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AN APPROACH TO FDI LOCATION CHOICE BASED ON THE USE OF SINGLE VALUED NEUTROSOPHIC NUMBERS: CASE OF NON-EU BALKAN COUNTRIES

Aleksandra Fedajev[1]; Dragiša Stanujkić[2]; Florentin Smarandache[3]

Abstract

The beginning of transition in former command economies was characterised by deep recession and numerous structural imbalances. Some of transition economies have overcome these problems relatively fast and some of them are still struggling to find their way to growth and development. One of the key drivers of economic expansion in advanced transition economieswereFDI. Foreign investors had different motives for investment. In accordance with them and business environment characteristics in these countries they chose the location of their investment. Having in mind that FDI are still very important generator of economic growth, the growing number of authors is dealing with the development of most efficient decision making method for FDI location choice. This paper presents a single valued neutrosophic numbers approach for selecting the most suitable country for investment. The effectiveness and usability of the proposed approach were demonstrated in the case of non-EU Balkan countries, bearing in mind that these countries are still lagging behind CEE economies in terms of growth and development.

Keywords: *FDI, transition economies, decision making, neutrosophy*

Introduction

The internationalization of businesses is one of the most important global trends in contemporary business conditions and one of the biggest challenges for MNEs Aleksandruk and Forte (2016).Investing money in new projects, as well as selecting a country for new investment, are real problems that deserve great attention, especially in the case of long-term investments, as in a case of FDI.Because of that, special attention is devoted to these problems in scientific and professional literature. As a proof of that, from numerous published articles, some of the most cited articles are listed: Yiu *et al.* (2007), Beim and Levesque (2006), Moen *et al.* (2004), Manigart, *et al.* (2002), Chung and Enderwick (2001), Wells *et al.* (1990).

Motives of foreign investors are different, but most of authors categorized them in these groups: market-seeking, efficiency-seeking, resource-seeking, strategic asset seeking Aleksandruk and Forte (2016), Maza and Villaverde (2015), Estrin and Uvalic (2014), Altomonte and Guagliano (2003), Tampakoudis et al. (2017). Having in mind that mentioned groups of investors have different investment aims, they also have different preferences about characteristics of business environmentin CEE countries. The mostly cited determinants of

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FDI in transition countries are: market size and attractiveness, institutional environment, political risk, transaction costs, bilateral exports, transition progress, financial market development, infrastructure, macroeconomic stability, administrative procedures, tax system, labor market and regulations, knowledge resources, natural resources, trade opennessDauti (2015), Obradović et al. (2012), Wilson and Baack (2012), Hengel, E. (2010), Tampakoudis et al. (2017), Wach and Wojciechowski (2016) .Bearing in mind all these criteria, it can be concluded that evaluation of any investment project location involves at least three mutually opposite criteria. So, problem of selecting the most appropriate investment projects can be expressed as follows: How to achieve as much as possible revenue in as is possible shorter period of time with as is possible smaller investments? Of course, the risk of investment should not be ignored here. Therefore, any investment project can be considered as a multiple criteria decision-making problem, and as some evidence for such an approach, the following: Altuntas and Dereli (2015), Kiliç and Kaya (2015), Popović *et al*. (2012), Ginevičius and Zubrecovas (2009), Dimova *et al*. (2006), Tzeng and Teng (1993), and so on.

In order to enable solving of complex problems of decision-making problems, Zadeh (1965) introduced fuzzy set theory. Based on the fuzzy set theory, a number of authors lather proposed some its extensions as follows: intuitionistic (Atanassov, 1986), interval-valued (Turksen 1986) and interval-valued intuitionistic (Atanassov and Gergov, 1989) fuzzy set theory. Further, Smarandache (1998) introduced the neutrosophic set as general framework generalizing the concepts of the classical, and all above mentioned fuzzy theories.In addition to the membership function, or the so-called truth-membership $T_A(x)$, proposed in fuzzy sets, Atanassov (986) introduced the non-membership function, or the so-called falsity-membership $F_A(x)$, which expresses non-membership to a set, thus creating the basis for the solving of a much larger number of decision-making problems. Finally, Smarandache (1999) introduced independent indeterminacy-membership $I_A(x)$, thus making the neutrosopic sets most suitable for solving some complex decision-making problems. In the next step, Smarandache (1998) and Wang*et al*. (2010) further introduced the single valued neutrosophic sets that are more suitable for solving many real-world decision-making problems.

Therefore, the rest of the manuscript is organized as follows: in Section 2, the basic elements of neutrosophic sets are considered and in Section 3, a procedure for evaluating investment projects is proposed. In Section 4, its usability is demonstrated. Finally, the conclusion is given.

Preliminaries

Definition 1. *Neutrosophic set*. Let *X*be the universe of discourse, with a generic element in *X* denoted by *x*. Then, the neutrosophic set *A* in *X* is as follows(Smarandache, 1999):

$$A = \{x < T_A(x), I_A(x), F_A(x) > | \, x \in X\}, \quad (1)$$

where$T_A(x)$, $I_A(x)$ and $F_A(x)$ are the truth-membership function, the indeterminacy-membership function and the falsity-membership function, respectively, $T_A, I_A, F_A : X \rightarrow]^{-}0,1^{+}[$ and $^{-}0 \leq T_A(x)+I_A(x)+U_A(x) \leq 3^{+}$.

Definition 2. *Single valued neutrosophic set*.Let *X* be the universe of discourse. The Single Valued Neutrosophic Set(SVNS) *A* over *X* is an object having the form (Smarandache, 1998, Wang *et al.* 2010):

$$A = \{x < T_A(x), I_A(x), F_A(x) > | \, x \in X\}, \quad (2)$$

where$T_A(x)$, $I_A(x)$ and $F_A(x)$ are the truth-membership function, the intermediacy-membership function and the falsity-membership function, respectively, $T_A, I_A, F_A : X \to [0,1]$ and $0 \leq T_A(x)+I_A(x)+U_A(x) \leq 3$.

Definition 3. *Single valued neutrosophic number*.For an SVNS A in X, the triple $< t_A, i_A, f_A >$ is called the single valued neutrosophic number (SVNN) (Smarandache, 1999).

Definition 4. *SVNNs*. Let $x_1 =< t_1, i_1, f_1 >$ and $x_2 =< t_2, i_2, f_2 >$ be two SVNNs and $\lambda > 0$; then, the basic operations are defined as follows:

$$x_1 + x_2 =< t_1 + t_2 - t_1 t_2, i_1 i_2, f_1 f_2 >. \quad (3)$$

$$x_1 \cdot x_2 =< t_1 t_2, i_1 + i_2 - i_1 i_{2,} f_1 + f_2 - f_1 f_2 >. \quad (4)$$

$$\lambda x_1 =< 1-(1-t_1)^{\lambda}, i_1^{\lambda}, f_1^{\lambda} >. \quad (5)$$

$$x_1^{\lambda} =< t_1^{\lambda}, i_1^{\lambda}, 1-(1-f_1)^{\lambda} >. \quad (6)$$

Definition 5. *Score function*. Let $x =< t, i, f >$ be a SVNN, then the score function $s_{(x)}$ of x is as follows (Smarandache, 1998):

$$s_{(x)} = (1+t-2i-f)/2, \quad (7)$$

where $s_x \in [-1,1]$.

Definition 6. *Single valued neutrosophic average*.Let $a_i =< t_i, i_i, f_i >$ be a collection of SVNNs and $W = (w_1, w_2, ..., w_n)^T$ be an associated weighting vector. Then the Single Valued Neutrosophic Weighted Average (SVNWA) operator of a_j is as follows(Smarandache, 2014):

$$SVNWA(a_1, a_2, ..., A_n) = \sum_{j=1}^{n} w_j a_j$$
$$= \left(1 - \prod_{j=1}^{n} (1-t_j)^{w_j}, \prod_{j=1}^{n} i_j^{w_j}, \prod_{j=1}^{n} f_j^{w_j} \right), \quad (8)$$

where: w_j is the element j of the weighting vector, $w_j \in [0,1]$ and $\sum_{j=1}^{n} w_j = 1$.

Framework for evaluating the strategies

Many complex decision-making problems require the participation of more experts and/or decision-makers in selection of the most appropriate alternative. Therefore, in this section, a framework for the evaluation of countries for new investment, based on group decision-making and the SVNNs method, is considered.

The selection process involving m alternatives that are evaluated on the basis of n criteria by K decision maker can be presented in detail using the following steps:

Step 1. Form a team of experts and / or decision-makers who will evaluate potential countries.

Step 2. Define the objectives that need to be achieved by the investment objectives. In this steep, the team of experts and / or decision-makers define the objectives to be achieved.

Step 3. Identify the possible countries. In this step, the team of experts and / or decision-makers identify countries - potential candidates for investment.

Step 4. Form a set of evaluation criteria. In this step, the team of experts and / or decision-makers selects the set of criteria on which basis the evaluation will be carried out.

Step 5. Determine the significance of the criteria. In the literature, many techniques for determining the weights of criteria are proposed, such as pair-wise comparisons (Saaty, 1977), SWARA (Kersulien*et al*. 2010), Best-worst method (Rezaei, 2015), PIPRECIA (Stanujkic *et al*., 2017).

In this approach, each expert and / or decision-maker evaluates the criteria by applying one of the above-mentioned techniques, after which the group weights are determined as follows:

$$w_j = \frac{1}{K}\sum_{k=1}^{K} w_j^k , \qquad (11)$$

where w_j^k denotes the weight of criterion *j* obtained from expert / decision-maker *k.*

Step 6. Evaluate the strategies in relation to the set of criteria. In this step, each expert forms his / her decision matrix, whose elements are SVNNs.

Step 7. Evaluate alternatives. The selection procedure can be described as follows:

- Form a group decision matrix, based on individual decision-making matrices formed by experts, using Eq. (8).
- Calculate the overall performance of each alternative, based on the group decision matrix, also using Eq. (8)
- Determine the value of the Score function for each alternative using Eq, (7).
- Rank the alternatives in relation to the value of the Score function, where the alternative with the highest value of the Score function is the most appropriate alternative.

Numerical Illustration

In order to present the usability of the SVNNs for solving different decision-making problems in the economics, a numerical illustration is presented below.In this numerical illustration, five Balkan countries, which are not members of the European Union, have been evaluated from the point of view of potential investors with different motives for investment.

At the very beginning of the evaluation, a team of three experts was formed. Based on the FDI determinants shown in Table 1, as well as their experiences and motives for investment, the experts performed out the evaluation the alternatives in relation to the selected set of evaluation criteria.

Table 1: *FDI determinants of the business environment*

		FDI Determinants				
		Market Size (GDP)	Average Salary	Rent	Tax Rate	Property Protection
		€	€		%	
A_1	Albania	4538	390	2	37.3	54.0
A_2	Bosnia	5181	440	1.1	23.7	41.2
A_3	Macedonia	5443	377	1.5	13.0	67.0
A_4	Montenegro	7670	512	0.8	22.1	58.0
A_5	Serbia	5900	459	1.5	39.7	50.3

Source: *Authors' calculation*

In the performed evaluation, the first of the three experts carried out evaluation from the market–seeking investor point of view, while the second and third experts were made evaluations from the point of view of resource-seeking and efficiency-seeking, respectively.

The performances of the alternative in relation to the evaluation criteria, as well as the weight of the criteria, obtained from a team of three experts are shown in Tables 2 to 4, whereby they evaluated the alternatives using a five-pointLikert scale, after which these values, for the purpose of further calculation, are transformed to the corresponding values in the interval [0, 1].

Table 2: *The ratings and weights obtained from the first of three experts*

	C_1			C_2			C_3			C_4			C_5		
w_j	0.25			0.19			0.13			0.21			0.21		
	t	*i*	*f*	*t*	*i*	*f*	*t*	*i*	*f*	*t*	*i*	*f*	*t*	*i*	*f*
A_1	2.00	0.00	0.00	3.00	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.10	3.00	0.00	0.10
A_2	3.00	0.00	0.00	4.00	0.00	0.00	1.00	0.00	0.00	2.00	0.00	0.00	2.00	0.00	0.00
A_3	3.00	0.00	1.00	3.00	0.00	0.00	1.00	0.00	0.00	4.00	0.00	0.00	5.00	0.00	0.00
A_4	5.00	0.00	2.00	4.00	0.00	1.00	1.00	0.00	0.00	2.00	0.00	0.10	4.00	0.00	0.00
A_5	4.00	0.00	0.00	4.00	0.00	2.00	1.00	0.00	0.00	1.00	0.00	0.00	3.00	0.00	0.00

Source: *Authors' calculation*

The ratings of alternatives obtained from the first of three experts, expressed using the SVNN, are shown in Table 5, while the overall ratings, the values of score function, as well as the ranking order of alternatives are shown in table 6.

Table 3: *The ratings and weights obtained from the second of three experts*

	C_1			C_2			C_3			C_4			C_5		
w_j	0.08			0.13			0.38			0.26			0.15		
	t	*i*	*f*	*t*	*i*	*f*	*t*	*i*	*f*	*t*	*i*	*f*	*t*	*i*	*f*
A_1	0.00	0.00	0.00	5.00	0.00	0.00	2.00	0.00	0.00	2.00	0.00	1.00	3.00	0.00	2.00
A_2	0.00	0.00	0.00	4.00	0.00	0.00	4.00	0.00	2.00	3.00	0.00	0.00	1.00	0.00	0.00
A_3	0.00	0.00	0.00	5.00	0.00	0.00	3.00	0.00	0.00	4.00	0.00	0.00	4.00	0.00	0.00
A_4	0.00	0.00	0.00	3.00	0.00	1.00	5.00	0.00	0.00	3.00	0.00	0.00	3.00	0.00	0.00
A_5	0.00	0.00	0.00	4.00	0.00	2.00	3.00	0.00	2.00	2.00	0.00	1.00	2.00	0.00	0.00

Source: *Authors' calculation*

Table 4: *The ratings and weights obtained from the third of three experts*

	C_1			C_2			C_3			C_4			C_5		
w_j	0.09			0.43			0.08			0.29			0.12		
	t	*i*	*f*	*t*	*i*	*f*	*t*	*i*	*f*	*t*	*i*	*f*	*t*	*i*	*f*
A_1	1.00	0.00	0.00	5.00	0.00	0.00	1.00	0.00	0.00	3.00	0.00	0.00	3.00	0.00	1.00
A_2	2.00	0.00	0.00	4.00	2.00	2.00	3.00	0.00	0.00	4.00	0.00	0.00	1.00	0.00	1.00
A_3	2.00	0.00	0.00	5.00	0.00	0.00	2.00	0.00	0.00	5.00	0.00	0.00	5.00	0.00	0.00
A_4	3.00	0.00	0.00	2.00	0.00	0.00	4.00	0.00	1.00	4.00	0.00	1.00	4.00	0.00	1.00
A_5	2.00	0.00	0.00	3.00	0.00	2.00	2.00	0.00	0.50	2.00	0.00	0.00	2.00	0.00	0.00

Source: *Authors' calculation*

Table 5: *The ratings obtained from the first of three experts expressed in the form of SVNN*

	C_1	C_2	C_3	C_4	C_5
	0.25	0.19	0.13	0.21	0.21
A_1	<0.4,0.0,0.0>	<0.6,0.0,0.0>	<0.2,0.0,0.0>	<0.2,0.0,0.0>	<0.6,0.0,0.0>
A_2	<0.6,0.0,0.0>	<0.8,0.0,0.0>	<0.2,0.0,0.0>	<0.4,0.0,0.0>	<0.4,0.0,0.0>
A_3	<0.6,0.0,0.2>	<0.6,0.0,0.0>	<0.2,0.0,0.0>	<0.8,0.0,0.0>	<1.0,0.0,0.0>
A_4	<1.0,0.0,0.4>	<0.8,0.0,0.2>	<0.2,0.0,0.0>	<0.4,0.0,0.0>	<0.8,0.0,0.0>
A_5	<0.8,0.0,0.0>	<0.8,0.0,0.4>	<0.2,0.0,0.0>	<0.2,0.0,0.0>	<0.6,0.0,0.0>

Source: *Authors' calculation*

Table 6: *The overall ratings, the values of score function, and the ranking order of alternatives obtained on the basis of responses of the first of three experts*

		Overall	S_i	*Rank*
A_1	Albania	<0.4,0.0,0.0>	0.718	5
A_2	Bosnia	<0.5,0.0,0.0>	0.772	4
A_3	Macedonia	<1.0,0.0,0.0>	0.999	1
A_4	Montenegro	<1.0,0.0,0.0>	0.999	1
A_5	Serbia	<0.6,0.0,0.0>	0.813	3

Source: *Authors' calculation*

As it can bee seen from Table 6, the most appropriate alternatives for market-seeking investors are alternatives denotes as A_3 and A_4.

The values of score function, as well as appropriate ranking order of alternatives obtained from three experts, are accounted for in Table 7.

Table 7: *The ranking orders obtained from three experts*

		E_1		E_2		E_3	
		S_i	*Rank*	S_i	*Rank*	S_i	*Rank*
A_1	Albania	0.718	5	0.999	1	0.999	1
A_2	Bosnia	0.772	4	0.816	4	0.862	3
A_3	Macedonia	0.999	1	0.999	1	0.999	1
A_4	Montenegro	0.999	1	0.999	1	0.830	4
A_5	Serbia	0.813	3	0.749	5	0.747	5

Source: *Authors' calculation*

As previously mentioned, alternatives denoted as A_3 and A_4 are the most appropriate for market-seeking investors, while alternatives denoted as A_1, A_3 and A_4 are more suitable for

resources-seeking investors. Finally, alternatives denoted as A_1 andA_3 and most suitable for efficiency-seeking investors.

The group ratings of considered alternatives, obtained by using Eq. (10), are encountered for in Table 8, whereby the experts, as well as potential investors, had the following weights:w_1=0.45, w_2=0.25 and w_3=0.30.

Table 8: *The overall ratings and weights obtained from three experts*

	C_1	C_2	C_3	C_4	C_5
	0.14	0.25	0.20	0.22	0.16
A_1	<0.2,0.0,0.0>	<1.0,0.0,0.0>	<0.2,0.0,0.0>	<0.3,0.0,0.0>	<0.6,0.0,0.0>
A_2	<0.4,0.0,0.0>	<0.8,0.0,0.0>	<0.5,0.0,0.0>	<0.6,0.0,0.0>	<0.2,0.0,0.0>
A_3	<0.4,0.0,0.0>	<1.0,0.0,0.0>	<0.3,0.0,0.0>	<1.0,0.0,0.0>	<1.0,0.0,0.0>
A_4	<1.0,0.0,0.0>	<0.6,0.0,0.0>	<1.0,0.0,0.0>	<0.6,0.0,0.0>	<0.7,0.0,0.0>
A_5	<0.5,0.0,0.0>	<0.7,0.0,0.4>	<0.3,0.0,0.0>	<0.3,0.0,0.0>	<0.5,0.0,0.0>

Source: *Authors' calculation*

The final ranking order of considered alternatives is accounting for in Table 9.

Table 9: *The final ranking order of alternatives*

		Overall	S_i	*Rank*
A_1	Albania	<1.0,0.0,0.0>	0.999	1
A_2	Bosnia	<0.5,0.0,0.0>	0.796	4
A_3	Macedonia	<1.0,0.0,0.0>	0.999	1
A_4	Montenegro	<1.0,0.0,0.0>	0.999	1
A_5	Serbia	<0.5,0.0,0.0>	0.766	5

Source: *Authors' calculation*

As it can be from Table 9, the most suitable business environment for investment is the three Balkan countries: Albania, Macedonia and Montenegro, with Bosnia and Herzegovina ranked at fourth position and Serbia ranked in the fifth position.

Conclusion

In this article, an easy-to-use multiple criteria decision-making approach for evaluating potential investment countries is considered. The proposed approach is based on the use of single valued neutrosophic numbers, which should provide easier expression of the preferences, doubt and uncertainty of the information on which basis the evaluation should be carried out.

The considered example of the investment country selection is characterized by a low level of doubt and uncertainty, that is, it is a rather well-structured investment decision-making problem, and it is chosen with the aim of easier presenting usability and efficiency of the proposed approach. Certainly, the mentioned approach can be also used for solving similar problems with greater imprecision and unreliability of the available information, in which case a more complex ranking procedure should be used.

Finally, the ranking results obtained in the presented evaluation indicate that Serbia is in unfavorable position in comparison to other considered countries and that something should

be undertaken to improve, or at least mitigate some negative characteristic of the existing business environment in Serbia, first of all to reform tax system and to improve and enforce implementation of regulation in the area of property protection.However, it should be mentioned that some characteristics of business environment are unfavorable for foreign investors, but favorable for wellbeing of citizens and economy as a whole, and that contributed to such position of Serbia in final rankings. Namely, investors prefer to pay low wages in order to lower their labor costs, but lowering wages will lead to lowering of living standard in the country. In addition, high rents on natural resources is also something that is not in favor of foreign investors, but it prevents the exploitation of natural resources for the needs of foreign companies and leave it for future generations in country. At the very end, it should be said that in this case small number of FDI determinants are taken into account and rankings will be certainly somewhat different if more of them are considered, so in the future researches authors will present more characteristics of business environment to foreign investors in order to let them know more about observed countries, as a potential location for their investments.

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