A FUZZY LOGIC BASED DECISION SUPPORT SYSTEM FOR QUANTITATIVE ASSESSMENT OF INBOUND TOURISM IMPACT

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Tourism is one of the leading sectors of the economy, both world and regional. But not always a high level of tourism has a positive impact on the country's economic performance. Factors such as rising prices for transport, food and housing; environmental pollution, and so on, are negative effects of tourism. Therefore, the problem of quantifying the impact of tourism on the development of territories is urgent. According to the classification of the United Nations Word Tourism Organization (UNWTO) [1] in relation to a certain territory the following forms of tourism are determined: domestic tourism, which comprises the activities of residents within the country; inbound tourism which comprises non-resident activities within the country; outbound tourism which comprises activities of residents outside their domestic country. But that is inbound tourism that is a factor that not only provides the inflow of currency, but also is a component of international integration and infrastructure development.

Fuzzy logic is now widely used in decision-making and expert systems, because it simulates the thinking process of humans [2]. As inputs in [3], the data published in the Travel and Tourism Competitiveness Report 2017 were used. This report is published by the UNWTO every two years. At the end of 2019, a new version of the report became available [4]. The purpose of this study is to analyze the changes in the quantitative indicators of inbound tourism impact that have occurred over the past 2 years in selected countries.

As a fuzzy inference system, we will consider the Mamdani algorithm [5], which consists of 4 stages: fuzzification, development of fuzzy rule base, fuzzy logical inference, defuzzification.

As input parameters we will take: x_1 is a number of arrivals to the country; x_2: average revenue from one arrival; x_3: percentage of employment in the travel and tourism industry of the total number of employed. Each of the input variables will be evaluated by fuzzy terms: α_{11} = "small number of arrivals", α_{12} = "middle number of arrivals", α_{13} = "high number of arrivals"; α_{21} = "small revenue per arrival", α_{22} = "middle revenue per arrival", α_{23} = "high revenue per arrival"; α_{31} = " small rate of employment", α_{32} = "middle rate of employment ", α_{33} = "high rate of employment".

Fuzzification will be carried out in the classes of triangular and piecewise linear z- and s-functions. The result of this step is a set of values $\mu_{\alpha_{ip}}(x_i) \in [0,1]$, where $i=\overline{1,3}$ and $p=\overline{1,3}$; $\mu_{\alpha_{ip}}(x_i)$ are the membership functions of the variables x_i to the term α_{ip}.

The rule base was created with the help of experts as follows:

$$R_k\text{: if } \left(x_1 \text{ is } a_{1k_1}\right) \text{and} \ldots \text{ and} \left(x_i \text{ is } a_{ik_i}\right) \text{and} \ldots \text{ and} \left(x_n \text{ is } a_{nk_n}\right) \text{then } y \text{ is } \beta_r,$$

where $i=1,3$, $r=1,3$, α_{ik_i} is a term, to evaluate the variable x_i in the *k*-th row. The total number of rules in the rule base is $k=n^m$.

Aggregation of preconditions for each rule is performed using the min operation, i.e.:

$$\lambda_k = \mu_{a_{1k_1}}(x_1) \wedge \ldots \wedge \mu_{a_{ik_i}}(x_i) \wedge \ldots \wedge \mu_{a_{nk_n}}(x_n) = \min\left\{\mu_{\alpha_{ik_i}}(x_i)\right\}.$$

Fuzzy implication is carried out as taking a minimum:

$$R_k : \gamma_k = \min\left\{\lambda_k, \mu_{\beta_k}(y)\right\}.$$

The resulting output fuzzy set is obtained by aggregation of all consequential parts of the rules:

$$\mu_\Sigma(y) = \vee\gamma_k = \max\{\gamma_k\} = \max\min\left\{\lambda_k, \mu_{\beta_k}(y)\right\}.$$

Defuzzification or obtaining a crisp number is performed using the center of gravity method:

$$y' = \frac{\int_\Omega y\mu_\Sigma(y)\,dy}{\int_\Omega \mu_\Sigma(y)\,dy},$$

where Ω is a domain of definition of output y'.

A qualitative assessment of the level of inbound tourism impact can be obtained on the basis of the Harrington scale [3].

To implement this decision support system, a Windows application was developed in C# programming language. Table 1 contains the input data collected from [4] and the obtained outputs.

Table 1

Inputs and Outputs of the System for Certain Countries

	France	**The USA**	**Spain**	**China**	**Italy**	**Poland**	**Bulgaria**	**Ukraine**
x_1, m	86.9	76.9	81.9	60.7	58.3	18.3	8.9	14.2
x_2, $	698.1	2739	832	537	759.3	699.5	455.4	88.16
x_3,%	4.6	3.7	5	2.8	6.6	2	2.9	1.3
y'	7.58	7.9	7.6	4.6	5	5	3.76	2.2

Comparing the outputs with the ones for 2017 year [3], we found out that the impact of inbound tourism on the economies of Ukraine, Bulgaria, Poland and Spain has improved, while for the USA, China and Italy the outcome is opposite.

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ДІАГНОСТИКА БАНКРУТСТВА ТА ПРОГНОЗУВАННЯ ФІНАНСОВОГО СТАНУ ПІДПРИЄМСТВА

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В умовах загострення фінансової кризи в Україні та світі ряд підприємств стає неплатоспроможними, що може призвести до їх банкрутства. Система фінансового менеджменту на підприємстві повинна оперативно реагувати на будь-які зміни в його діяльності.