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Using Fuzzy Logic for Evaluating the Level of Countries' (Regions') Economic Development

Summary: There are several divisions of countries and regions in the world. Besides geo-political divisions, there also are economic divisions. The most common economic division is the that on developed countries and the poor ones. These divisions are a consequence of the level of: GDP, GDP per capita, unemployment rate, industrial growth, and so on. The question is how to define a mathematical model based on which the following will be assessed: who is rich and who is poor, or who is economically developed and who is not? How the boundaries of transition from one category to another can be defined? This paper presents a model for evaluating the level of economic development of countries and regions using "fuzzy" logic. The model was tested on a sample of 19 EU member countries and aspirants for membership.

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Key words: Model, Evaluation, Economy development, Fuzzy sets.

JEL: C52, E01, O11.

Determining the size and level of development of some subjects often is a matter of debate and disagreement between the facts of that which is "major" and which is "small" or "medium" developed, which is "high" and which is "poor" developed, and so on. For example, the score of company size (large, small, or medium) or their infrastructural facilities development, number of employees, size of income and so on, or all together (low, medium, or highly developed). Such is the case with the evaluation of the markets, industries, agriculture, and others. Which is the big business entity that is small? Which market is highly developed and which is a poorly developed one? Which reforms are large and which are small? Which region is highly developed and which is medium or small? How the border of crossing from one grade to another can be defined? These are all questions that are persisting in practice, and they give different answers or assessments.

The assessments are given based on experience, intuition, and subjective attitude of some institutions and experts. Institution that can occur are as follows: the government, ministries, agencies, companies, EU agencies, financial institutions (International: World Bank, European Bank for Reconstruction and Development (EBRD), International Monetary Fund (IMF), European Investment Bank (EIB) ... or domestic banks), and experts who perform personally or representing organizations (market monitoring, compatibility of regulations and reforms to the EU, etc.). Except that, there is uncertainty about the input data which are necessary to make certain assessments and decisions. It shows that a whole series of parameter assessment is characterized by uncertainties, subjectivity, imprecision, and multiple meaning.

1. An Overview of Existing Evaluation Models

The evaluation of the reforms level is usually performed with the heuristic evaluation method of some specialists or experts, which is based on individual opinion, reasoning, and intuition and without any application of mathematical methods. Estimates are given in the form of reports. Paul Amos (2005), in the World Bank report, defines railway reforms as low, medium, and high.

IBM Business Consulting Services (2007) has done a study for the evaluation of the level of liberalization in the 27 EU countries. In the study, a benchmarking method was applied.

In the recent literature, a use of the models of computable general equilibrium (CGE) can be found. In assessing the level of liberalization of the Jordanian market and its conformity with the European Union economy, Omar Feraboli (2006) uses dynamic CGE. Edward J. Balistreri, Thomas F. Rutherford, and David G. Tarr (2009) developed a model, which employs a 55-sector small open economy CGE model of the Kenyan economy to assess the impact of the liberalization of regulatory barriers against foreign and domestic business service providers in Kenya. For the evaluation of the situation of certain sectors, Balistreri, Rutherford, and Tarr (2009) applies benchmarking analysis. However, Jeffery Bor Yungchang et al. (2010), in the assessment of the public research and development investment in Taiwan, and Doina Maria Radulescu and Michael Stimmelmayr (2010), in designing the analysis of the impact of fundamental tax reforms and the particular capital income tax reforms for Germany, uses dynamic CGE.

Nathalie Homlong and Elisabeth Springler (2010) used macroeconomic statistical data in the quantitative assessment of the potential and needs of the Indian state.

Zhu-Quan Yang, Jin-Ye Wang, and Zhong-Jun Wu (2007) used the SWOT analysis in the assessment of the Development Countermeasures for Ecotourism in Pengzuping Nature Reserve. SWOT analysis was used by South East Europe Transport Observatory (SEETO 2009) in the evaluation of the level of development of the railway market. It often is used for the evaluation of the commercial business of the countries in the banking sector (see Brazil Commercial Banking Report Q4 2009). Miika Kajanus, Jyrki Kangas, and Mikko Kurttila (2004) applied hybrid models such as A'WOT analysis (combining the SWOT analysis and the Analytic Hierarchy Process) for the strategic planning of rural tourism.

For the evaluation of the dynamic effects of trade openness on financial development, Kim Dong-Hyeon, Linb Shu-Chin, and Suen Yu-Bo (2010) used statistical analysis for the period 1960-2005 by performing (static) cross-sectional regression.

One of the recognized criteria in ranking countries, based on the economic development, is their global competitiveness index score (see an overview World Economic Forum 2009). The global competitiveness index is a comprehensive assessment of the countries' competitiveness, which is based on statistical indicators. The competitiveness score of each country is calculated on the basis of various factors: institutions (public and private), infrastructure, macroeconomic stability, health and primary education, higher education and training, goods market efficiency, labor market efficiency, financial market sophistication, technological readiness, market size, and business sophistication.

Certain elements in the statistics analysis often are insufficiently precise, and the assessment of their value is subjective. CGE and dynamic general equilibrium analysis use statistical database. The comparative benchmarking method is based on the concept of innovative way of utilization of the best practice and experience. In applying this method, basic danger comes with the process of reduction to a simple method of comparison or innovating with copying.

The SWOT analysis is a widely applied method of analysis. The application of this analysis for the evaluation of level economy development also implies the use of intuition and subjective evaluation. However, the SWOT analysis is not only used as a direct research method. Chang Hsu-His and Huang Wen-Chih (2006) believe that results of SWOT analysis too often are only a superficial and imprecise listing or an incomplete qualitative examination of internal and external factors.

Conventionally, a mathematical model of a system is constructed by analyzing input–output measurements from the system. However, an additional important source of information about engineering systems is human expert knowledge known as linguistic information. It provides qualitative instructions and descriptions of the system. Yuanhua Qiao, Nir Keren, and Sam M. Mannan (2009) consider that the fuzzy model can easily include this type of information, whereas a conventional mathematical model fails in that.

The countries sizing is given according to the experience, intuition, subjective attitude, or particular institutions of experts. However, uncertainty regarding the input data necessary for certain decision making also is present. This implies that all parameters of evaluation are characterized by uncertainty, subjectivity, inaccuracy, and ambiguity. Dušan Teodorović and Shinya Kikuchi (2000) believe that fuzzy sets theory (scattered—inarticulate sets) is a suitable tool for uncertainty, subjectivity, ambiguity, and inaccuracy treatment. Modeling with uncertainty requires more than probability theory.

Gordan Stojić et al. (2010) apply the theory of "fuzzy" sets for modeling evaluation of the size of countries (regions).

Ibrahim Ozkan, Lutfi Erden, and Burhan I. Türkşen (2009) analyzed the effects of the country size, where the relative gross national product (GNP), the domestic investment and saving where included, and the data from the panel of OECD 21 countries for the years between 1970 and 2003 are presented in the paper. In using fuzzy logic, Ozkan, Erden, and Türkşen (2009) clustered the countries, based on their relative sizes, into groups such as ‘‘small,” “medium,” “large,” and “very large” countries.

The possibility of applying fuzzy logic in the economy was stated by Endre Pap (2009). Pap (2009) has developed hybrid probabilistic–possibilistic mixtures based upon a pair of triangular conorm and triangular norm satisfying restricted distributivity law, and the corresponding non-additive S-measure is presented. A triangular conorm and triangular norm are a kind of binary operation used in the framework of probabilistic metric spaces and in multi-valued logic, specifically in fuzzy logic.

One of the most common evaluations of the economic development of the GDP is the growth rate of GDP or GNP. The score of the economic development on the basis of GDP or GNP does not reflect all aspects of the economic development of the countries. So you can get that China, India, and other countries with large population are the most developed countries in the world. Taking into consideration the GDP as a reflection on GDP per capita, more realistic picture of economic power countries can be obtained. The literature often takes into account the unemployment rate and the volume of trade with foreign countries and, more often, the amount of investment (World Bank, IMF, CIA The World Factbook).

In assessing the level of economic development of countries and regions in this paper, the following criteria are defined: population, GDP, GDP per capita, and unemployment rate.

See Table 1 in the Appendix

2. Fuzzy Model

Fuzzy sets are sets whose elements have degrees of membership. In classical set theory, the membership of elements in a set is assessed in binary terms according to a bivalent condition—an element either belongs or does not belong to the set. By contrast, fuzzy set theory permits the gradual assessment of the membership of elements in a set; this is described with the aid of a membership function valued in the real unit interval [0, 1].

Qiao, Keren, and Mannan (2009) believe that the core technique of fuzzy logic is based on three basic concepts: (1) fuzzy set: unlike crisp sets, a fuzzy set has a smooth boundary, that is, the elements of the fuzzy set can be partly within the set. Membership functions are employed to provide gradual transition from regions completely outside a set to regions completely in the set; (2) linguistic variables: variables that are qualitatively and quantitatively described by a fuzzy set. Similar to a conventional set, a fuzzy set can describe the value of a variable; (3) fuzzy "if-then" rules: a scheme describing a functional mapping or a logic formula that generalizes an implication of two-valued logic. The main feature of the application of fuzzy "if-then" rules is its capability to perform inference under partial matching. It computes the degree the input data match the condition of a rule. This matching degree is combined with the consequence of the rule to form a conclusion inferred by the fuzzy rule.

2.1 Defining Fuzzy Variable

In the model for the evaluation of the level of economic development, there are defined fuzzy output variable A and fuzzy input variables (criteria) B, C, D, and E.

Fuzzy output variable A evaluates the level of economic development in countries where there is uncertainty about the dynamics of execution, the number of reform steps taken, the implementation of the defined economic policy, market liberalization, social and political reasons, the willingness of the government structure regarding the implementation of reforms, political changes, and so on. It is assumed that the level of economic development may be "low," "medium," or "high" and the quantification of scores from 0 to 10. There are defined membership functions Eqs. (1), (2), and (3).

$$\mu_{A_{LOW}}(x)=\begin{cases}1 & x\le 0\\ (10-x)/10 & 0\le x\le 10\\ 0 & x\ge 10\end{cases} \tag{1}$$

$$\mu_{A_{MEDIUM}}(x)=\begin{cases}0 & x\le 0\\ x/5 & 0\le x\le 5\\ (10-x)/5 & 5\le x\le 10\\ 0 & x>10\end{cases} \tag{2}$$

$$\mu_{A_{HIGH}}(x)=\begin{cases}0 & x\le 0\\ x/10 & 0\le x\le 10\\ 1 & x\ge 10\end{cases} \tag{3}$$

Membership functions to fuzzy sets A_{LOW}, A_{MEDIUM} and A_{HIGH} are shown in Figure 1.

See Figure 1 in the Appendix.

Fuzzy input variable B describes the number of inhabitants. It is assumed that the population can be "small" (SP), "medium" (MP), or "large" (LP). There are defined membership functions Eqs. (4), (5), and (6).

$$\mu_{B_{SP}}(x)=\begin{cases}1 & x\le 0\\ (50-x)/50 & 0\le x\le 50\\ 0 & x\ge 50\end{cases} \tag{4}$$

$$\mu_{B_{MP}}(x)=\begin{cases}0 & x\le 0\\ x/20 & 0\le x\le 20\\ 1 & 20\le x\le 30\\ (50-x)/20 & 30\le x\le 50\\ 0 & x\ge 50\end{cases} \tag{5}$$

$$\mu_{B_{LP}}(x)=\begin{cases}0 & x\le 0\\ x/50 & 0\le x\le 50\\ 1 & x\ge 50\end{cases} \tag{6}$$

Membership functions to fuzzy sets B_{SP}, B_{MP}, and B_{LP} are shown in Figure 2.

See Figure 2 in the Appendix.

Fuzzy variable C describes the GDP. According to the great dispersion of the size of GDP, between "poor" and "rich," between "big" and "small" countries, and so on, it was assumed that GDP will be "very low" (VL), "low" (LO), "medium" (ME), "high" (HI), or "very high" (VH). There are defined membership functions Eqs. (7), (8), (9), (10), and (11).

$$\mu_{C_{VL}}(x)=\begin{cases}1 & x\le 50000\\ (100000-x)/50000 & 50000\le x\le 100000\\ 0 & x\ge 100000\end{cases} \quad (7)$$

$$\mu_{C_{LO}}(x)=\begin{cases}0 & x\le 0\\ x/100000 & 0\le x\le 100000\\ (200000-x)/100000 & 100000\le x\le 200000\\ 0 & x\ge 200000\end{cases} \quad (8)$$

$$\mu_{C_{ME}}(x)=\begin{cases}0 & x\le 100000\\ (x-100000)/100000 & 100000\le x\le 200000\\ 1 & 200000\le x\le 500000\\ (600000-x)/100000 & 500000\le x\le 600000\\ 0 & x\ge 600000\end{cases} \quad (9)$$

$$\mu_{C_{HI}}(x)=\begin{cases}0 & x\le 500000\\ (x-500000)/100000 & 500000\le x\le 600000\\ 1 & 600000\le x\le 900000\\ (1000000-x)/100000 & 900000\le x\le 1000000\\ 0 & x\ge 1000000\end{cases} \quad (10)$$

$$\mu_{C_{VH}}(x)=\begin{cases}0 & x\le 900000\\ (x-900000)/100000 & 900000\le x\le 1000000\\ 1 & x\ge 1000000\end{cases} \quad (11)$$

Membership functions to fuzzy sets C_{VL}, C_{LO}, C_{ME}, C_{HI}, and C_{VH} are shown in Figure 3.

See Figure 3 in the Appendix.

Fuzzy variable D describes the criterion of GDP per capita. It is assumed that the GDP per capita can be "low (LPC)," "medium (MPC)," or high (HPC). There are defined membership functions Eqs. (12), (13), and (14).

$$\mu_{D_{LPC}}(x)=\begin{cases}1 & x\le 0\\ (30000-x)/30000 & 0\le x\le 30000\\ 0 & x\ge 30000\end{cases} \quad (12)$$

$$\mu_{D_{MPC}}(x)=\begin{cases}0 & x\le 0\\ x/15000 & 0\le x\le 15000\\ (30000-x)/30000 & 15000\le x\le 30000\\ 0 & x\ge 30000\end{cases} \quad (13)$$

$$\mu_{D_{HPC}}(x)=\begin{cases} 0 & x\le 0 \\ x/30000 & 0\le x\le 30000 \\ 1 & x\ge 30000 \end{cases} \tag{14}$$

Membership functions to fuzzy sets D_{LPC}, D_{MPC}, and D_{HPC} are shown in Figure 4.

See Figure 4 in the Appendix.

The unemployment rate is represented by fuzzy variable E. It is assumed that there is "low (LUR), medium (MUR), or high (HUR) unemployment rate." There are defined membership functions Eqs. (15), (16), and (17).

$$\mu_{E_{LUR}}(x)=\begin{cases} 1 & x\le 0 \\ (20-x)/20 & 0\le x\le 20 \\ 0 & x\ge 20 \end{cases} \tag{15}$$

$$\mu_{E_{MUR}}(x)=\begin{cases} 0 & x\le 0 \\ x/10 & 0\le x\le 10 \\ (20-x)/10 & 10\le x\le 20 \\ 0 & x\ge 20 \end{cases} \tag{16}$$

$$\mu_{E_{HUR}}(x)=\begin{cases} 0 & x\le 0 \\ x/20 & 0\le x\le 20 \\ 1 & x\ge 20 \end{cases} \tag{17}$$

Membership functions to fuzzy sets E_{LUR}, E_{MUR}, and E_{HUR} are shown in Figure 5.

See Figure 5 in the Appendix.

2.2 Fuzzy Logic

Fuzzy logic is the base of fuzzy system. It enables making decisions based on incomplete information, and models based on fuzzy logic consisted of the so-called "if-then" rules. "If-then" rules are interconnected with "else" or "and."

Fuzzy logic is defined using algorithms for approximate reasoning. When we assume that $x = [x_1, x_2, \dots, x_n]$ is a vector of features describing any object or state and $y = [y_1, y_2, \dots, y_m]$ is the vector of output values of a system, the rules are represented in the following form:

$$\begin{aligned} &R^r : IF\ x_1\ is\ A_1^r\ AND\ x_2\ is\ A_2^r\ AND \dots AND\ x_n\ is\ A_n^r \\ &THEN\ y_1\ is\ B_1^r, y_2\ is\ B_2^r, \dots, y_m\ is\ B_m^r \end{aligned} \tag{18}$$

where $x\in X = X_1\times X_2\times\cdots\times X_n$, $y\in Y=Y_1\times Y_2\times\cdots\times Y_m$ and $A^r = A_1^r\times A_2^r\times\cdots\times A_n^r\subseteq X$, $B^r = B_1^r\times B_2^r\times\cdots\times B_n^r\subseteq Y$ are the fuzzy sets.

The special significance of fuzzy logic is in the possibility of its application for modeling complex systems in which the correlation of certain variables that exist in the model is very difficult to determine. Possible rules are with weight 1, and the less possible with weight 0.5.

See Algorithms for Approximate Reasoning in the Appendix.

3. Model Test Results

The incoming variables in fuzzy systems represent the so-called linguistic variables. The outcome is given in a continual phase. An adequate level of belonging is determined for all possible outcome sums of variables. Fuzzy set $\tilde{A}$, can define the set U as a set of ordered pairs:

$$\tilde{A} = \left\{ \left(x, \mu_{\tilde{A}}(x) \right) \middle| \, x \in U \right\} \tag{19}$$

where $\mu_{\tilde{A}}(x)$ is the so-called membership function or the characteristic Ã function, and it represents the *grade of membership* of the element x to the fuzzy set Ã, that is, $\mu_{\tilde{A}} : U \to M$, where M is usually adopted for the unit interval [0,1].

After being observed, the levels of belonging of a particular outcome sums of variables are to be made by defuzzification.

Defuzzification is the process of producing a quantifiable result in fuzzy logic, given fuzzy sets and corresponding membership degrees. It is typically needed in fuzzy control systems. These will have a number of rules that transform a number of variables into a fuzzy result, that is, the result is described in terms of membership in fuzzy sets. The authors decided to use the center of area method, defuzzification, and Mamdani fuzzy inference systems.

Werner Van Leekwijck and Etienne E. Kerre (1999) consider that the best known defuzzification operator is the center of gravity defuzzification method (COG). It is the basic general deffuzification method that computes the center of gravity of the area under the membership function. The value x^* of the output, which is resulting from the COG method, is given in the following equation:

$$x^* = \sum_{i=x_{\min}}^{x_{\max}} x_i \cdot \mu(x_i) \Bigg/ \sum_{i=x_{\min}}^{x_{\max}} \mu(x_i) \tag{20}$$

where the $\mu(x_i)$ is a membership function. The formula shows that COG calculates the expected value when A is considered to be probability distribution.

Assessment results of the size of the countries in randomly selected sample are shown in Figure 6.

See Figure 6 in the Appendix.

To estimate the validity of the proposed model, sensitivity analysis is carried out, by changing the shape functions belonging to fuzzy sets of input and output variables and with changing methods of operators for the following cases: (i) Membership functions has triangular shape and trapezoidal numbers, as defined in point 2.1 of this paper; the method used for "prod" (product of array elements) for the "AND" operator and the method "probor" (Probably "OR") for the "OR" operator; (ii) Gaussian curve built-in membership function (gaussmf). The results are shown in the Figure 7.

See Figure 7 in the Appendix.

Defined test cases for the fuzzy models (a and b) obtained by the evaluation are the same or with negligible differences (Figure 7). This indicates that the proposed fuzzy model for assessing the level of economic development gives valid results.

Comparative review of the results of evaluation of economic development of the countries according to the World Economic Forum 2009 and the proposed fuzzy model in this paper is given in Table 2. World Economic Forum (2009) has performed only the ranking and not the classification of countries as "low," "medium," or "high" level. Based on their place in the overall ranking, a classification of the development of the countries is assumed. As can be seen from Table 2, a large difference in the classification cannot be seen.

See Table 2 in the Appendix.

The difference appears in the classification of Italy and the Netherlands and a small difference in the classification of Bulgaria (on the border between "low" and "medium").

4. Conclusion

The economic globalization, which is constantly growing, is making the interdependence of the countries around the world and seeks to unite the various world economy integrated into the global economy. In this process, a very important procedure is the evaluation of the "similarity" of the economic development of countries.

The evaluation of the level of economic development of countries and regions is a very common process that runs in the theory and practice. In general, it is based on statistical analysis of the height or the growth rate of the following elements: GDP, GDP per capita, the size of the unemployment rate, and so on. In the final form, the result of the evaluation of the economic development is the grading of whether a country or region is "developed" or "underdeveloped."

This paper presents a new way of modeling and evaluating the level of economic development of countries and regions on the basis of its parameters (population, GDP, GDP per capita, and unemployment rate) by applying the theory of fuzzy sets, which allows solving the problems including uncertainty, subjectivity, ambiguity, and uncertainty. There are four defined fuzzy inputs and one output fuzzy variable. With the testing, an evaluation of the level of economic development of the country was conducted, which was based on randomly selected sample of EU member states and aspirants.

The model for the evaluation of the level of economic development, with certain modifications on the rules and values of variables, can be applied to other economic sectors such as the assessment of market liberalization or its certain elements: telecommunication, transport, agriculture, and so on, as well as in the evaluation of reforms of judicial system approaching the EU, EU compliance in various areas of reform, and so on.

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Appendix

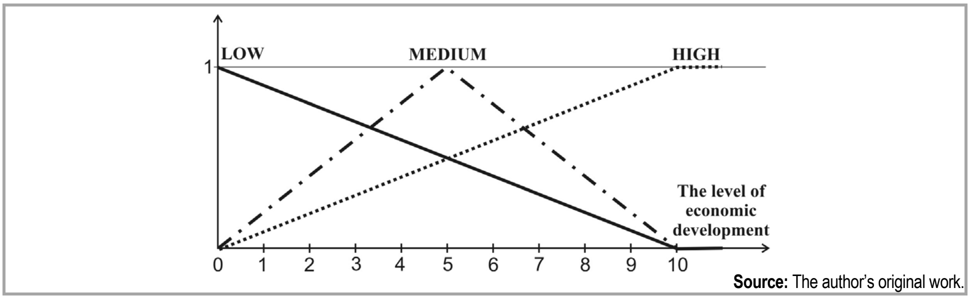


Figure 1 Membership Functions to Fuzzy Sets: A_{LOW}, A_{MEDIUM}, and A_{HIGH}

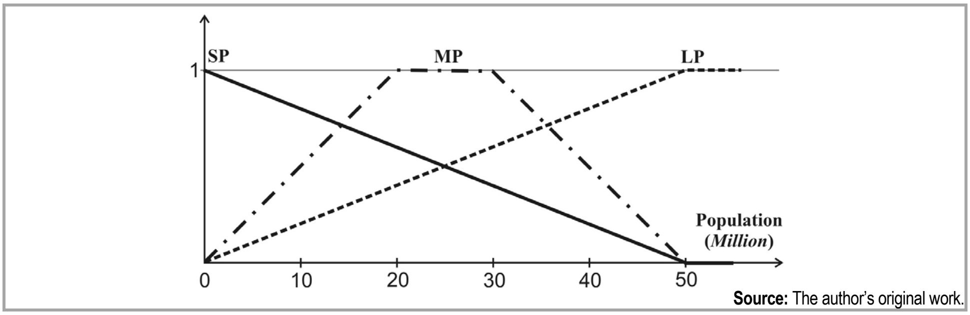


Figure 2 Membership Functions to Fuzzy Sets: B_{SP}, B_{MP}, and B_{LP}

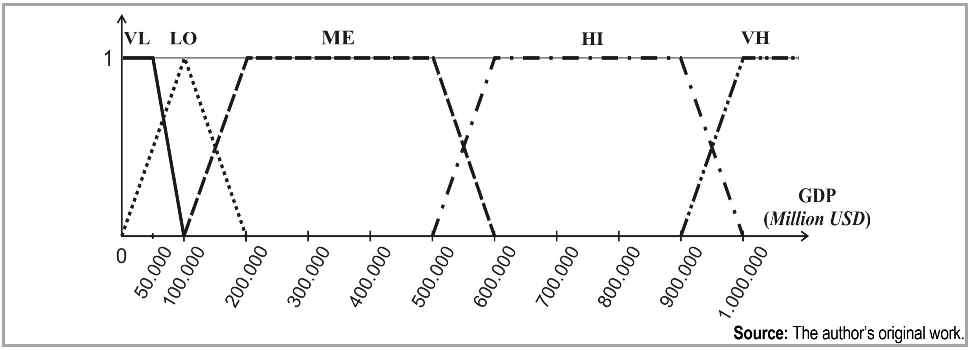
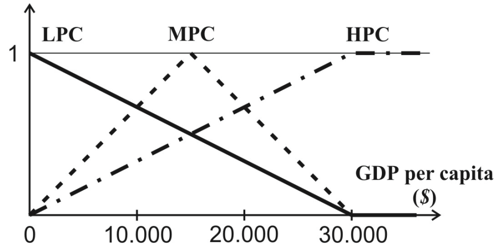
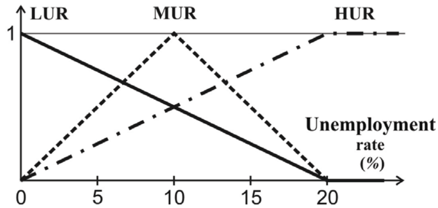


Figure 3 Membership Functions to Fuzzy Sets C_{VL}, C_{LO}, C_{ME}, C_{HI}, and C_{VH}



Source: The author's original work.

Figure 4 Membership Functions to Fuzzy Sets: D_{LPC}, D_{MPC}, and D_{HPC}



Source: The author's original work.

Figure 5 Membership Functions to Fuzzy Sets: E_{LUR}, E_{MUR}, and E_{HUR}

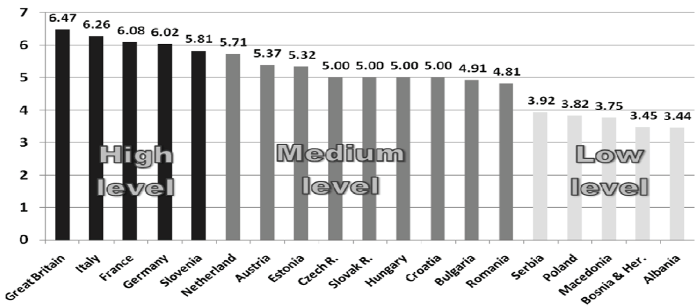


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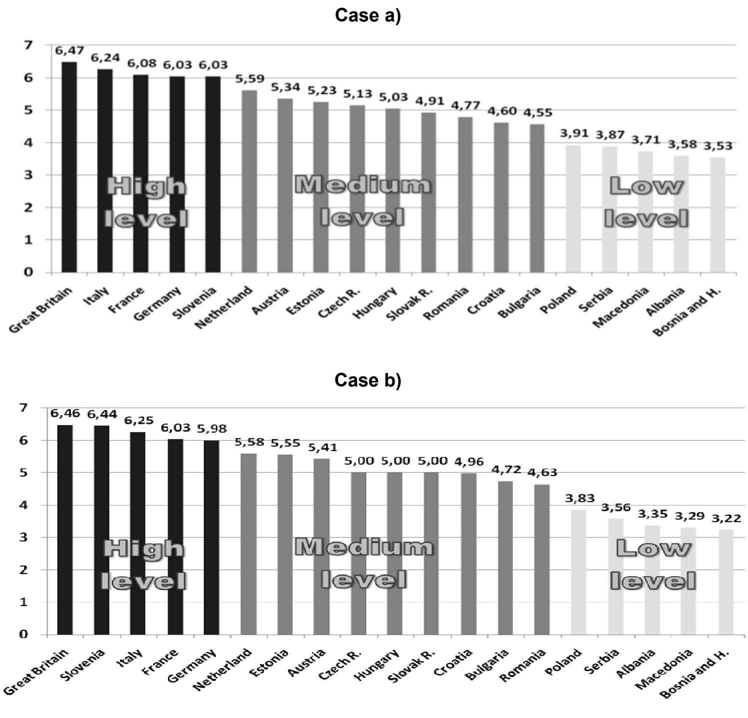
Figure 6 Grade of the Level of Economic Development of Selected Countries



Source: The author's original work.

Figure 7 Sensitivity Analysis

Table 1 Average Values of the Input Criteria for Year 2004-2008

State	Population (*Million*)	GDP (*Million $*)	GDP per capita (*$*)	Unemployment rate *(%)*
Germany	82.00	2,501,000	32,000	9.8
France	65.00	1,830,200	31,000	8.9
Great Britain	58.90	1,873,000	33,180	5.1
Italy	59.90	1,667,800	29,620	7.4
Netherland	16.50	518,940	35,340	5.4
Poland	38.10	509,340	14,460	15.1
Austria	8.30	274,040	35,660	4.4
Czech R.	10.50	197,780	21,500	8.1
Romania	21.50	191,320	9,760	4.9
Hungary	10.00	163,380	17,540	7.1
Slovak R.	5.38	88,146	17,800	10.3
Croatia	4.50	55,976	13,720	14.8
Slovenia	2.05	43,886	24,400	7.7
Bulgaria	7.60	69,982	10,420	9.6
Serbia	7.40	36,140	7,080	23.8
Estonia	1.34	22,640	18,000	7.4
Bosnia and H.	3.90	26,776	6,240	41.0
Albania	3.60	18,326	5,300	13.7
Macedonia	2.10	15,586	7,920	36.3

Source: Adapted from CIA World Factbook.

Table 2 Comparative Review of Countries Assessment of the Economic Development

World Economic Forum 2009		Fuzzy model	
Country	Evaluate	Country	Evaluate
Germany	5.46	UK	6.47
Netherland	5.41	Italy	6.26
UK	5.30	France	6.08
France	5.22	Germany	6.02
Austria	5.20		
		Slovenia	5.81
Estonia	4.67	Netherland	5.71
Czech R.	4.62	Austria	5.37
Slovenia	4.50	Estonia	5.32
Slovak R.	4.40	Czech R.	5.00
Italy	4.35	Slovak R.	5.00
Poland	4.28	Hungary	5.00
Croatia	4.22	Croatia	5.00
Hungary	4.22	Bulgaria	4.91
Romania	4.10	Romania	4.81
Bulgaria	4.03	Serbia	3.92
Serbia	3.90	Poland	3.82
Macedonia	3.87	Macedonia	3.75
Bosnia and Herzegovina	3.56	Bosnia and Herzegovina	3.45
Albania	3.55	Albania	3.44

Source: The author's original work and World Economic Forum (2009).

Algorithms for Approximate Reasoning

I. SMALL Population:

1. If (GDP is VL, LO, or ME) and (per capita is LPC) and (unemployment rate is ANY), then (the level of economic development is LOW)—weight: (1).
2. If (GDP is VL, LO, or ME) and (per capita is MPC) and (unemployment rate is LUR or MUR), then (the level of economic development is MEDIUM)—weight: (1).
3. If (GDP is VL, LO, or ME) and (per capita is MPC) and (unemployment rate is HUR), then (the level of economic development is LOW)—weight: (1).
4. If (GDP is VL, LO, or ME) and (per capita is HPC) and (unemployment rate is LUR or MUR), then (the level of economic development is HIGH)—weight: (1).
5. If (GDP is VL, LO or ME) and (per capita is HPC) and (unemployment rate is HUR), then (the level of economic development is MEDIUM) —weight: (0.5).
6. If (GDP is HI or VH) and (per capita is ANY) and (unemployment rate is ANY), then (the level of economic development is LOW)—weight: (0).
7. If (GDP is HI or VH) and (per capita is ANY) and (unemployment rate is ANY), then (the level of economic development is MEDIUM)—weight: (0).
8. If (GDP is HI or VH) and (per capita is ANY) and (unemployment rate is ANY), then (the level of economic development is HIGH)—weight: (0).

II. MEDIUM Population:

1. If (GDP is VL) and (per capita is ANY) and (unemployment rate is ANY), then (the level of economic development is LOW)—weight: (0).
2. If (GDP is VL) and (per capita is ANY) and (unemployment rate is ANY), then (the level of economic development is MEDIUM)—weight: (0).
3. If (GDP is VL) and (per capita is ANY) and (unemployment rate is ANY), then (the level of economic development is HIGH)—weight: (0).
4. If (GDP is LO, ME, or HI) and (per capita is LPC) and (unemployment rate is ANY), then (the level of economic development is LOW)—weight: (1).
5. If (GDP is LO, ME, or HI) and (per capita is MPC) and (unemployment rate is LUR), then (the level of economic development is MEDIUM)—weight: (1).
6. If (GDP is LO, ME, or HI) and (per capita is MPC) and (unemployment rate is MUR), then (the level of economic development is MEDIUM)—weight: (0.5).
7. If (GDP is LO, ME, or HI) and (per capita is MPC) and (unemployment rate is HUR), then (the level of economic development is LOW)—weight: (1).
8. If (GDP is LO, ME, or HI) and (per capita is HPC) and (unemployment rate is LUR), then (the level of economic development is HIGH)—weight: (1).
9. If (GDP is LO, ME, or HI) and (per capita is HPC) and (unemployment rate is MUR), then (the level of economic development is HIGH)—weight: (0.5).
10. If (GDP is LO, ME, or HI) and (per capita is HPC) and (unemployment rate is HUR), then (the level of economic development is MEDIUM)—weight: (0.5).
11. If (GDP is VH) and (per capita is ANY) and (unemployment rate is ANY), then (the level of economic development is LOW)—weight: (0).
12. If (GDP is VH) and (per capita is ANY) and (unemployment rate is ANY), then (the level of economic development is MEDIUM)—weight: (0).
13. If (GDP is VH) and (per capita is ANY) and (unemployment rate is ANY), then (the level of economic development is HIGH)—weight: (0).

III. HIGH Population:

1. If (GDP is VL or LO) and (per capita is ANY) and (unemployment rate is ANY), then (the level of economic development is LOW)—weight: (0).
2. If (GDP is VL or LO) and (per capita is ANY) and (unemployment rate is ANY), then (the level of economic development is MEDIUM)—weight: (0).
3. If (GDP is VL or LO) and (per capita is ANY) and (unemployment rate is ANY), then (the level of economic development is HIGH)—weight: (0).

4. If (GDP is ME, HI, or VH) and (per capita is LPC) and (unemployment rate is ANY), then (the level of economic development is LOW)—weight: (1).
5. If (GDP is ME, HI, or VH) and (per capita is MPC) and (unemployment rate is LUR), then (the level of economic development is MEDIUM)—weight: (1).
6. If (GDP is ME, HI, or VH) and (per capita is MPC) and (unemployment rate is MUR), then (the level of economic development is MEDIUM)—weight: (0.5).
7. If (GDP is ME, HI, or VH) and (per capita is MPC) and (unemployment rate is HUR), then (the level of economic development is LOW)—weight: (1).
8. If (GDP is ME, HI, or VH) and (per capita is HPC) and (unemployment rate is LUR), then (the level of economic development is HIGH)—weight: (1).
9. If (GDP is ME, HI, or VH) and (per capita is HPC) and (unemployment rate is MUR), then (the level of economic development is HIGH)—weight: (0.5).
10. If (GDP is ME, HI, or VH) and (per capita is HPC) and (unemployment rate is HUR), then (the level of economic development is MEDIUM)—weight: (0.5).