.

Table 3 Correlation matrix

Correlations						
		1	2	3	4	5
1 Number of employees	Pearson Correlation	1	-.319	-.245	-.336	-.255
	Sig. (2-tailed)		.441	.558	.416	.541
	N	8	8	8	8	8

2 Assets	Pearson Correlation	-.319	1	.993**	.976**	.988**
	Sig. (2-tailed)	.441		.000	.000	.000
	N	8	8	8	8	8
3 Equity	Pearson Correlation	-.245	.993**	1	.982**	.993**
	Sig. (2-tailed)	.558	.000		.000	.000
	N	8	8	8	8	8
4 Operating (functional) income	Pearson Correlation	-.336	.976**	.982**	1	.960**
	Sig. (2-tailed)	.416	.000	.000		.000
	N	8	8	8	8	8
5 Net profit	Pearson Correlation	-.255	.988**	.993**	.960**	1
	Sig. (2-tailed)	.541	.000	.000	.000	
	N	8	8	8	8	8
**Correlation is significant at the 0.01 level (2-tailed).						

Note: Author's calculation by the use of software program SPSS

The correlation matrix shows that there is a strong correlation between the analysed variables at the level of statistical significance (Sig. (2-tailed) = .000 <.05), except for the number of employees. A more efficient management of assets, equity, operating (functional) income and profit can significantly affect the improvement of efficiency of insurance companies. In that sense, it is also necessary to significantly improve the efficiency of human resource management through training, career advancement, flexible employment and working hours and an adequate remuneration system. Here, the sale of insurance services via the Internet also plays a significant role.

The weight coefficient (weights) of the criteria is determined by using the AHP method (Saaty, 2008). They are presented in the Table 4 and in the Figure 1.

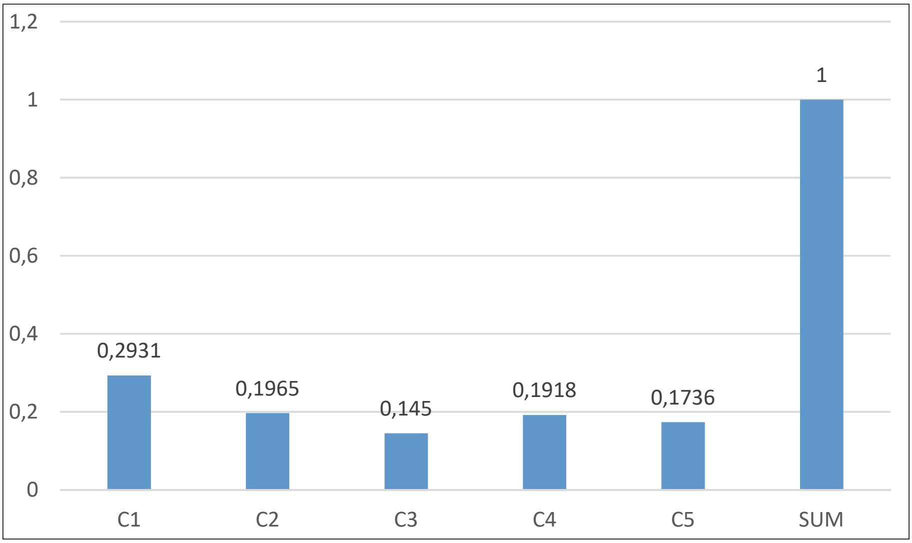
Table 4 Weight coefficient of criteria

AHP With Arirthmetic Mean Method					
Initial Comparisons Matrix					
	C1	**C2**	**C3**	**C4**	**C5**
C1	1	2	2	2	1
C2	0.5	1	1	1	2
C3	0.5	1	1	0.5	1
C4	0.5	1	2	1	1
C5	1	0.5	1	1	1
SUM	3.5	5.5	7	5.5	6

Normalized Matrix						
	C1	**C2**	**C3**	**C4**	**C5**	**Weights of Criteria**
C1	0.2857	0.3636	0.2857	0.3636	0.1667	0.2931
C2	0.1429	0.1818	0.1429	0.1818	0.3333	0.1965
C3	0.1429	0.1818	0.1429	0.0909	0.1667	0.1450
C4	0.1429	0.1818	0.2857	0.1818	0.1667	0.1918
C5	0.2857	0.0909	0.1429	0.1818	0.1667	0.1736
					SUM	**1**
Consistency Ratio	**0.0483**	**COMPARE WITH 0.1; IT SHOULD BE LESS THAN 0.1.**				

Note: Author's calculation by using the software program AHP Software-Excel

Figure 1 Criteria ranking



Source: Author's figure

The most significant criterion is the number of employees, followed by the assets, operating (functional) income, net profit and equity. This shows that a more efficient human capital management, among other things, can significantly affect the achievement of the targeted efficiency of insurance companies in Serbia.

Table 5 shows the initial decision-making matrix.

Table 5 Initial matrix

Initial Matrix					
Weights of criteria	0.2931	0.1965	0.145	0.1918	0.1736
Kind of criteria	-1	1	1	1	1
	C1	**C2**	**C3**	**C4**	**C5**
A1	10918	138052	28617	55424	2009
A2	11295	167768	35177	58747	2900
A3	11252	191796	44795	70572	4625
A4	11043	215589	50816	79017	6009
A5	10894	232968	53981	82209	6634
A6	10649	279227	61703	86850	9072
A7	10917	299739	72147	92194	11680
A8	11164	314197	76871	95274	13003
MAX	11295	314197	76871	95274	13003
MIN	10649	138052	28617	55424	2009
0-Optimal Value	10649	314197	76871	95274	13003

Note: Author's calculation

The Table 6 shows the normalized decision-making matrix.

Table 6 Normalized matrix

Normalized Matrix						
Weights of criteria	0.2931	0.1965	0.145	0.1918	0.1736	1
Kind of criteria	-1	1	1	1	1	
	C1	**C2**	**C3**	**C4**	**C5**	
0-Optimal Value	0.1145	0.1459	0.1534	0.1331	0.1886	
A1	0.1117	0.0641	0.0571	0.0775	0.0291	
A2	0.1079	0.0779	0.0702	0.0821	0.0421	
A3	0.1083	0.0891	0.0894	0.0986	0.0671	
A4	0.1104	0.1001	0.1014	0.1104	0.0872	
A5	0.1119	0.1082	0.1078	0.1149	0.0962	
A6	0.1145	0.1297	0.1232	0.1214	0.1316	
A7	0.1117	0.1392	0.1440	0.1288	0.1694	
A8	0.1092	0.1459	0.1534	0.1331	0.1886	

Note: Author's calculation

The Table 7 shows the weight normalized decision-making matrix.

Table 7 Weight normalized matrix

Normalized Weighted Matrix					
	C1	**C2**	**C3**	**C4**	**C5**
0-Optimal Value	0.0336	0.0287	0.0222	0.0255	0.0327
A1	0.0327	0.0126	0.0083	0.0149	0.0051
A2	0.0316	0.0153	0.0102	0.0157	0.0073
A3	0.0318	0.0175	0.0130	0.0189	0.0116
A4	0.0324	0.0197	0.0147	0.0212	0.0151
A5	0.0328	0.0213	0.0156	0.0220	0.0167
A6	0.0336	0.0255	0.0179	0.0233	0.0228
A7	0.0327	0.0273	0.0209	0.0247	0.0294
A8	0.0320	0.0287	0.0222	0.0255	0.0327

Note: Author's calculation

The Table 8 shows the alternatives ranking.

Table 8 Alternatives ranking

		S	**K**	**K**	**Ranking**
	0-Optimal Value	0.1428	1.0000	1.0000	
2013	**A1**	0.0735	0.5150	0.5150	8
2014	**A2**	0.0802	0.5616	0.5616	7
2015	**A3**	0.0928	0.6500	0.6500	6
2016	**A4**	0.1030	0.7219	0.7219	5
2017	**A5**	0.1084	0.7595	0.7595	4
2018	**A6**	0.1230	0.8617	0.8617	3
2019	**A7**	0.1351	0.9463	0.9463	2
2020	**A8**	0.1412	0.9892	0.9892	1

Note: Author's calculation by using the ARASSoftwre-Excel

The obtained results of empirical research based on the ARAS method show that insurance companies were most efficient in the year of 2020, followed by 2019, 2018, 2017, 2016, 2015, 2014 and 2013. In the observed time period (2013–2020), the efficiency of insurance companies in Serbia has continuously increased. This was positively affected by numerous macro and micro factors (economic climate, employment, standard of living, digitalization of overall business, increasingly developed understanding of the importance of insurance coverage of all types). The negative impact of the coronavirus pandemic is negligible and largely compensated for, *inter alia*, by the increased electronic sale of insurance services, as well as by concluding the infrastructure (property) insurance. We should, by all means, add the increasingly raised awareness of the significance of concluding the insurance coverage against potential risks of all kinds.

V. Conclusion

Based on the results obtained from the empirical efficiency research of the insurance companies in Serbia following the ARAS method, it can be concluded that the greatest efficiency was recorded in the year 2020, followed by 2019, 2018, 2017, 2016, 2015, 2014 and 2013. It is especially characteristic that, in the observed time period (2013–2020), the efficiency of insurance companies in Serbia was continuously increasing. This was positively affected by a number of macro and micro factors such as the economic climate, employment, living standard, digitalization of the entire business, raising awareness of the importance of concluding non-life and life insurance. The negative impact of the Covid 19 pandemics was negligible and largely compensated for, *inter alia*, by the increased electronic sale of insurance services as well as the infrastructure (property) insurance. The insurance against all types of potential risks has certainly proved to gain importance in the context of the Coronavirus pandemics.

In order to achieve the highest efficiency of insurance companies in Serbia in the future, it is necessary to more efficiently manage their assets, equity, operating (functional) income, profit and, in particular, the human resources.

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Translated from Serbian by: ***Bojana Papović***