OPTIMISATION OF A TRAVEL AGENCY'S PRODUCT PORTFOLIO USING A FUZZY RULE-BASED SYSTEM

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Abstract: *This paper focusses on the use of a fuzzy rule-based system for the tourism area, specifically, the optimisation of production for companies operating in the tourism industry. Many travel agencies and other travel companies operate in the current market, and they not only need to win customers, but also retain them. It is necessary to include everything from the cheapest trip alternatives to expensive luxury destinations, and the best in the respective price ranges must be chosen. In this study, the fuzzy rule-based system was used to evaluate the indefinite information in tourism, which is often difficult to quantify, whether this relates to the sociopolitical situation at the destination, weather or satisfaction with the accommodation services. A correct selection of products can be complicated by the fact that consumers in tourism may intend to both satisfy the same needs and several needs by buying a service. The knowledge base includes the rules for dealing with situations of the different combinations of input criteria to achieve the optimum output. The aim of this work was to design a model for optimising the product portfolios of companies operating in the field of tourism using the fuzzy rule-based system. A further goal was determining the appropriate criteria for performing optimisation.*

Keywords: *Multi-criteria Analysis Options, Expert Systems, Fuzzy Rule-based System, Tourism, Portfolio, Optimisation.*

JEL Classification*: C02, M11, R41.*

Introduction

Tourism is in constant interaction with the external environment, and it is subject to the effects of unfavourable economic development and the political and security situations of the target destinations. Tourists change their requirements according to specific criteria, often choosing holiday destinations closer to home, and their expenditures at their place of residence are declining. Travel agency clients are demanding the highest level of service and maximum satisfaction of their needs for the money they spend. Thus, service providers must continually improve, expand and adapt their offers.

The appropriate selection of products is often complicated, as the consumers may intend to both satisfy the same needs and several needs by buying a tourism service. In practice, this means that even people with different needs may seek the same services (Tangeland et al., 2013).

There are some approaches to decision making that primarily depend on the nature of the issues, time and manager capabilities. The more unique the problem is, the more the results will be affected by uncertainty. Thus, expert systems, which have become essential tools for decision making, are increasingly prominent. Expert systems represent a type of knowledge system based on the experience provided by an expert in the relevant field. The achieved decision making reaches expert-level quality. A characteristic of this is work with uncertain information, wherein categorical conclusions cannot be derived by common methods (Siler & Buckley, 2005). Fuzzy modelling in the area of Balanced Scorecard was described by Pokorný, Keprt and Menšik (2013), who expressed customer satisfaction key performance indicators (KPIs) as vague fuzzy numbers and explained the usefulness of managerial decision making. Moreover, Sohrabi et al. (2012), p. 96, used fuzzy logic for the following reasons:

> *the selection of the most appropriate hotel entails a rather complicated decision-making process. A comprehensive hotel selection model can empower the hotel managers, the tourists, and the tourism industry to make decisions based on more effective indicators of high quality services for a higher rate of satisfaction.*

This is done using computer programs with artificial intelligence, which are especially useful and necessary in situations that are not sufficiently structured, wherein the classic methods of decision-making support cannot be used (Zimmermann, 1987). Expert systems can be used to diagnose errors, faults or malfunctions (Leondes, 2002). In tourism, they offer travel agencies and tourists the possibility of finding the most appropriate set of services according to the established criteria. To accomplish this, it is first necessary to set the basic attributes that will be used to model the situations. For this reason, fundamental variables need to be specified.

1 Problem statement

As in other sectors, when making choices and decisions in the field of tourism, it is necessary to focus on a wide range of information. Because of this, choosing the right information for decision making is also more difficult.

The present article discusses the optimisation of the product portfolio of a companies that operate in the tourism market. The aim of the work is to use a fuzzy rule-based system to design a multi-criteria model of analysis for decision-making support alternatives that can optimise a travel agency's production.

2 Problem solving

In the case of a travel agency, it is necessary for clients to set up a package of services that will be demanded, sought after and competitive on the market. Given that tourism services are similar, their quality will depend on the choice of a suitable, reliable and stable supplier that will ensure that the travel agency can provide consistent services to clients. If the task is to choose a suitable service provider, the input variables would likely be *price*, *reliability*, *speed and quality of delivery*, and certainly, *the trendiness of the destination*. In the proposed model, a quality supplier will be considered as a standard.

When creating a system, it is first necessary to select the number of input and output variables, their attributes, the membership function, and the number of rule blocks. The input variables are selected according to previous research and statistics. Research has especially focussed on destination popularity, shopping behaviour, the effects of crises on tourism and the trust of travel agency clients; the statistics have considered the traffic of individual tourism destinations.

According to the research carried out by Chang and Chang (2015), of 10 basic attributes studied, 3 had the greatest influence on the decision making of consumers in the tourism domain, namely price/costs, tourist services and information and the safety of tourist destinations. The results of this study suggest that top management should include these attributes at an early stage in the decision-making process related to tourist destinations to achieve maximum efficiency with minimal resources. The UOE and ACTA (2010) research showed that when purchasing a trip, travel agency clients are most often interested in the destination, price, references and quality of hotels and accommodation.

According to Pike (2008), the destination is the basic unit of analysis in tourism, and it forms the pillar of any modelling of the tourism system. In a study by Tkaczynski et al. (2010), the authors recommended a two-step approach to choosing a destination that meets the preferences of all the interested travellers. The first step involves understanding the diversity of those interested and identifying relevant variables for segmentation. The second involves segmentation based on the variables identified in the first step. Compared with the current practices, segments derived from a two-stage segmentation approach capture the characteristics of more of the tourists visiting the area. A segmentation approach can help in identifying popular tourist destinations, maximising limited resources and focussing on more types of tourists.

The Neckermann Travel Agency (2016) stated that Bulgaria, Spain, Greece and Croatia are the bestselling destinations for Europe for the upcoming season. Moreover, eTravel (2016) stated that the premium destinations in terms of safety are Bulgaria, Croatia, Greece, Spain and Italy. According to Invia.cz's (2016) research, the preferences of Czech tourists are constantly changing, mainly due to the unclear sociopolitical situation in the world. Travel agency clients tend to prefer European destinations. Due to terrorist attacks, for example in Turkey or in Egypt, the safety of target destinations has become an important criterion when choosing holidays; hotel complex owners see this shift as a stimulus to raise prices. The most popular current destinations include Greece (especially the islands of Crete, Rhodes, Zakynthos and Corfu), Bulgaria, Croatia, Italy and Spain.

The decision to choose a destination is almost always accompanied by a hotel selection (hotel quality), and it is therefore necessary to understand the correlation between the choice of the destination and the hotel selection. In his work, Pappa (2015) described tourists' views of Crete as a destination. The study focussed on explaining consumers' purchasing behaviour and consumption patterns concerning the destination and hotel choice. Pappa (2015) found that tourist preferences can vary significantly according to gender, age, education and income. The research results also indicated that younger and more informed consumers have a better overview of the destination due to their increased use of information technology. Conversely, older people primarily depend on traditional advertising methods.

Price policy is still crucial for all tourists, regardless of their financial status, and incomes play a significant role when choosing accommodations and additional services. Higher-income clients typically require a higher quality of service (Pappa, 2015).

References – information from tourists who have visited the given destination/hotel in the past – play an important role in choosing a holiday. Bigné et al.'s (2001) research focussed on the relationship between the image of the destination perceived by tourists when selecting a trip and the satisfaction gained from the holiday after it is over. The results pointed to the influence of the quality and satisfaction that tourists perceive, as well as their intention to return and willingness to recommend a destination. Referring to other relationships, it affirmed that quality has a positive influence on satisfaction and intention to return, while satisfaction determines willingness to recommend a destination.

As part of their tourism consumer research, Chen and Chen (2010) summarised the views of 447 respondents, and they employed a structural equation modelling (SEM) technique to evaluate the results. The results showed direct effects of previous experience on perceived quality and satisfaction. Overall, it can be stated that an 'experience with quality–perceived value–satisfaction → towards buying behaviour–intentions' relationship seems to be evident.

According to Bhatia (2012), whether tourists are arriving for a longer holiday or just a short or one-day stay, their needs can be generally summarised. This concerns access to information – it is important to promote access to information before travel (references) and at the destination so that tourists can make the most of their stay. In terms of facilities (e.g. quality of the hotel, accommodations), different types of tourists look for different facility characteristics for travel. To save time, business travellers usually prefer fast check in and checkout capacity at the hotel, electronic tickets or internet availability at the hotel. Young travellers will look for accommodation where it is possible to use various student discounts, and they prefer cheap accommodation and good and cheap food and entertainment. Furthermore, Bhatia (2012) specified the importance of transport services and facilities that are not only suitable, but also safe and reliable, and primarily offer the highest quality for the invested money. According to research by the UOE and ACTA (2010), 57% of tourists check references on the internet, 33% follow their friends' recommendations, 14% trust the travel agency employees, 20% do not check references, and 6% acquire information in a different way.

3 Methods

The fundamentals of the fuzzy logic and fuzzy sets theory, in which "how many" components relate (or do not) relate to a particular set is determined, were created by Lotfi A. Zadeh in the 1960s. Fuzzy logic is often talked about as computing with words (Martínez, Rodriguez, Herrera, 2015; Pal, Polkowski, Skowron, 2004; Zadeh, 1996). Fuzzy sets are suitable for solving tasks with an indefinite nature of input values. Whereas according to the theory of classical sets, an element either belongs or does not belong to a set *(0 or 1)*, and there are therefore only two states. In fuzzy logic, the variable x and its affiliation to a set is labelled $\mu(x)$, and it is defined in the range *0-1*; zero means complete non-membership and one full membership. The use of membership rates corresponds better in some situations than using conventional ways of including members in a set according to presence or absence. Fuzzy logic thus measures the certainty or uncertainty of the element's affiliation to the set. Similarly, a person decides mentally and physically during activities that are not fully algorithmized. Using fuzzy logic, a solution can be found for the given case from the rules that have been defined for similar cases. The Fuzzy method overcomes the limitations of some other methods, accepts indeterminate and missing data, different types of criteria, a dependence of criteria, and complex relationships between these criteria and the overall assessment. The mathematical model is in accordance with the human method of assessing variants. The creation of the system consists of three basic steps: Fuzzification, Fuzzy inference and Defuzzification (Dostál, Rais, Sojka, 2005).

Fuzzification means converting real variables into language variables using about three to seven attributes of the base variable. The level of attribute membership of the variable in the set is expressed by a mathematical function. To each element *u* of the universe *U* is assigned the function of its jurisdiction of the fuzzy set F (Pokorný, 2004 in Volná, 2012):

$$F = \{(\mu_F(u)) / u \in U\} \tag{1}$$

Fuzzy inference defines the behaviour of the system according to certain logical rules of type <IF>, <THEN>, and conditional sentences that evaluate the status of the appropriate variable. The rules of fuzzy logic represent an expert system. Each compound of properties of variables entering the system and occurring under the condition <IF> <THEN> represents one rule. For each rule, it is necessary to determine the weight in the relevant system that can be modified during the system optimization process. The outcome of the fuzzy logic system depends to a large extent on the correct determination of the meaning of the defined rules, Tab. 5. In this paper Mamdani´s fuzzy inference method will be used. For example the first rule, Tab. 5:

$$IF <\kappa 1.D> AND <\kappa 2.L> AND <\kappa 3.N> AND <\kappa 4.L> THEN <out.L> \tag{2}$$

To determine the fuzzy inference method for a knowledge rule block, the input aggregator and the result aggregator must be determined. By default, the MIN operator is for input aggregation and the MAX operator for the result aggregation. Aggregation of inputs is the first step of fuzzy inference and determines to what extent the IF part of the rule is met. Special operators are used for the IF assumptions degree of validity. The aggregation is calculated by Mamdami as follows:

$$\mu_{out}(u) = max\ \{min\ \{\alpha_1, \mu_{\kappa 1}(u)\}, min\ \{\alpha_2, \mu_{\kappa 2}(u)\}, min\ \{\alpha_3, \mu_{\kappa 3}(u)\}, min\ \{\alpha_4, \mu_{\kappa 4}(u)\}\} \tag{3}$$

A completely defined block of knowledge rules requires an operator to be determined for the result of the aggregation. If there is more than one fuzzy rule in the same condition, for the aggregate result, it is necessary to define how to calculate the final result for this condition (over all rules).

The result of fuzzy inference is a language variable. In the case of placement of a product in a portfolio, the attributes may have values such as very low, low, medium, high and very high suitability to include. A degree of affiliation is used to convert the fuzzy output to a sharp value, and this conversion is known as Defuzzification.

Defuzzification converts the result of fuzzy inference realistic values so as to best represent the result of a fuzzy calculation (Dostál, Rais, Sojka 2005). Defuzzification can be done in several ways; in this case, the *Center of Maximum (CoM*) centre of gravity of singletons - was chosen. It replaces the functional dependence of each output term by its typical value, and it determines the sharp output variable as its centre of gravity.

$$u_{out} = \frac{\sum_{i=1}^{n} \alpha_i * u_i}{\sum_{i=1}^{n} \alpha_i} \tag{4}$$

where u_{out} is the resulting value of the output variable, a_i is the value of affiliation of the *i* term and u_i is the coordinates of the output variable of the *i* term (Volná, 2012).

4 Mathematical modelling

To optimise the product portfolio of a travel agency (TA), four input variables and one output variable were selected. Moreover, 17 memberships were assigned (Tab. 1), and 81 rules were defined in one rule block (Tab. 5).

Tab. 1: Description of Input Criteria and Output Criterion

Variable Name IN	Type	Units	Min	Max	Default	Term Names
$\kappa1_{TA}$ Destination		Units	1	10	5.5	decrease steady increase
$\kappa2_{TA}$ Price		CZK	0	30000	15000	low medium high
$\kappa3_{TA}$ References		Units	0	6	3	negative zero positive
$\kappa4_{TA}$ Hotel_quality		Stars	1	5	3	low medium high
Variable Name OUT	**Type**	**Unit**	**Min**	**Max**	**Default**	**Term Names**
SUITABILITY TO INCLUDE		Units	0	100	50	very_low low medium high very_high

Source: (Authors, 2017)

'Destination' $\kappa1_{TA}$ is an aggregated criterion that includes both the popularity of destinations and the security of the destination country. According to the CSO statistics (2015), Neckermann (2016), Invia.cz (2016) and eTravel (2016), the countries that are most preferred for holidays are the individual destinations that are ranked and rated as shown below in the system for optimising the product portfolio (Tab. 2).

Tab. 2: Ratings of destinations

Destination	Units	Destination	Units
Greece	10 b.	Turkey	5 b.
Bulgaria	9 b.	Egypt	4 b.
Croatia	8 b.	Tunisia	3 b.
Spain	7 b.	Canary Islands	2 b.
Italy	6 b.	Cyprus	1 b.

Source: (Authors, 2017)

'Price' $\kappa2_{TA}$ expresses the amount that customers are generally willing to invest in their holidays. A price of up to 8000 CZK is considered low in the system, a price of 15 000 CZK represents the middle range and a price of 22 000 CZK and up is considered high (UOE & ACTA, 2010).

'References' $\kappa3_{TA}$ shows the value of the criterion based on an evaluation of hotels on the publicly accessible portal Holidaycheck.com. The rating scale is set at 0–6 points.

'Hotel Quality' $\kappa4_{TA}$ is derived from the number of stars of the relevant accommodation facility. Hotels are classified into five categories according to multiple parameters. The lowest value is set at 1–3 three stars, and the highest value at 3–5, with the intermediate level set at 3 stars. Two- to 4-star hotels also fall under the intermediate category.

Tab. 3: Important Values for Fuzzification of the Input Variable

Term IN	**Shape**	**DESTINATION Definition Points (x, y)**				
decrease	linear	(1, 1)	(3.25, 1)	(5.5, 0)	(10, 0)	
steady	linear	(1, 0)	(3.25, 0)	(5.5, 1)	(7.75, 0)	(10, 0)
increase	linear	(1, 0)	(5.5, 0)	(7.75, 1)	(10, 1)	
Term IN	**Shape**	**PRICE Definition Points (x, y)**				
low	linear	(0, 1)	(8000, 1)	(15000, 0)	(30000, 0)	
medium	linear	(0, 0)	(8000, 0)	(15000, 1)	(22000, 0)	(30000, 0)
high	linear	(0, 0)	(15000, 0)	(22000, 1)	(30000, 1)	
Term IN	**Shape**	**REFERENCES Definition Points (x, y)**				
negative	linear	(0, 1)	(3, 1)	(4, 0)	(6, 0)	
zero	linear	(0, 0)	(3, 0)	(4, 1)	(5, 0)	(6, 0)
positive	linear	(0, 0)	(4, 0)	(5, 1)	(6, 1)	
Term IN	**Shape**	**HOTEL QUALITY Definition Points (x, y)**				
low	linear	(1, 1)	(2, 1)	(3, 0)	(5, 0)	
medium	linear	(1, 0)	(2, 0)	(3, 1)	(4, 0)	(5, 0)
high	linear	(1, 0)	(3, 0)	(4, 1)	(5, 1)	

Source: (Authors, 2017)

The **'SUITABILITY TO INCLUDE'** output variable can acquire five values (for a more detailed breakdown of the output).

Tab. 4: Important Values for the 'SUITABILITY TO INCLUDE' Output Variable

Term OUT	**Shape**	**SUITABILITY TO INCLUDE Definition Points (x, y)**				
very_low	linear	(0, 0)	(16.666, 1)	(33.334, 0)	(100, 0)	
low	linear	(0, 0)	(16.666, 0)	(33.334, 1)	(50, 0)	(100, 0)
medium	linear	(0, 0)	(33.334, 0)	(50, 1)	(66.666, 0)	(100, 0)
high	linear	(0, 0)	(50, 0)	(66.666, 1)	(83.334, 0)	(100, 0)
very_high	linear	(0, 0)	(66.666, 0)	(83.334, 1)	(100, 0)	

Source: (Authors, 2017)

Tab. 5: Basis of the Knowledge Rules

IF	κ1	κ2	κ3	κ4	DoS	OUT	IF	κ1	κ2	κ3	κ4	DoS	OUT
1	D	L	N	L	1.00	L	42	S	M	Z	H	1.00	M
2	D	L	N	M	1.00	M	43	S	M	P	L	1.00	M
3	D	L	N	H	1.00	M	44	S	M	P	M	1.00	H
4	D	L	Z	L	1.00	M	45	S	M	P	H	1.00	H
5	D	L	Z	M	1.00	M	46	S	H	N	L	1.00	VL
6	D	L	Z	H	1.00	H	47	S	H	N	M	1.00	L
7	D	L	P	L	1.00	H	48	S	H	N	H	1.00	L
8	D	L	P	M	1.00	H	49	S	H	Z	L	1.00	L
9	D	L	P	H	1.00	H	50	S	H	Z	M	1.00	L
10	D	M	N	L	1.00	L	51	S	H	Z	H	1.00	M
11	D	M	N	M	1.00	L	52	S	H	P	L	1.00	M
12	D	M	N	H	1.00	L	53	S	H	P	M	1.00	M
13	D	M	Z	L	1.00	L	54	S	H	P	H	1.00	M
14	D	M	Z	M	1.00	M	55	I	L	N	L	1.00	M
15	D	M	Z	H	1.00	M	56	I	L	N	M	1.00	M
16	D	M	P	L	1.00	M	57	I	L	N	H	1.00	H
17	D	M	P	M	1.00	M	58	I	L	Z	L	1.00	H
18	D	M	P	H	1.00	H	59	I	L	Z	M	1.00	H
19	D	H	N	L	1.00	VL	60	I	L	Z	H	1.00	H
20	D	H	N	M	1.00	VL	61	I	L	P	L	1.00	H
21	D	H	N	H	1.00	L	62	I	L	P	M	1.00	VH
22	D	H	Z	L	1.00	L	63	I	L	P	H	1.00	VH
23	D	H	Z	M	1.00	L	64	I	M	N	L	1.00	L
24	D	H	Z	H	1.00	L	65	I	M	N	M	1.00	M
25	D	H	P	L	1.00	L	66	I	M	N	H	1.00	M
26	D	H	P	M	1.00	M	67	I	M	Z	L	1.00	M
27	D	H	P	H	1.00	M	68	I	M	Z	M	1.00	M
28	S	L	N	L	1.00	M	69	I	M	Z	H	1.00	H
29	S	L	N	M	1.00	M	70	I	M	P	L	1.00	H
30	S	L	N	H	1.00	M	71	I	M	P	M	1.00	H
31	S	L	Z	L	1.00	M	72	I	M	P	H	1.00	H
32	S	L	Z	M	1.00	H	73	I	H	N	L	1.00	L
33	S	L	Z	H	1.00	H	74	I	H	N	M	1.00	L
34	S	L	P	L	1.00	H	75	I	H	N	H	1.00	L
35	S	L	P	M	1.00	H	76	I	H	Z	L	1.00	L
36	S	L	P	H	1.00	VH	77	I	H	Z	M	1.00	M
37	S	M	N	L	1.00	L	78	I	H	Z	H	1.00	M
38	S	M	N	M	1.00	L	79	I	H	P	L	1.00	M
39	S	M	N	H	1.00	M	80	I	H	P	M	1.00	M
40	S	M	Z	L	1.00	M	81	I	H	P	H	1.00	H
41	S	M	Z	M	1.00	M							

Source: (Authors, 2017)

Fig. 1 shows the structure of the fuzzy rule-based system. The connecting lines represent the data flow.

Fig. 1: Structure of the fuzzy rule-based system.

Source: (Authors, 2017)

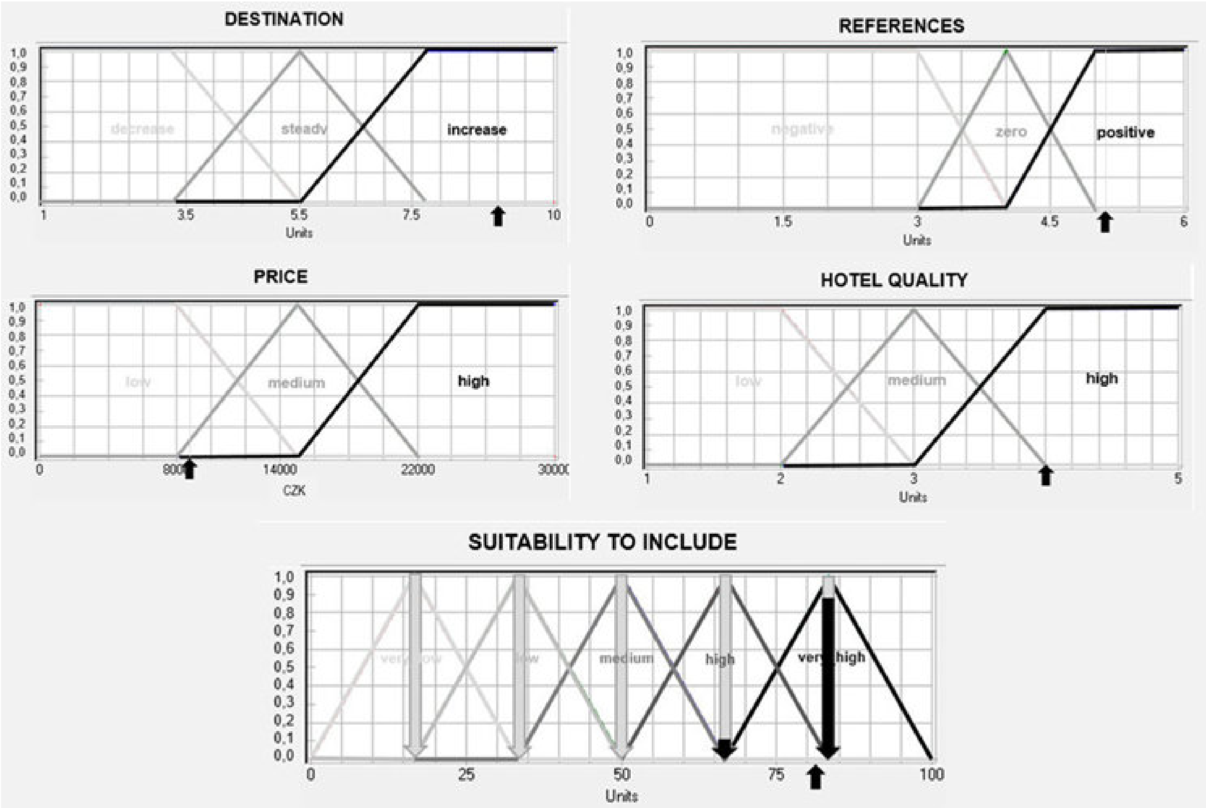
The assembled model can be used to optimise the travel agency's product portfolio. The proposed methodology is verified on a realistic offer of 149 trips. With the help of the system, the offerings of all-inclusive trips in the 'Summer by the Sea' catalogue are optimised. The limit for inclusion in the portfolio is set at 60 points.

5 Discussion

The functionality of the system was tested on a travel agency's product offerings. A total of 149 service packages were entered into the optimisation system. A minimum limit of 60 points was set for inclusion in the service portfolio; here, it is necessary to emphasise the role of the decision maker who sets the limit. The minimum value was not fulfilled by 34 of the included trips (22.8%) out of a total of 149. This consisted of 18 trips out of 35 for the destination of Turkey, 4 out of 56 for Greece, 3 out of 43 for Bulgaria, 3 out of 7 for Croatia, and 6 out of 8 for Spain. Turkey has long been at the top in terms of sales of trips. In most cases, the holiday packages provide accommodation at hotel complexes that offer all additional services. Compared with other destinations, the price/quality ratio is attractive for the customer, and weather stability is also ensured in Turkey. Due to the political situation in recent years, customers are increasingly inclined toward European travel, and Turkey has moved to sixth place in the sale of trips (CSO, 2015; Invia, 2016; eTravel 2016). At present, the destination of Bulgaria is attracting customers due to its good price/quality ratio, putting it in second place as a bestseller (Invia, 2016). A certain disadvantage of this country may be the weather. Within Europe, trips to Spain are in the higher price range, and according to the Invia (2016), Spain occupies the fourth position in sales; customers especially appreciate the high-quality all-inclusive programmes. Since the organising travel agency is only able to influence the price from among the set criteria (destination, price, references, hotel quality), a price is proposed for each trip that has not reached the minimum limit to achieve the required 60 points for inclusion in the portfolio.

The highest value of 81.690 points for SUITABILITY TO INCLUDE in the portfolio was achieved by the trip to Hotel Glarus Beach in Bulgaria (destination: 9, price: 8690 CZK, references: 5.1, hotel quality: 4). This trip falls into the high and very high segments of the output Suitability to Include, as evident from Fig. 2.

Fig. 2: Suitability to include for Hotel Glarus Beach.



Source: (Authors, 2017)

Conclusion

Currently, given the world's unstable political and security situation, including in some tourist destinations, it is important for travel agents to monitor the situation carefully. They must respond quickly to any changes that and always have 'spare stock' solutions ready for clients.

The aim of this work was to use a fuzzy rule-based system to design a model for optimisation of a product portfolio in tourism. The model was designed according to the criteria that are the most important for travel agency clients and had emerged from previous research. It was found that the choice of destination is important for customers, as well as the costs associated with the holiday; they focus on the price, quality of the services provided, hotel quality and previous experience (i.e. references and information). Based on these preferences, the product portfolio of some travel agencies that have been operating in the Czech market was optimised. The suitability for inclusion in the portfolio was rated for trips to individual destinations, and the assembled model can be used to support decision making. Due to the variability of the designed system, it can represent an important means of resolving decision-making situations.

The fuzzy logic method can be used in a variety of contexts, but it is important to emphasise the role of the decision maker, who must correctly choose the relevant input criteria and knowledge rule base, according to which, the system evaluates the suitability of the output. Further research presents the opportunity to create a similar model for the direct selection of the trip by the tour operator's or travel agency's end customer.

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