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MULTI-CRITERIA EVALUATION OF INSURANCE INDUSTRIES PERFORMANCE: AN ANALYSIS OF EDAS BASED ON THE ENTROPY WEIGHT

Abstract: *Insurance industries have grown remarkably since the late 1990s. Governments require a benchmarking tool to measure their insurance industry's performance according to specific various indicators. The best practice benchmarking of insurance can be achieved by evaluating numerous insurance industries through prioritizing and identifying the top industries. This paper presents a multi-criteria evaluation framework for insurance performance of Organization for Economic Cooperation and Development (OECD) countries by investigating conflicting and incommensurate insurance indicators for the period of 2010–2017. For the basis of the evaluation, eight main insurance performance inductors were identified and then their weights were determined using the entropy method. The resultant entropy weights were then applied in the evaluation based on distance from average solution (EDAS) method for determining preferential rankings of insurance industries. The ranked insurance industries were classified into groups of similar levels of performance. Sensitivity analysis was applied to the main criteria to examine the robustness of the prioritizing results. The results indicate insurance markets in United States, the United Kingdom, Germany, France, and Japan are ranked higher than the remaining 25 OECD countries.*

Key words*: Multi-Criteria Decision-Making; EDAS; Shannon's entropy; insurance industries; OECD countries*

1. Introduction

The development of the insurance industry development is a strong promoter of economic growth sustainability for countries worldwide. The insurance industry has witnessed an important and enhanced growth since the late 1990s (Arena, 2008). Since 1950, a prominent portion of the global insurance industry has grown at an annual rate of over 10% (Chen et al., 2012). Many studies focused on understanding insurance market growth with economic and financial sectors in industrialized and developed countries. In this regard, various studies have been conducted in insurance industry, including but not limited to Ward and Zurbruegg (2000), Arena (2008), Haiss and Sumegi (2008), Lee (2011), Chen et al. (2012), Pradhan et al. (2015), and Pradhan et al. (2017). Authors considered several variables and indicators of performance such as: gross claims payments, insurance density, and insurance penetration (Pradhan, Arvin & Norman, 2015; Pradhan et al., 2017). Recent theoretical and empirical approaches to insurance performed at the

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international level are still concentrated in two main approaches, causality approaches and data envelopment analysis (DEA), and their extended approaches (Pradhan, Arvin & Norman, 2015; Pradhan et al., 2017).

Despite the increasing research on insurance markets in developed and emerging countries, several issues remain unclear: how the insurance performance indicators (IPIs) in various countries, which are conflicting and incommensurate in its nature, can be weighed and prioritized, and determining how to select the country most suitable for benchmarking considering each conflicting and incommensurate IPIs. In this context, what is the ranking of insurance industries across multiple countries based on IPIs? Which countries are at a similar level of efficient insurance performance according to IPIs? To the best of my knowledge, no researchers have focused much on the insurance performance in the Organization for Economic Cooperation and Development (OECD) countries by considering the issues mentioned above. OECD insurance industries are worthy of study since annual real premium growth in the life and/or the non-life insurance sectors in the OECD countries continued to rise in 2017 according to Global Insurance Market Trends (OECD, 2018). OECD is an international economic organization that was officially established in 1961 and now has 36 member countries worldwide, from North and South America to Europe and Asia Pacific. Its mission is providing a forum to promote governments to work together for comparing policies, experiences, solutions to common global issues, and recognizing good practices.

In accordance with the issues emphasized above, the current research problem in insurance is a conflicting and incommensurate Multi-Criteria problem (the IPI) with a finite number of feasible alternatives (the OECD countries). This problem is called a discrete Multi-Criteria decision-making (MCDM) problem (Triantaphyllou, 2000). Multi-Criteria analyses offer flexible techniques to handle the complexity of the current research issues. In the literature, many different MCDM methodological approaches were used to calculate weighting multiple criteria and prioritize alternatives (Ture et al., 2019; Ponsiglione et al., 2018). In typical MCDM methods, the weights of criteria reflect the relative importance in decision process. Many objective weighting procedures were developed in the literature for identifying criteria weights, such as Shannon entropy, multiple objective programming, etc. (Wang & Lee, 2009). Shannon entropy is a suitable method for assessing the relative importance of criteria (Wang & Lee, 2009; Gray, 2011; Danesh et al., 2018).

Outranking methods in Multi-Criteria analyses, which focus on finding a feasible solution closest to the ideal solution and then ranking set of alternatives, are appropriate and applicable to measuring and assessing issues similar to those that are the focus here. For instance, the technique for order preference by similarity to ideal solution (TOPSIS), elimination and choice expressing reality (ELECTRE), and vise kriterijumska optimisacija kompromisno resenje (VIKOR), preference ranking organization method for enrichment of evaluations (PROMETHEE) can be employed for different MCDM problems (Sharma et al., 2013; Keshavarz et al., 2015; Dhiman et al., 2019; Hamurcu & Eren, 2019; Pereira et al., 2019). TOPSIS and VIKOR are the more popular and widely used MCDM techniques (Yazdani & Payam, 2015; Hamurcu & Eren, 2019). These methods search for a compromise solution that ensures the alternative is closest as possible to the positive ideal solution and the farthest from the negative ideal solution (Hamurcu & Eren, 2019). The evaluation based on distance from average solution (EDAS) method was proposed by Keshavarz et al. (2015) for ranking alternative based on distances of each alternative from the average solution according to each criterion. The EDAS method is similarly based on verified approaches used in some noticeable MCDM methods (Hamurcu & Eren, 2019). In comparison with existing methods, the EDAS model only considers the average solution for achieving more perfect and efficient aggregation results (Zhang et al., 2019). As such, the EDAS based on Shannon's entropy weight was selected for this study.

In this context, the goal of this study was to provide a Multi-Criteria evaluation framework for insurance performance in OECD countries by investigating conflicting and incommensurate IPIs for the period of 2010–2017. To accomplish this task, a contextual framework was built for identifying IPIs. These IPI were weighted with the help of Shannon's entropy. The OECD insurance industries were also evaluated and ranked using the EDAS method. Sensitivity analysis was performed for different weighted criteria to assess the robustness of the results. Thus, the findings provide three valuable contributions to the literature. First, the findings contribute to the growing literature on the insurance industry in the OECD context, which has not yet been studied extensively. Second, I used a methodological framework based on EDAS with Shannon's entropy weight that considers IPIs in building a list of rankings OECD insurance industries; this methodology provides more consistent results by applying a sensitivity analysis. Third, the results of this research are expected to assist governments and policy makers in insurance organizations in OECD countries.

This paper is organized as follows. Section 2 provides the contextual setting, which includes formal definitions for the IPIs included in the analysis. Section 3 discusses the research methodology. Section 4 presents the empirical evaluation of the application to the OECD insurance industries. Section 5 provides further discussions and outlines the implications of this finding. Section 6 concludes and highlights the research limitations.

2. Contextual Setting of the IPIs

In this section, the indicators that reflect the most essential characteristics of the insurance markets in the OECD are presented. These indicators were obtained and selected by analyzing the OECD Insurance Statistics publication (OECD, 2019) and the other documents that are available on OECD websites (https://www.oecd-ilibrary.org and https://www.oecd.org/finance/insurance/). Those materials provide official information on the diverse insurance activities in OECD countries. The selected IPIs were defined based on the insurance literature (Chen et al., 2001; Wipf & Garand, 2008; Ma & Pope, 2008; Pervan & Kramaric, 2012; Mehari & Aemiro, 2013; Vojak, 2014; Kwon & Wolfrom, 2016). The next sections define the IPIs related to official measures of the insurance performance in the OECD countries.

Gross written premiums (GWP): An accurate formulation for GWP, as percentage of the gross domestic product (GDP), only has meaning in the context of the insurance industry. GWP is expressed as the sum of direct and indirect written premiums before the effect of ceded reinsurance is considered, and it is calculated on premiums growth (Pervan & Kramaric, 2012). Premium growth can be interpreted as a measure of solvency or to what extent the country is capable of increasing revenues. Premium growth (PG) can be calculated in terms of the GWP with the following equation (Pervan & Kramaric, 2012):

$$PG_t = \frac{GWP_t - GWP_{t-1}}{GWP_{t-1}} \qquad (1)$$

where premium growth in year t is given by the value of GWP in the same year minus and divided by the GWP of the previous year.

Reinsurance premiums (RP): Insurance companies usually insure part of their premiums using reinsurance (Wipf & Garand, 2008). Reinsurance is an insurance contract and RP represent the premiums assigned to an amount paid by an insurance company (insurer) to reduce its overall risk exposure, in which some part of its own insurance liabilities is ceded to another insurance company (reinsurer) (Chen et al., 2001)

Net written premiums (NWP) are expressed as the premiums retained by the insurer after the subtraction of the RP paid to local or international reinsurers from GWP. In other words, after RP plus any reinsurance assumed (RA) are deducted from GWP is called NWP (Wipf & Garand, 2008). NWP indicates of the level of sales for risks that the insurer covers. NWP in year t can be calculated as:

$$NWP_t = GWP_t - (RP_t + RA_t) \qquad (2)$$

The higher the reinsurance premiums, the lower the potential claims; the higher the reinsurance premiums, the lower the revenues, and vice versa. The reduction in reinsurance premiums that increases revenues simultaneously increases the risk of exposure to potential claims from these premiums.

Gross claims payments (GCP) are the collective of all claims paid throughout an accounting period adjusted by the modification in the claims provision for that accounting period after deducting reinsurance recoveries. The GCP can be used to drive the incurred claims ratio (ICR)/loss ratio (LR) indicator (Wipf & Garand, 2008), and is discussed in detail below. GCP is calculated by adding paid claims (PC) and unpaid claims (UPC) minus the estimate of unpaid claims (EUPC) at the end of the prior valuation period.

$$\mathrm{GCP} = (PC + UPC) - EUPC \qquad (3)$$

The number of insurance undertakings (NIU) includes all insurers authorized and licensed in the reporting country containing all professional insurance companies (life, non-life, composite, reinsurance), but excluding any other scheme of social security controlled by the government.

Insurance density (ID) is a the most commonly used indicator for explaining the level of national insurance and the level of insurance protection (Pervan & Kramaric, 2012; Mehari & Aemiro, 2013; Vojak, 2014; Kwon & Wolfrom, 2016). ID indicates the average annual per capita premium within a country expressed in U.S. dollars and defined as GWP per capita. ID is an indicator of the development of insurance within a country and is calculated as the ratio of GWP (in USD) to total population of a given country and can be used as a proxy for per capita consumption of insurance. ID is expressed as follows (Kwon & Wolfrom, 2016):

$$ID = \frac{GWP}{Total\ Population\ of\ the\ Country} \qquad (4)$$

ID indicates how much each person in a country spends on insurance in terms of premium. For example, if a country generates a total insurance premium of say, USD $10 billion and the population of the that country is 10 million people, the insurance density (per capital premium) would be USD $1000.

Insurance penetration (IP) is called also insurance spending, indicating the insurance sector level development in a country. It is the second most commonly used indicator applied to analyzing the insurance industry (Pervan & Kramaric, 2012; Mehari & Aemiro, 2013; Vojak, 2014; Kwon & Wolfrom, 2016). This indicator is measured as the real annualized value of total premiums per capita and is calculated as GWP, or premiums at the market level, divided by the total country's GDP (Pervan & Kramaric, 2012):

$$IP = \left(\frac{GWP}{GDP}\right) \times 100 \qquad (5)$$

IP is a measure of the relative importance of insurance as a component of a country's overall economy. PR is an alternative term used for coverage ratio or participation rate (Wipf & Garand, 2008). Retention ratio (RR) is one of financial soundness indicators for the insurance and reinsurance market. The RR is used for measuring the underwriting performance of an insurance company. This ratio evaluates the insurance company's success in retaining existing insurance contracts for renewal, or a ratio of the number of contracts renewed to the number of contracts conditional on renewal (Kwon & Wolfrom, 2016). RR is a measure of how much of the risk is being carried by an insurer rather than being passed to reinsurers (Vojak, 2014). RR is calculated as:

$$RR = \left(\frac{NWP}{GWP}\right) \times 100 \qquad (6)$$

3. Research Methodology

Assume m alternatives (countries) $A_i(i = 1,2 \ldots m)$ are to be assessed against n selection criteria (IPIs) $C_j(j = 1,2,\ldots n)$. Quantitative values x_{ij} can be assigned to each alternative A_i, representing the performance of A_i with respect to criterion C_j. x_{ij} is needed to determinate the decision matrix $X = \{x\_ij, i = 1,2 \ldots m; j = 1,2 \ldots n\}$ and the weighting vector W represents the relative importance weights of C_j selection criteria for the problem.

The decision matrix X and the weighting vector W can be expressed as:

$$X = \begin{array}{c c} & \begin{array}{cccc} C_1 & C_2 & \ldots & C_n \end{array} \\ \begin{array}{c} A_1 \\ A_2 \\ \vdots \\ A_m \end{array} & \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & & x_{2n} \\ & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \end{array} \qquad (7)$$

$$W = \{w_1, w_2, \ldots . w_n\} \qquad (8)$$

Given decision matrix X and the weighting vector W, the MCDM method (EDAS based on the Shannon's entropy weight) is applied to prioritize the OECD countries based on selection criteria (their IPIs). To achieve the objective of this study, the IPIs were first weighed through Shannon entropy and then the OECD countries were ranked within EDAS method. In the following sub-sections, these two methods are discussed.

3.1 Shannon's Entropy

Shannon introduced the entropy method (also referred to as Shannon's entropy) to information theory for measuring the amount of useful information within the data provided (Shannon, 1948). Shannon's concept uses the entropy measure, which is a well-known method for determining objective weights in MCDM problems (Yoon & Hwang, 1995; Wang & Lee, 2009; Gray, 2011). The measure has been widely used in many fields such as social sciences, physics, engineering, mathematics, medicine, economy, finance, and so forth (Gray, 2011).

Shannon entropy was applied in this research for assessing the weights of the insurance indicators for OECD countries. The steps for calculating Shannon's entropy are as follows (Wang & Lee, 2009).

Step 1: The decision matrix needs to be normalized for each criterion C_j for calculating the probability distribution as follows:

$$p_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \qquad (9)$$

Step 2: The value of entropy e_j is calculated as

$$e_j = -h \sum_{i=1}^{m} p_{ij} \ln p_{ij} \qquad (10)$$

where $(\ln(m))^{-1}$ is the entropy constant and $h = (\ln(m))^{-1}$

Step 3: The divergence degree d_j of the inherent knowledge of each criterion C_j is calculated as:

$$d_j = 1 - e_j \qquad (11)$$

Step 4: The objective weight (w_i) for each criterion C_j can be obtained as follows:

$$w_j = \frac{d_j}{\sum_{s=1}^{n} d_s}\ ;\ j\ =\ 1,2\ldots,n \quad (12)$$

3.2 EDAS Method

In the EDAS method, two novel distance measures, the positive distance from average (PDA) and the negative distance from average (NDA), are needed (Keshavarz et al., 2015). These two measures indicate the difference between each alternative and the average solution, and then the alternatives are evaluated according to higher values of the PDA and lower values of the NDA (Keshavarz et al., 2015; Kahraman et al., 2017).

After constructing the decision matrix X, classical EDAS is calculated using the following steps (Keshavarz et al., 2015; Kahraman et al., 2017):

Step 1: Calculate the average solution (AV_j) with respect to all criteria

$$AV_j = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \quad (13)$$

Step 2: Compute the PDA and the NDA matrixes with respect to lower and upper values of matrix as shown following formulas.

If the jth criterion is beneficial,

$$PDA_{ij} = \frac{MAX\left(0,(x_{ij}-AV_j)\right)}{AV_j} \quad \text{and}$$
$$NDA_{ij} = \frac{MAX\left(0,(AV_j-x_{ij})\right)}{AV_j} \quad (14)$$

If the jth criterion is not beneficial,

$$PDA_{ij} = \frac{MAX\ (0,(AV_j-x_{ij}))}{AV_j} \quad \text{and}$$
$$NDA_{ij} = \frac{MAX\ (0,(x_{ij}-AV_j))}{AV_j} \quad (15)$$

where PDA_{ij} and NDA_{ij} denote the positive and negative distance of the ith alternative from average solution in terms of jth criterion for the lower level of decision matrix, respectively.

Step 3: Determine weighted summation of PDA and NDA for all alternatives:

$$SP_i = \sum_{j=1}^{n} w_j\ PDA_{ij} \quad \text{and}$$
$$SN_i = \sum_{j=1}^{n} w_j\ PDA_{ij} \quad (16)$$

Step 4: Normalize the values of SP and SN for all alternatives, as follows:

$$NSP_i = \frac{SP_i}{MAX\ (SP_i)} \quad \text{and}$$
$$NSN_i = 1 - \frac{SN_i}{MAX\ (SN_i)} \quad (17)$$

Step 5: Determine the appraisal score (AS) for all alternatives:

$$AS_i = \frac{1}{2}\ (NSP_i + NSN_i) \quad (18)$$

Step 6: Rank the alternatives according to the decreasing values of AS. The alternative with the highest AS is the best choice between the candidate alternatives.

4. Application to the OECD Insurance Industries

4.1. Data Collection

In this study, annual data for the OECD countries for the period 2010–2017 were obtained from the OECD Insurance Statistics publication (OECD, 2019). The publication provides major official information on the various insurance activities in OECD countries. This document has been published annually and available on their website (https://www.oecd-ilibrary.org). According to available data, I used variables in the 2010–2017 period, including 8 IPIs (Section 2), which reflect the 27 OECD insurance industries to benchmark the international insurance performance of these countries for all type of insurance companies (life, non-life, composite, reinsurance). The 27 countries are

Australia (AUS), Belgium (BEL), Chile (CHL), Czech Republic (CZE), Denmark (DNK), Finland (FIN), France (FRA), Germany (DEU), Hungary (HUN), Iceland (ISL), Italy (ITA), Japan (JPN), Latvia (LVA), Luxembourg (LUX), Mexico (MEX), Netherlands (NLD), Norway (NOR), Poland (POL), Portugal (PRT), Slovakia (SVK), Slovenia (SVN), Spain (ESP), Sweden (SWE), Switzerland (CHE), Turkey (TUR), the United Kingdom (GBR), the United States (USA). Due to space limitations, Table 1 only shows the raw Multi-Criteria evaluation matrix of the national insurance industry in the 27 OECD countries according to the 8 IPIs in 2017. According to Equation (7), the data in Table 1 were used to create the decision matrix for 27 alternatives (27 OECD countries) with respect to 8 conflict and incommensurate criteria (8 IPIs).

Table 1. The data of 27 OECD countries and IPI in 2017.

		Criterion (IPI)							
		GWP *	**RP ***	**NWP ***	**GCP ****	**NIU ***	**ID ***	**IP ***	**RR ***
		(Million USD)	**(Million USD)**	**(Million USD)**	**(Million USD)**	**(*n*)**	**(Million USD)**	**(%)**	**(%)**
Alternatives (OECD Countries)	**AUS**	72,339.1	9959	24,712	61,603	125	2541	4.444	77
	BEL	30,762.9	3508	10,749	30,449	114	2647	6.073	88
	CHL	12,860.5	1468	2462	9950	69	693	4.599	83
	CZE	6401.6	1161	2786	3881	49	590	2.891	79
	DNK	37,549.3	1177	10,428	24,022	156	6315	11.006	97
	FIN	10,058.6	229	4727	8353	47	1798	3.923	97
	FRA	313,542.5	25,730	114,636	277,873	631	4225	10.602	88
	DEU	310,439.2	35,819	175,098	173,383	368	2829	6.336	87
	HUN	3483.6	417	1387	2165	40	350	2.456	87
	ISL	611	17	540	426	8	1772	2.46	96
	ITA	150,359.4	4861	34,521	106,946	213	2431	7.576	96
	JPN	390,095.6	21,111	75,969	315,183	93	2893	7.428	90
	LVA	727.9	49	515	407	17	373	2.389	93
	LUX	24,253.9	643	1348	14,690	291	41,011	38.829	86
	MEX	26,568.8	4423	10,725	13,392	115	211	2.254	81
	NLD	80,266.2	1247	63,410	87,371	140	4615	9.49	98
	NOR	20,406.6	860	7254	12,966	100	3858	5.108	93
	POL	16,498.6	1865	8135	10,542	61	420	3.034	88
	PRT	12,909.1	1211	4136	10,798	73	1186	5.573	89
	SVK	5035	359	862	217	38	925	5.254	92
	SVN	2589.6	329	1680	1773	21	1102	4.67	86
	ESP	74,058.2	5731	35,147	55,508	220	1470	5.181	91
	SWE	44,382.3	1160	9461	16,730	203	4248	8.027	97
	CHE	67,772.5	4815	32,472	52,032	192	6904	8.562	93
	TUR	13,074.1	3534	7358	6120	63	152	1.444	72
	GBR	394,100.4	35,008	89,835	417,974	294	5112	12.801	88
	USA	2,836,293.2	586,502	1,240,381	1,646,030	4396	6706	11.215	71

* Beneficial criterion. ** Non-beneficial criterion. Source: OECD Insurance Statistics Database.

4.2. Data Analysis and Results

In this section, the EDAS based on the Shannon's entropy weight is applied to a Multi-Criteria evaluation process of the national insurance industry in 27 OECD countries according to 8 IPI for 2010 until 2017. According to EDAS procedure based on the Shannon's entropy weight, the weights for all IPI were defined by the entropy method as discussed in Section 3.1.

Table 2 (see Appendix) shows the Shannon's entropy weighting results for the objective weights and prioritizes all the IPI from 2010 to 2017. The obtained objective weights and their rankings in descending order are presented in Table 2. The obtained Shannon's entropy weights show that RP, NWP, and GWP were rated more important than the remaining criteria in 2010 and 2014–2017. GCP is shown to be the most important criterion followed by RP and NWP and in 2011 and 2012. ID, IP, and RR were rated relatively lower.

After obtaining IPI weights, the next step was to rank the insurance industries of the 27 OECD countries on the basis of these criteria weights using the EDAS method. The raw Multi-Criteria evaluation matrix of the national insurance industry in the 27 OECD countries on the basis of the 8 IPIs in 2010–2017 and the weights obtained for all IPI were used for applying the EDAS method through Equations (13)–(18). The computed results of the 27 OECD countries ranked using the EDAS method between 2010 to 2017 are presented in Table 3 (Appendix). Figure 1 depicts the measurements of the insurance industries' performance in OECD countries in the period 2010–2017 obtained by applying the proposed method. According to the findings, the American insurance industry performed the best according to the IPIs, while the worst performing was Latvia. The top five ranking are the United States, the United Kingdom, Germany, France, and Japan. The bottom five ranking countries are Latvia, Turkey, Slovakia, Hungary, and Iceland except in 2017. In 2017, the five worst-performing insurance industries were Latvia, Turkey, Czech Republic, Hungary, and Iceland.

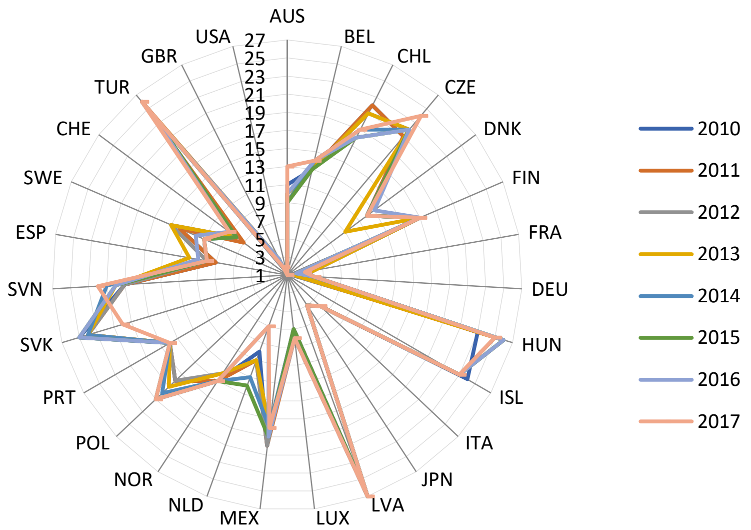

Figure 1. OECD insurance industries rankings for 2010–2017.

The ranking alternatives (insurance industries OECD countries) for the case being may provide a basis for classifying the countries into groups with similar levels of performance. This classification identifies which countries' insurance industries are performing at a similar level according to the IPI indicators. In this regard, a classification system established using the mean and standard deviation of the ranking values for all alternatives (⟦AS⟧_i) using EDAS based on the Shannon's entropy weight is appropriate in such situations (Ture, Dogan & Kocak, 2019):

I. Group 1: Highly efficient performance, if $AS_i \geq MAS_i + SAS_i$
II. Group 2: Medium–high efficiency, if $MAS_i + SAS_i > AS_i \geq MAS_i$
III. Group 3: Medium–low efficiency, if $MAS_i > AS_i \geq MAS_i - SAS_i$
IV. Group 4: Low efficiency performance, if $AS_i < MAS_i - SAS_i$

where MAS_i is the mean value of the overall measured values of AS_i obtained by EDAS based on the Shannon's entropy weight and SAS_i is the standard deviation of the overall measure values of AS_i. The classifications of the insurance industries in the selected OECD countries during 2010–2017 are presented in Table 4 (see Appendix).

4.3. Sensitivity Analysis

Sensitivity analysis was adopted to assess the robustness of the results obtained from the proposed method. Thus, one-way sensitivity analysis was conducted by changing the weight of one criterion from 0.1 to 0.9 at time and dividing its remaining criterion weight from one into the other criterion through formulating proportional to their original weights. By applying this process, the effects of the changes on country rankings and classifications into groups of similar levels of performance were observed. All scenarios were generated using MATLAB software (The MathWorks, Inc., USA). To save space, one-way sensitivity analysis with changing weights for the RP criterion, one of the most relative important criterions, is only detailed for 2017. The obtained results for this scenario are provided in Figure 2 and Table 5 (see Appendix). According to the results in Figure 2 and Table 4, the first four ranking countries with the best insurance industry performance remained same in this scenario: the United States, the United Kingdom, Germany, and France.

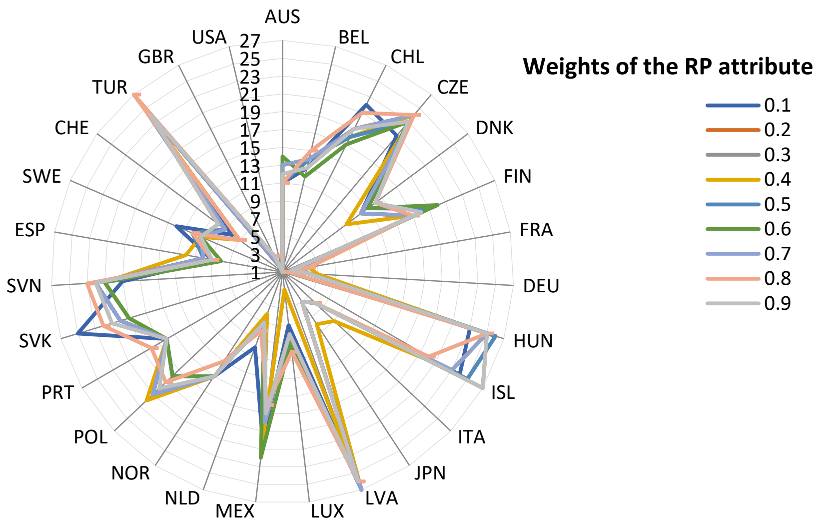

Figure 2. Sensitivity analysis on changing weights of the RP criterion in 2017

By applying all scenarios, the top four ranked countries remained the same in all tests. Although the order ranking for the remaining countries slightly change, those countries were all categorized into the same levels of performance. This suggests that the main empirical results are robust.

5. Discussions and Implications

Some of the results presented in Section 4 have implications for ranking of insurance industries in OECD countries based on IPIs in 2010–2017. The results show that the RP criterion has the highest weight coefficient (24%) in 2010 and 2014–2017 and the second highest weight coefficient at 11% and 16% in 2011 and 2012, respectively. These results indicate that mitigating risk via reinsurance is crucial to protecting insurance industries from financial ruin. The next indicator with the second highest weight coefficient (around 17% to 19%) is NWP in 2010 and 2014–2017, which had the third highest weight coefficients of 7% and 11% in 2011 and 2012, respectively. Generally, GWP had the third highest weight coefficient, ranging from 15% to 16% in 2010 and 2014–2017, and was ranked the fourth highest at 7% and 11% in 2011 and 2012, respectively. NWP and GWP logically remains slightly high as when these two indicators increase, they indicate the expected returns from investment in insurance industries. Thus, RP, NWP, and GWP are considered the most effective of the IPIs in the 27 OECD countries.

Most importantly, the results indicate that, in general, the United States, the United Kingdom, Germany, France, and Japan were top ranked during 2010–2017. A possible explanation for this finding is that these industrialized countries have strong economies and a high economic growth rate. Similar results were reported by Arena (2008), Chen et al. (2012), and Pradhan et al. (2015). They examined the relationship among insurance and economic growth and concluded that insurance activity promotes economic growth and vice versa. Another possible reason for the obtained ranking results is related to the country's insurance improvement level. The insurance in countries such as the United States, the United Kingdom, France, and Germany have undergone many reforms and several changes, especially transitioning health insurance toward national accountability and financial stability (Yaya & Danhoundo, 2015). In contrast, the lowest ranked countries during 2010–2017 were Latvia, Turkey, Hungary, and Iceland. Thus, the insurance policies implemented in those countries may be inefficient. At this point, these countries need to strengthen their insurance industry by reforming insurance policies.

The classification the OECD countries into groups of similar performance levels should be noted. According to obtained results in Table 4 (Appendix), the group containing the United States, the United Kingdom, Germany, and France showed a high level of performance during 2010–2017. This result is imputed to their competitive and strong national insurance industries and entrepreneurship. Japan was classified in the high level group in 2010–2012 and 2016, and in the medium–high level group in the remaining years. The classification of the rest of the OECD countries varied between the medium–high, medium–low, and low levels during 2010–2017. This lack of variation might be due to the IPIs, financial systems, economic growth, political environments, and environments of the national insurance institutions in these countries as discussed by Pradhan et al. (2015) and Lee et al. (2016). Another factor affecting the variation between performance level groups is the nature of the phases of insurance market development (e.g., developed, emerging, and developing). Most of the countries (around 14–17 countries) were classified as medium–low performance in 2010–2017. In most cases, these are countries considered less developed or developing.

The sensitivity analysis result showed that United States, the United Kingdom, Germany, and France are the best alternatives in all cases. This finding supports the published literature about the positive influence of economic growth rates on insurance industry performance (Arena, 2008; Chen et al., 2012; Pradhan et al., 2015; Pradhan et al., 2017). Although sensitivity analysis produced consistent results in terms of the level of performance, the ranking of the countries changed in the medium–low level of insurance performance. A possible explanation reason for this finding is the instability of the insurance sector performance in those countries, indicating the need for these countries to consider the countries with a high level of insurance performance (the United States, the United Kingdom, Germany, and France) as a benchmark to improve and reform their insurance systems.

The methodological framework in this paper can provide a benchmarking tool for governments and policymakers in the insurance field to assist with identifying the most efficient policies and strategies for their insurance industries. This benchmarking tool provides standards for improving poorly performing insurance systems. In this research, the benchmarking tool assists with ranking the leading countries in insurance as a benchmark for other less countries in insurance that desire to overcome some obstacles affecting their insurance performance. The empirical findings in this research provide an important direction for the governments that should prioritize modification of strategic regulations and composing new policies to reinforce insurance industry as part of a competitive economy.

6. Conclusions

The aim of this study was to provide a Multi-Criteria evaluation framework for ranking the insurance performance of OECD countries by considering conflicting and incommensurate IPIs for the period of 2010–2017. To identify the IPIs, this paper provides a contextual setting framework that reflects the essential characteristics of the insurance markets in the OECD. IPIs were weighted and prioritized using Shannon's entropy. Correspondingly, the entropy weight of the IPIs provided the data for calculating the ranking of the performance of the insurance industries in the 27 OECD in 2010–2017. The outranking method called the EDAS method was applied. The efficiency of the insurance industries of the 27 OECD countries were characterized into groups of high, medium–high, medium–low, and low to assist with understanding the ranking orders. Finally, sensitivity analysis considering different weighting criteria was conducted to assess the robustness of the results.

The results revealed that the industrialized countries (the United States, the United Kingdom, Germany, France, and Japan) that have high economic growth rates are were ranked at the top and insurance performance was highly efficient during 2010–2017. In accordance with these study findings, the performance of the insurance industries in the less developed countries in the OECD (Table 4, Appendix) was classified as medium–low during 2010–2017. These countries could benefit from the experience and best practices of countries with higher levels of insurance performance. The methodology and finding proposed here could provide a source of guidance for governments and policymakers for the conduct and reform of insurance policies to reinforce the insurance industry to help create a competitive economy in the context of comparable countries.

Future research should focus on ranking insurance industries in OECD countries using the same data set in an uncertain environment. Thus, determining different criteria based on experts' judgment (which is considered uncertain judgment) and assigning the weights of criteria as subjective weights can be examined in future research. Different fuzzy multi-criteria outranking techniques for uncertain environment can be applied in future research.

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Appendix

Table 2. Shannon's entropy weights

		2010		2011		2012		2013	
		Weight	Rank	Weight	Rank	Weight	Rank	Weight	Rank
Criterion (IPI)	GWP	0.1536	3	0.0732	4	0.1054	4	0.1556	3
	RP	0.247	1	0.1114	2	0.1611	2	0.2442	1
	NWP	0.1715	2	0.0798	3	0.1144	3	0.1819	2
	GCP	0.145	4	0.6223	1	0.4376	1	0.1428	4
	NIU	0.1293	5	0.0614	5	0.0887	5	0.1392	5
	ID	0.1106	6	0.0387	6	0.0672	6	0.1008	6
	IP	0.0428	7	0.0131	7	0.0254	7	0.0352	7
	RR	0.0002	8	0.0001	8	0.0002	8	0.0003	8
		2014		**2015**		**2016**		**2017**	
		Weight	Rank	Weight	Rank	Weight	Rank	Weight	Rank
Criterion (IPI)	GWP	0.1564	3	0.1681	3	0.1564	3	0.1681	3
	RP	0.2426	1	0.2425	1	0.2426	1	0.2425	1
	NWP	0.1823	2	0.1868	2	0.1823	2	0.1868	2
	GCP	0.14	5	0.1489	4	0.14	5	0.1489	4
	NIU	0.1405	4	0.1354	5	0.1405	4	0.1354	5
	ID	0.1021	6	0.0875	6	0.1021	6	0.0875	6
	IP	0.0358	7	0.0305	7	0.0358	7	0.0305	7
	RR	0.0003	8	0.0003	8	0.0003	8	0.0003	8

(Year)

Table 3. Rankings based on EDAS method

		2010		2011		2012		2013	
		AS	Rank	AS	Rank	AS	Rank	AS	Rank
Alternatives (OECD Countries)	AUS	0.24345	11	0.2652	10	0.27682	9	0.27536	10
	BEL	0.21315	13	0.20719	13	0.21221	13	0.20088	13
	CHL	0.041627	22	0.045514	22	0.05384	21	0.054274	21
	CZE	0.047153	21	0.048023	21	0.042075	22	0.042597	22
	DNK	0.22186	12	0.21269	12	0.21442	12	0.27999	9
	FIN	0.095491	17	0.082119	17	0.068251	17	0.096283	17
	FRA	0.49923	3	0.49768	4	0.49023	4	0.50103	4
	DEU	0.49596	4	0.50456	2	0.49959	3	0.51199	2
	HUN	0.025227	23	0.021766	25	0.015112	26	0.016544	26
	ISL	0.024195	24	0.026652	23	0.023112	23	0.021911	23
	ITA	0.38187	6	0.34903	6	0.34969	6	0.35618	6
	JPN	0.46871	5	0.48345	5	0.465	5	0.43169	5
	LVA	0.00033511	27	0.00041363	27	0.00044936	27	0.00057475	27
	LUX	0.33041	7	0.28269	8	0.31224	7	0.31177	7
	MEX	0.050334	20	0.049649	20	0.054868	20	0.063412	18
	NLD	0.24978	10	0.25833	11	0.24155	11	0.26259	11
	NOR	0.14467	15	0.15448	15	0.16802	14	0.1638	14
	POL	0.062573	18	0.063848	18	0.062306	18	0.05669	19
	PRT	0.13361	16	0.10969	16	0.099795	16	0.11695	16
	SVK	0.024097	25	0.023706	24	0.019972	24	0.020536	24
	SVN	0.055937	19	0.062042	19	0.057187	19	0.056531	20
	ESP	0.26904	9	0.26894	9	0.25346	10	0.25887	12
	SWE	0.17074	14	0.1692	14	0.14957	15	0.16032	15
	CHE	0.28941	8	0.28777	7	0.30356	8	0.30751	8
	TUR	0.016805	26	0.0097117	26	0.015878	25	0.018418	25
	GBR	0.52275	2	0.50436	3	0.51316	2	0.50843	3
	USA	0.98744	1	0.9876	1	0.98771	1	0.98481	1

Table 3. Rankings based on EDAS method (continued)

		Year							
		2014		2015		2016		2017	
		AS	Rank	AS	Rank	AS	Rank	AS	Rank
Alternatives (OECD Countries)	AUS	0.28852	9	0.25653	9	0.23517	10	0.20236	13
	BEL	0.19518	14	0.18209	13	0.17427	14	0.15949	14
	CHL	0.048505	19	0.059857	18	0.065185	18	0.055524	19
	CZE	0.034797	22	0.028356	22	0.02614	22	0.019662	24
	DNK	0.21659	12	0.20561	12	0.2084	13	0.20792	12
	FIN	0.095321	17	0.095362	17	0.076622	17	0.066062	17
	FRA	0.50227	3	0.50204	2	0.51654	2	0.52054	3
	DEU	0.49517	4	0.492	4	0.48951	4	0.48701	4
	HUN	0.012841	26	0.0099201	26	0.013757	26	0.0092207	25
	ISL	0.017479	23	0.019887	23	0.023376	23	0.025988	23
	ITA	0.35788	6	0.35512	6	0.32824	6	0.31967	6
	JPN	0.4174	5	0.416	5	0.45306	5	0.4249	5
	LVA	0.00056633	27	0.00050334	27	0.0005299	27	0.00034642	27
	LUX	0.31053	7	0.29628	7	0.29207	8	0.29868	8
	MEX	0.058678	18	0.054627	19	0.053654	19	0.055772	18
	NLD	0.20864	13	0.17574	14	0.31564	7	0.31286	7
	NOR	0.16271	15	0.15445	15	0.15971	15	0.14344	15
	POL	0.047595	20	0.043489	21	0.043954	21	0.044737	21
	PRT	0.11765	16	0.10906	16	0.090046	16	0.082764	16
	SVK	0.015798	24	0.011271	25	0.01754	25	0.049945	20
	SVN	0.047046	21	0.048223	20	0.049053	20	0.04124	22
	ESP	0.24754	10	0.22894	10	0.23316	11	0.2201	10
	SWE	0.22769	11	0.21461	11	0.20923	12	0.21118	11
	CHE	0.30261	8	0.29622	8	0.28503	9	0.2788	9
	TUR	0.013267	25	0.011919	24	0.018054	24	0.0086829	26
	GBR	0.50425	2	0.50171	3	0.51583	3	0.53053	2
	USA	0.98832	1	0.98628	1	0.98618	1	0.98496	1

Table 4. Groups of OECD countries with similar levels of insurance performance according to IPIs

		Level of Efficient Performance			
		High	Medium–High	Medium–Low	Low
Year	2010	FRA, DEU, JPN, GBR, USA	AUS, ITA, LUX, NLD, ESP, CHE	BEL, CHL, CZE, DNK, FIN, HUN, ISL, LVA, MEX, NOR, POL, PRT, SVK, SVN, SWE, TUR	/
	2011	FRA, DEU, JPN, GBR, USA	AUS, ITA, LUX, NLD, ESP, CHE	BEL, CHL, CZE, DNK, FIN, HUN, ISL, LVA, MEX, NOR, POL, PRT, SVK, SVN, SWE, TUR	/
	2012	FRA, DEU, JPN, GBR, USA	AUS, ITA, LUX, NLD, ESP, CHE	BEL, CHL, CZE, DNK, FIN, HUN, ISL, LVA, MEX, NOR, POL, PRT, SVK, SVN, SWE, TUR	/
	2013	FRA, DEU, GBR, USA	AUS, DNK, ITA, JPN, LUX, NLD, ESP, CHE	BEL, CHL, CZE, FIN, HUN, ISL, MEX, NOR, POL, PRT, SVK, SVN, SWE, TUR	LVA
	2014	FRA, DEU, GBR, USA	AUS, ITA, JPN, LUX, NLD, ESP, SWE, CHE	BEL, CHL, CZE, FIN, HUN, ISL, LVA, MEX, NLD, NOR, POL, PRT, SVK, SVN, TUR	/
	2015	FRA, DEU, GBR, USA	AUS, ITA, JPN, LUX, ESP, SWE, CHE	BEL, CHL, CZE, DNK, FIN, HUN, ISL, LVA, MEX, NLD, NOR, POL, PRT, SVK, SVN, TUR	/
	2016	FRA, DEU, JPN, GBR, USA	AUS, ITA, LUX, NLD, ESP, CHE	BEL, CHL, CZE, DNK, FIN, HUN, ISL, LVA, MEX, NOR, POL, PRT, SVK, SVN, SWE, TUR	/
	2017	FRA, DEU, GBR, USA	ITA, JPN, LUX, NLD, ESP, CHE	AUS, BEL, CHL, CZE, DNK, FIN, HUN, ISL, LVA, MEX, NOR, POL, PRT, SVK, SVN, SWE, TUR	/

Table 5. Sensitivity analysis on changing weights of the RP criterion in 2017.

		Changing Weights of the RP Criterion									
		0.1		**0.2**		**0.3**		**0.4**		**0.5**	
		AS	**Rank**	**AS**	**Rank**	**AS**	**Rank**	**AS**	**Rank**	**AS**	**Rank**
Alternatives (OECD Countries)	**AUS**	0.24345	11	0.24345	13	0.21535	11	0.39336	13	0.21535	11
	BEL	0.21315	13	0.21315	14	0.16252	14	0.38386	14	0.16252	14
	CHL	0.041627	22	0.041627	19	0.064096	18	0.34181	18	0.06409	18
	CZE	0.04715	21	0.047153	24	0.032276	23	0.32736	24	0.03227	23
	DNK	0.22186	12	0.22186	12	0.20217	13	0.40999	10	0.20217	13
	FIN	0.095491	17	0.095491	17	0.06143	19	0.34763	17	0.06143	19
	FRA	0.49923	3	0.49923	3	0.52076	3	0.50033	4	0.52076	3
	DEU	0.49596	4	0.49596	4	0.48841	4	0.4803	5	0.48841	4
	HUN	0.025227	23	0.025227	25	0.014423	26	0.3234	25	0.01442	26
	ISL	0.024195	24	0.024195	23	0.022621	25	0.33194	23	0.02262	25
	ITA	0.38187	6	0.38187	6	0.31389	6	0.42829	9	0.31389	6
	JPN	0.46871	5	0.46871	5	0.42399	5	0.43329	8	0.42399	5
	LVA	0.0003351	27	0.0003351	27	0	27	0.32036	27	0	27
	LUX	0.33041	7	0.33041	8	0.30295	8	0.51665	3	0.30295	8
	MEX	0.050334	20	0.050334	18	0.066216	17	0.33877	20	0.06621	17
	NLD	0.24978	10	0.24978	7	0.30528	7	0.44361	6	0.30528	7
	NOR	0.14467	15	0.14467	15	0.14192	15	0.37938	15	0.14192	15
	POL	0.062573	18	0.062573	21	0.048711	21	0.33618	22	0.04871	21
	PRT	0.13361	16	0.13361	16	0.085489	16	0.35393	16	0.08548	16
	SVK	0.024097	25	0.024097	20	0.050129	20	0.34134	19	0.05012	20
	SVN	0.055937	19	0.055937	22	0.047117	22	0.33782	21	0.04711	22
	ESP	0.26904	9	0.26904	10	0.21983	10	0.401	12	0.21983	10
	SWE	0.17074	14	0.17074	11	0.20536	12	0.40513	11	0.20536	12
	CHE	0.28941	8	0.28941	9	0.27621	9	0.43333	7	0.27621	9
	TUR	0.016805	26	0.016805	26	0.027948	24	0.32096	26	0.02794	24
	GBR	0.52275	2	0.52275	2	0.53071	2	0.52094	2	0.53071	2
	USA	0.98744	1	0.98744	1	1	1	0.53	1	1	1

Table 5. Sensitivity analysis on changing weights of the RP criterion in 2017. (continued)

		Changing Weights of the RP Criterion							
		0.6		0.7		0.8		0.9	
		AS	Rank	AS	Rank	AS	Rank	AS	Rank
Alternatives (OECD Countries)	AUS	0.32823	14	0.20236	13	0.39191	11	0.34823	12
	BEL	0.34574	12	0.15949	14	0.37152	15	0.34574	13
	CHL	0.31605	17	0.05552	19	0.33658	21	0.31605	19
	CZE	0.29938	23	0.01966	24	0.33189	24	0.2993	23
	DNK	0.33258	13	0.20792	12	0.37184	14	0.33258	14
	FIN	0.30918	20	0.06606	17	0.34725	17	0.31918	18
	FRA	0.5211	2	0.52054	3	0.44981	4	0.5211	4
	DEU	0.51632	4	0.48701	4	0.49414	2	0.61632	3
	HUN	0.29689	25	0.00922	25	0.3301	25	0.29689	25
	ISL	0.28952	27	0.02598	23	0.33951	20	0.28952	27
	ITA	0.42824	6	0.31967	6	0.41426	6	0.42824	6
	JPN	0.48396	5	0.4249	5	0.41528	5	0.48396	5
	LVA	0.2924	26	0.00034	27	0.32699	26	0.2924	26
	LUX	0.36572	9	0.29868	8	0.39757	10	0.39872	8
	MEX	0.30159	22	0.05577	18	0.35054	16	0.32159	17
	NLD	0.40178	7	0.31286	7	0.4078	8	0.40178	7
	NOR	0.32431	15	0.14344	15	0.37643	13	0.32431	15
	POL	0.31376	18	0.04473	21	0.34105	19	0.31376	20
	PRT	0.32407	16	0.08276	16	0.34366	18	0.32407	16
	SVK	0.31081	19	0.04994	20	0.33337	22	0.31081	21
	SVN	0.30435	21	0.04124	22	0.33201	23	0.30435	22
	ESP	0.3892	8	0.2201	10	0.39845	9	0.3892	9
	SWE	0.35436	11	0.21118	11	0.39118	12	0.35436	11
	CHE	0.3604	10	0.2788	9	0.41161	7	0.3604	10
	TUR	0.29885	24	0.00868	26	0.32489	27	0.29885	24
	GBR	0.51911	3	0.53053	2	0.49272	3	0.61911	2
	USA	0.96629	1	0.98496	1	0.5	1	0.96629	1