Original Scientific Paper

doi:10.5937/jaes15-13399 Paper number: 15(2017)3, 439, 258 - 271

A FUZZY LOGIC-BASED MODEL FOR ANALYSIS AND EVALUATION OF SERVICES IN A MANUFACTURING COMPANY

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In an increasingly competitive market, companies must look for new ways to gain competitive advantage. One of these ways is the provision of services. This article presents a multicriteria model for analysis and evaluation of services in a manufacturing company. We divided the services that the manufacturing company can offer to its customers into pre-sales, sales and after-sales services. In the second phase we developed a specific model for the furniture industry. The model was tested with information obtained in a survey by eight kitchen manufacturers from four European countries and was applied to determine the level of services offered. Results have shown that the model can be a useful tool when evaluating the competitiveness of individual manufacturing companies in terms of service provision. Based on the results, companies can develop their business strategies to meet the needs and expectations of potential customers from this perspective as well.

Key words: Manufacturing company, Customer, Services, Service economy, Product

INTRODUCTION

In developed market economies, the service industry is already generating approximately three quarters of gross domestic product and employing about two thirds of the working population. Analysts (Buera & Kaboski, 2012; Grönroos & Ojasalo, 2004; Gummesson, 1998, 2014; Hoekman & Mattoo, 2012; Jones, 1988) predict that the ratio between the manufacturing and the service industry will continue to change in favor of the latter.

Services are usually performed and used at the same time, changing quickly, transient and cannot be stored. For this reason, many authors (Brady & Cronin, 2001; Cronin Jr & Taylor, 1992; Gummesson, 1991; McLaughlin & Coffey, 1990; Muyeed, 2012; Sahay, 2005; Schembri & Sandberg, 2002; Zeithaml, 2000) believe that it is extremely difficult to determine and monitor service quality. We cannot measure it precisely and the sole criterion of quality is customer satisfaction with the service, which is closely linked to customer expectations (Santouridis & Trivellas, 2010). One of the attempts to measure customer satisfaction by multiple indicators is with various customer satisfaction indexes (Ahn & Sohn, 2009; Johnson et al., 2001; Nabavi et al., 2014; Sun & Kim, 2013). The quality of service changes depending on where, when and by whom it is carried out. To maintain or gain new customers, each manufacturing company must complement its product range with service activities. In recent years, it has become increasingly clear that companies that do not include good services in marketing their products cannot strengthen their competitive position on the markets. Companies that do not offer services and companies with poor services eventually lose even the most loyal customers (Ahn & Sohn, 2009; Brax, 2005; Murali et al., 2016b).

Many authors (Ahmad & Butt, 2012; Alzola & Robaina, 2010; Godley, 2013; Kasper & Lemmink, 1989; Posselt & Gerstner, 2005) divide services into pre-sales services and after-sales services, but the best way to nail customer service is to

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think of the customers' experience before, during and after their purchase. So, services that can be provided by a manufacturing company to customers can be divided into pre-sales services, sales services and after-sales services. Marketers need to develop a set of services that will support the products sold by the company in such a way that they will satisfy the customers better than the competitors. Good pre-sales services, sales services and after-sales services are the key to customer retention. Consumers will not make a repeat purchase or continue with a company's services if they have a bad experience.

If a manufacturing company wants to be successful in the field of services offered, it must establish a system for performance monitoring. This means that the company regularly reviews and evaluates its services and the services of its competitors. These assessments can be quantitative or qualitative. Quantitative advantages can be easily measured. Qualitative benefits of services relate mainly to the quality of the service performed, rated by customers according to their expectations, and the actual results of the services. Quality of service can thus be defined as the difference between the expected and the actual service, as perceived by the customer. It is essential to emphasize that customer expectations vary, but in general, the level of service quality expected by customers is constantly increasing.

The aim of this study is to develop a new model that will enable the measurement of performed services. It should enable the incorporation of qualitative and quantitative information, measurable and unmeasurable data, and tangible and intangible opinions, experiences and judgments of customers and experts. There are numerous multicriteria decision methods that are widely used as part of decision support systems (Chai et al., 2013; Ho et al., 2010; Pezdevšek Malovrh et al., 2016; Zavadskas & Turskis, 2011). We decided to build a model on the mathematical foundations of fuzzy sets that support the integration of imprecise information about real-world complex problems in a consistent way (Ratnayake, 2014).

The paper is organized as follows. In Section 2 a literature review of existing models for service evaluation is carried out and a new model is developed. Then a brief introduction to applied methods, namely the analytic hierarchy process and fuzzy logic approach, and an overview of literature employing these two concepts are provided in Section 3. In Section 4 the general model is adopted for the furniture industry. Section 4 presents the results of the evaluation of eight kitchen manufacturers from four European countries and offers a discussion on the model and the results. In Section 6 some conclusions are drawn.

MODEL DEVELOPMENT

The growth of the service economy presents great challenges for manufacturing companies. The increased importance of service industries has stimulated interest in productivity measures for this sector of the economy. There are numerous options for measuring the performance of services used by a company to determine what bothers the customers and what could be improved, such as a book of comments and complaints, customer surveys, covert or comparison shopping for services and similar activities. However, none of these activities explicitly show how successful the company is when offering service activities. Service companies must develop creative ways to fund their distinctive advantages. To create a successful service offering, managers need to determine which attributes to target for excellence and which to target for inferior performance. These choices should be heavily informed by the needs of customers. Managers should discover the relative importance customers place on attributes and then match the investment in excellence with those priorities (Frei, 2008).

There are several attempts in literature to develop a model for measuring services, especially after-sales services. Fuzzy clustering and the association rule was applied by Ahn and Sohn (2009) to identify customer groups and the importance of after-sales services for them. Multiple regression analysis was used by Murali et al. (2016b) in the analysis of the influence of after-sales services on customer satisfaction, customer retention and customer loyalty. Gaiardelli et al. (2007) proposed an integrated framework based on indicators of customer satisfaction and metrics evaluation of several activities for the after-sales network performance measurement in automotive companies. Several authors performed statistical studies to investigate whether after-sales service quality has an impact on customer satisfaction (Fazlzadeh et al., 2011; Murali et al., 2016a; Rigopoulou et al., 2008; Shaharudrn et al., 2009; Shahrouzifard & Faraji, 2016). Qualitative and quantitative analysis in after-sales services using quality function deployment was carried out by Pakdil et al. (2012). However, the results of the literature review show that there is no model that incorporates the measurement of the whole spectrum of pre-sales, sales and after-sales services.

The aim of this study was to develop a general model that would enable companies to review and analyze this segment of business. We consider fuzzy and multicriteria decision methods to assess the performance of companies' services as a good foundation for such a model. In this study we proposed a four-stage model for the evaluation of companies' services that is based on fuzzy logic and the analytic hierarchy process (Figure 1).

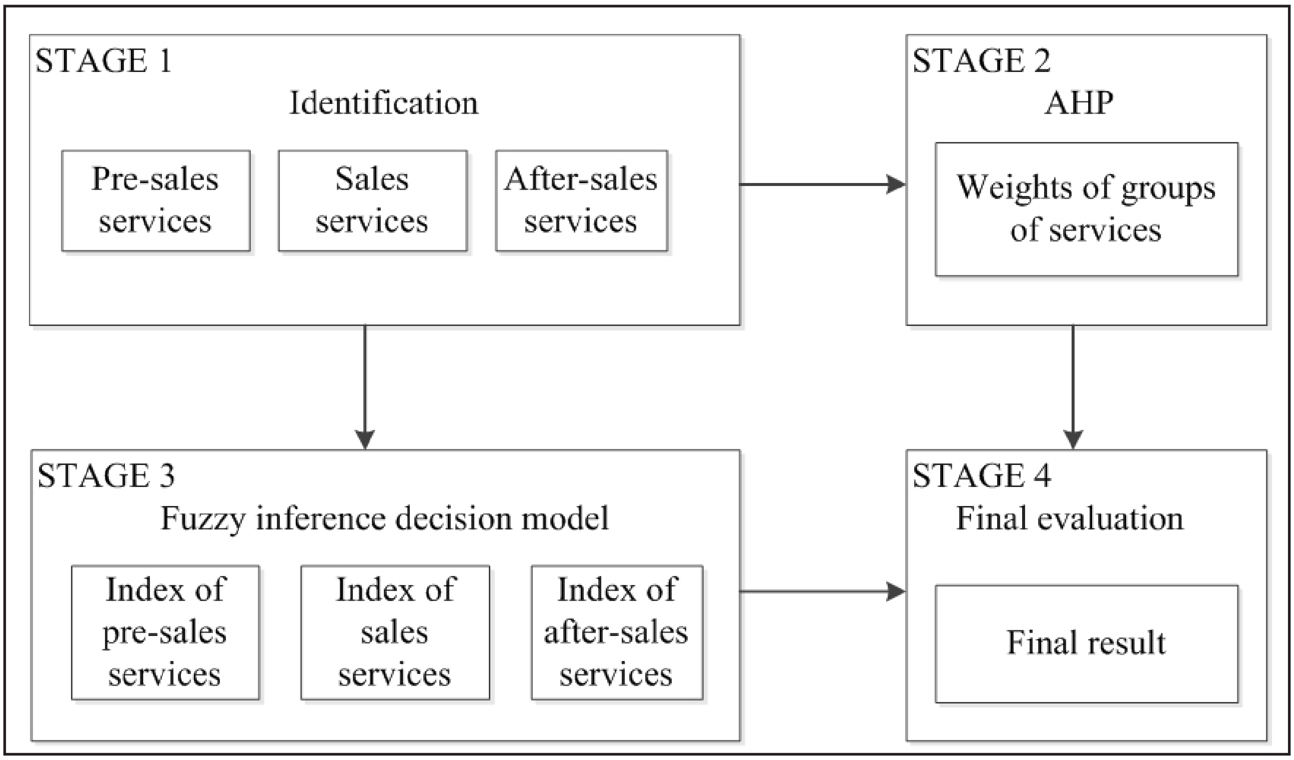

Figure 1: A four-stage model for service evaluation

In the first stage, pre-sales services, sales services and after-sales services should be identified. Pre-sales services are a set of activities normally carried out before a customer is acquired. They can offer extra content or merchandise that would normally be of a high price for free, thereby increasing the perceived value of this product. Sales services are services that the company carries out during the consumer buying decision process. They relate mainly to the payment facilities offered by the company to customers. After-sales services consist, among other things, of delivery, warranty, technical advice, product upgrading, repair and spare parts delivery (Ahn & Sohn, 2009; Saccani et al., 2006).

In the second stage, the importance of groups of services should be determined. We selected the analytic hierarchy process (AHP) to perform this task. AHP is a widely used hierarchical multicriteria methodology for prioritizing alternatives that enables comparisons of quantitative and qualitative elements (Saaty & Vargas, 2007). In the third stage, a fuzzy logic inference decision system (FIS) is applied to evaluate each group of services separately. FIS enables the modeling of complex and uncertain systems with soft data and imprecise information (Gharibi et al., 2012; Zadeh, 1965). The results of the third stage are indexes of all three groups of services. In the final stage, the results of AHP and the fuzzy model are aggregated into the final evaluation of services.

The presented model is sufficiently universal that it can be applied in many areas of sales. It enables the inclusion of only one or two groups of services instead of all three in the model. In stage two, any other group method for ranking objects can be employed. We suggested the AHP method as we believe that AHP is one of the most suitable methods for preference analysis of a group of objects. It enables the comparison of pairs of objects rather than ranking the entire group simultaneously. Measurable and unmeasurable objects can be compared. The method has strong mathematical and psychological foundations (Ananda & Herath, 2003; Saaty & Ozdemir, 2003). In stage three, we employed FIS as it is suitable for modeling the human thinking process and can handle uncertainties, impreciseness and vagueness of data and judgments in complex real-world systems (Afrinaldi & Zhang, 2014; Nilashi et al., 2015). Nevertheless, any other multicriteria method for evaluation can be applied in stage three.

To demonstrate the employability of the developed model we adapted it to the furniture industry and presented it in Section 4. But first we revise the basis of AHP and FIS in the next section.

METHODS

AHP

To define the importance of groups of services the analytic hierarchy process (AHP) (Saaty, 1980) is applied in this study. AHP has also been used in numerous applications in supplier and vendor selection (Koul & Verma, 2011; Luzon & El-Sayegh, 2016; Noorul Haq & Kannan, 2006; Yadav & Sharma, 2015). In AHP, the objects are pairwise compared using a 1–9 AHP scale and comparison matrix A of n compared objects is constructed:

$$A = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ \frac{1}{a_{12}} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{1}{a_{1n}} & \frac{1}{a_{2n}} & \cdots & 1 \end{bmatrix} \quad 1)$$

The weights, , of compared objects are derived from comparison matrix A by the eigenvector method:

$$Aw = \lambda_{\max} w \ , \quad 2)$$

with as the principal eigenvalue of comparison matrix A. The consistency of comparisons is measured by the consistency ratio CR,

$$CR = \frac{\lambda_{\max} - n}{(n-1)RI} \quad 3)$$

where denotes a random index. According to Saaty (2006), is considered acceptable. The geometric mean (Saaty & Peniwati, 2008) is applied to aggregate individual judgments into group judgments.

A FUZZY LOGIC APPROACH

Fuzzy logic was first introduced by Zadeh (1965). FIS has been used in many applications since then. It has been applied in

- environmental models including:
  - waste management (Vesely et al., 2016)
  - forecasting air quality (Carbajal-Hernández et al., 2012a; Fisher, 2006; Sowlat et al., 2011)
  - water quality (Carbajal-Hernández et al., 2012b; Che Osmi et al., 2016; Gharibi et al., 2012; Ocampo-Duque et al., 2006)
- models for performing risk assessment (Camastra et al., 2015; Jamshidi et al., 2013; Rodríguez et al., 2016)
- in the field of manufacturing and sales for supporting customers' requirements (Juang et al., 2007)
- forecasting automobile sales (Wang et al., 2011)
- stock price prediction (Chang & Liu, 2008)
- supplier selection (Lima Junior et al., 2013)
- measuring customer satisfaction (Zani et al., 2013).

Similarly to our model, FIS has been applied in models for evaluating the performance level of several fields (Nadali et al., 2011; Nilashi et al., 2015). A combination of AHP and FIS has also been employed in several applications (Carreño et al., 2011; Donevska et al., 2011; Nilashi et al., 2015; Rodríguez et al., 2016).

A fuzzy logic inference system is a process from a given input of empirical values to an output including three main parts (Carbajal-Hernández et al., 2012b; Jamshidi et al., 2013; Ocampo-Duque et al., 2006; Ross, 2004): (1) membership functions; (2) fuzzy set operations; (3) IF-THEN inference rules. A Mamdani-type inference system (Mamdani & Assilian, 1975) is used in our model because of the more intuitive and human-like nature of its rules compared to other types (Che Osmi et al., 2016; Kovac et al., 2012).

A fuzzy set A is defined as a set of ordered pairs:

$$A = \{(x, \mu_A(x)) | x \in X\}, \ \mu_A(x) : \mathrm{X} \to [0,1], \quad 4)$$

where is a membership function of x in A and X is the universe of discourse. The element x can only partly belong to the fuzzy set A. The grade of membership in fuzzy set A is determined by the value of the membership function. Membership functions can have different shapes such as triangular, trapezoidal or Gaussian. Linear membership functions are easier to use and provide good performance (Carbajal-Hernández et al., 2012b). For the purpose of this study, trapezoidal membership functions (Figure 2) are selected and presented as:

$$\mu(x;a,b,c,d) = \min\left\{\frac{x-a}{b-a}, 1, \frac{d-x}{d-c}\right\} \quad 5)$$

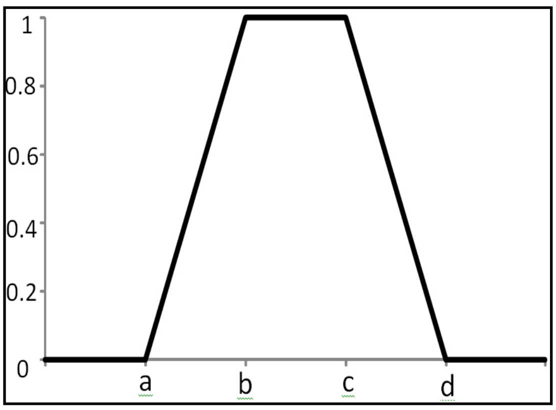

Figure 2: Trapezoidal membership function of fuzzy set

In the fuzzification process empirical data of inputs are transformed into linguistic variables of fuzzy sets. The membership functions are used to associate a grade with each linguistic term. The second part of fuzzy inference systems is IF-THEN rules. The basic fuzzy operations that are used in the antecedent (IF part) and the consequent (THEN part) parts of rules are intersection (AND)

$$\mu_{A \cap B}(x) = \mu_A(x) \cap \mu_B(x) = \min(\mu_A(x), \mu_B(x)) \quad 6)$$

union (OR)

$$\mu_{A \cup B}(x) = \mu_A(x) \cup \mu_B(x) = \max(\mu_A(x), \mu_B(x)) \quad 7)$$

and negation (NOT) (Ross, 2004)

$$\mu_{\bar{A}}(x) = 1 - \mu_A(x) . \quad 8)$$

The general form of inference rules is given as:

$$\text{IF } P \text{ is } p, \text{ THEN } Q \text{ is } q, \quad 9)$$

where p and q are linguistic terms for linguistic variables P and Q, respectively. The fuzzy operator AND is applied in the IF part if it consist of n parts.

$$\text{IF } (P_1 \text{ is } p_1 \text{ AND } P_2 \text{ is } p_2 \text{ AND } \ldots \text{ AND } P_n \text{ is } p_n)$$
$$\text{THEN } Q \text{ is } q, \quad 10)$$

where are linguistic terms for linguistic variables , respectively. Max–min composition, as one of the most commonly used in the Mamdani inference model (Jamshidi et al., 2013; Monjezi & Rezaei, 2011; Ross, 2004), is applied:

$$\mu_C(\mathrm{z}) = \max\left(\min\left(\mu_A(x), \mu_B(\mathrm{y})\right)\right) \quad 11)$$

where μ_C, μ_A, μ_B are membership functions of output z and inputs x and y, respectively. Finally, the defuzzification process is used to transform fuzzy sets into crisp value. There are several suitable methods in the literature (Gharibi et al., 2012; Ross, 2004). We selected the center of maximum technique, which is one of the most frequently used (Joss et al., 2008; Pathak et al., 2005; Ross, 2004). The crisp output is computed as weighted mean of the term membership center points, weighted by the inference results:

$$x^* = \frac{\sum_{k=1}^{n} x_k \mu_{C_k}(x)}{\sum_{k=1}^{n} \mu_{C_k}(x)} \qquad 12)$$

where is defuzzified output, , k=1,…,n are aggregated membership functions and , k=1,…,n are output variables (centers of the area).

FUZZY MODEL OF FURNITURE INDUSTRY

In this section we adopt the general four-stage model for the furniture industry, specifically for kitchen manufacturers. The main purpose of the model is to evaluate the performance level of companies regarding their services associated with sales. Many companies offer a variety of services related to wood. Even companies that are engaged in furniture manufacturing have the option of including various service activities in their offer when marketing their products. This way, they can gain a decisive advantage over their competitors.

To develop the model, in the first stage pre-sales, sales and after-sales services should first be identified. If a wood company has an effective service network, the kitchen buyer will wait for a shorter period of time for its transport and installation – time is a measurable value.

We decided to include the three most often offered pre-sales services in the furniture industry in the model: measurement at home, expert advice and design (3D drawing). Measuring for furniture is certainly high on buyers' list. When measuring the room for new furniture it is not enough to simply measure the size of the room, as windows, fireplaces and doorways should also be taken into account, since these features will influence the placement of the furniture, so expert advice given by someone who has studied a subject thoroughly or who is very skilled at a particular job can be very important. The same can be said for design (3D drawing). All three services can be free or the customer may have to pay fixed percentages of the purchase price. This is also the way that we measured them in the model.

Three sales services that we included in the model are cash discount, interest-free credit and installment sale. A cash discount is an incentive that a seller offers to a buyer in return for paying a bill owed before the scheduled due date. The seller will usually reduce the amount owed by the buyer by a small percentage. Interest-free credit is a credit or loan where no interest is paid by the borrower. Installment sale is a transaction in which the sales price is paid in two or more installments over months or years. In the model, cash discount is measured in percentages, interest-free credit in percentages of the interest rate and installment sale in number of installments.

When buying furniture, customers are often interested in the possibility of delivery and assembly of purchased products, which could be characterized as the most important after-sales services in furniture industry and were, as such, incorporated into the model. We can find many different offers for home delivery of furniture on the market. Some companies offer free delivery of purchased furniture, other companies offer free delivery in a certain area, some companies offer delivery with the price determined by the distance from the store, while some companies simply do not offer such services. Differences between sellers can be found even in furniture delivery to apartments – some sellers offer free delivery to the apartment, while others offer free delivery only to lower floors of apartment buildings and charge for the service otherwise. Similarly, differences between sellers can be found in regard to furniture assembly. Assembling furniture can be a complex and time-consuming process, whether it's a kitchen, cupboard, desk or bookshelf. Unassembled furniture can be difficult to construct, with an assortment of parts, screws, bolts and washers that can be hard to assemble properly. The price the seller offers for furniture assembly is very important. Because of the vast diversity in the offers for these two after-sales services we divided furniture assembly and delivery into two subcategories: free (usually above a fixed amount, measured in euros, where fewer euros signifies a better result) and invoiced (measured in percentages of purchase price). In addition, we added warranty, which is measured in years, to the after-sales services in our model. A warranty is an agreement between the seller and the buyer of furniture to provide repair or replacement for covered components of the product for some specified time period.

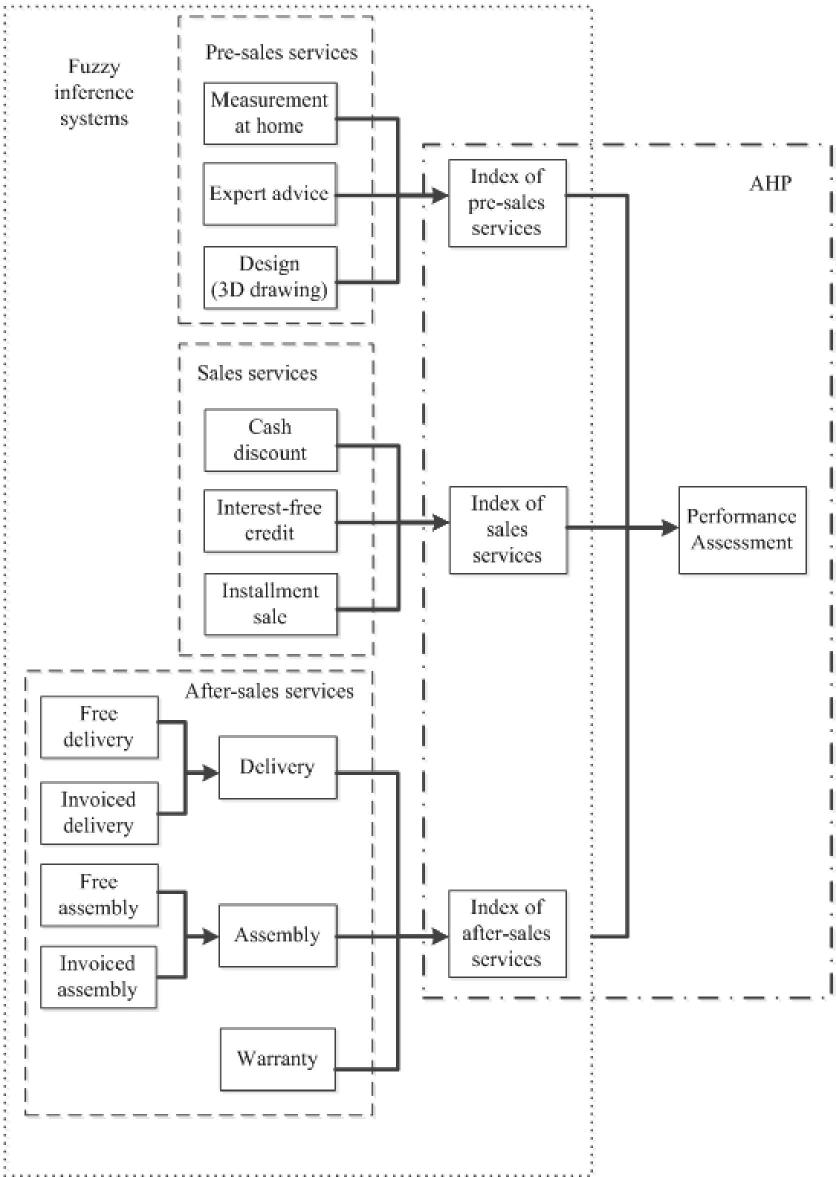

Figure 3: Decision tree of the model for a furniture manufacturing company

The final list of services that can be provided by a furniture manufacturing company to customers and the decision tree of the developed model are presented in Figure 3.

In the second stage, the AHP method was used to compare pre-sales, sales and after-sales services. Twelve marketing experts (managers and academics) from several European countries (Slovenia, Croatia, Poland, Slovakia, Serbia and Macedonia) were selected. The AHP Excel template (Goepel, 2013) was used to perform calculations.

In the third stage, three fuzzy inference systems were built. Their results are indexes of all three groups of services. The first linguistic terms and their membership functions for all services were developed. Usually "the best values" of parameters of membership functions do not exist and a heuristic approach can be used to set the parameters (Fisher, 2006; Tron & Margaliot, 2004; Vesely et al., 2016). We defined parameters on the basis of expert knowledge, experience and judgments. We tested similar values of parameters and performed sensitive analysis until we decided that the model's performance was acceptable. Table 1 presents parameters of membership functions in the fuzzy inference system.

Table 1: Parameters of membership functions in the fuzzy inference system

Services	Units	poor				good				very good				excellent		
		a	b	c	d	a	b	c	d	a	b	c	d	a	b	c = d
Measurement at home	%	2.5	3	5	5	1	1.5	2.5	3	0	0	1	1.5			
Expert advice	%	2.5	3	5	5	1	1.5	2.5	3	0	0	1	1.5			
Design (3D drawing)	%	2.5	3	5	5	1	1.5	2.5	3	0	0	1	1.5			
Cash discount	%	0	0	1	2	1	2	4	5	4	5	7	8	7	8	20
Interest-free credit	%	5	7	15	15	1	3	poor	7	0	0	1	3			
Installment sale	number of installments	0	0	3	9	3	9	18	24	18	24	48	48			
Delivery	-	0	0	1	3	1	3	4	6	4	6	7	9	7	9	20
Free delivery	euros	5000	5000	2500	2000	2500	2000	1000	500	1000	500	0	0			
Invoiced delivery	%	25	25	12	8	12	8	6	2	6	2	0	0			
Furniture assembly	-	0	0	1	3	1	3	4	6	4	6	7	9	7	9	10
Free assembly	euros	5000	5000	2500	2000	2500	2000	1000	500	1000	500	0	0			
Invoiced assembly	%	25	25	12	8	12	8	6	2	6	2	0	0			
Warranty	years	0	0	1	2	1	2	3	5	3	5	10	10			
Pre-sales services	-	0	0	10	30	10	30	40	60	40	60	70	90	70	90	100
Sales services	-	0	0	10	30	10	30	40	60	40	60	70	90	70	90	100
After-sales services	-	0	0	10	30	10	30	40	60	40	60	70	90	70	90	100

Then inference IF-THEN rules were defined. Table 2 presents IF-THEN rules for pre-sales services. The remaining IF-THEN rules were similarly defined.

Table 2: IF-THEN rules for pre-sales activities

IF part			THEN part
Measurement at home	Expert advice	Design (3D drawing)	Pre-sales services
poor	poor	poor	poor
poor	poor	good	poor
poor	poor	very good	poor
poor	good	poor	poor
poor	good	good	good
poor	good	very good	good
poor	very good	poor	poor
poor	very good	good	good
poor	very good	very good	very good
good	poor	poor	poor
good	poor	good	good
good	poor	very good	good
good	good	poor	good
good	good	good	good
good	good	very good	very good
good	very good	poor	good
good	very good	good	very good
good	very good	very good	excelent
very good	poor	poor	poor
very good	poor	good	good
very good	poor	very good	very good
very good	good	poor	good
very good	good	good	very good
very good	good	very good	excellent
very good	very good	poor	very good
very good	very good	good	excellent
very good	very good	very good	excellent

Finally, parameters for the center of maxima were selected regarding membership functions of groups of services:

$$x^* = \frac{5 \cdot \mu_{poor}(x) + 35 \cdot \mu_{good}(x) + 65 \cdot \mu_{verygood}(x) + 95 \cdot \mu_{excellent}(x)}{\mu_{poor}(x) + \mu_{good}(x) + \mu_{verygood}(x) + \mu_{excellent}(x)} \qquad 13)$$

The result of falls into the interval and should be normalized (Carbajal-Hernández et al., 2012b) using expression (14) so that the final index takes values in the interval [0,100].

$$I = 100 \cdot \frac{x^* - 5}{95 - 5} \qquad 14)$$

Eight kitchen manufacturers from four European countries (Slovenia (SI1, SI2), Croatia (HR1, HR2), Poland (PL1, PL2) and Slovakia (SK1, SK2)) were selected for model evaluation. The services that they provide are presented in Table 3. The dashes in Table 3 denote that the company does not offer that service. We included this information as the worst possibility in the model.

Table 3: The inputs for the fuzzy inference system of eight furniture companies

	SI1	SI2	HR1	HR2	PL1	PL2	SK1	SK2
Measurement at home	0%	0%	0%	3%	2%	0%	0%	2%
Expert advice	0%	0%	0%	0%	0%	0%	0%	0%
Design (3D drawing)	0%	0%	0%	0%	2%	0%	-	0%
Cash discount	2%	5%	5%	3%	2%	7%	10%	5%
Interest - free credit	-	-	-	2%	1.5%	0%	1%	-
Installment sale	6	-	6	12	12	48	18	-
Free delivery	1200	3000	3000	0	1500	5000	1500	1500
Invoiced delivery	10%	5%	5%	0%	5%	2%	10%	10%
Free assembly	1200	3000	3000	0	0	1500	1500	1500
Invoiced assembly	10%	5%	15%	0%	0%	5%	15%	-
Warranty	3	4	4	3	5	5	3	5

RESULTS AND DISCUSSION

The results of the model are presented in Table 4. Weights of AHP comparison of groups of services in sales are written in column 2. The indexes for all groups of services for eight kitchen manufacturers, which are the results of FIS, are listed in columns 3 to 10. Aggregated results of both methods (final indexes) and the ranking of the kitchen manufacturers are presented in lines 5 and 6.

Table 4: Weights of AHP comparison of groups of services, indexes of all groups of services for all companies, final index of services for all companies and their ranking

	AHP weights	SI1	SI2	HR1	HR2	PL1	PL2	SK1	SK2
Pre-sales services	0.392	100.0	100.0	100.0	66.7	66.7	100.0	66.7	100.0
Sales services	0.121	16.7	0.0	16.7	50.0	58.3	100.0	100.0	0.0
After-sales services	0.487	16.7	11.1	11.1	100.0	75.0	41.7	16.7	16.7
Final index of services		**49.3**	**44.6**	**46.6**	**80.9**	**69.7**	**71.6**	**46.4**	**47.3**
Ranks		4	8	6	1	3	2	7	5

By using the AHP method we got the weights for groups of services. Table 4 shows that, according to experts, the most important (AHP weight of 0.487) are after-sales services (delivery, furniture assembly and warranty), slightly less important (AHP weight of 0.392) are pre-sales services (measurement at home, expert advice and 3D drawing) and the least important (AHP weight of 0.121) are sales services (paying benefits).

Analysis of eight companies showed that selected companies offer relatively good pre-sales services. Five of the eight analyzed companies in the light of these services reached the maximum index. Companies have achieved much worse ratings in terms of sales and after-sales services. Only one company (HR2) reached the maximum score in terms of after-sales services, while all the others achieved very low ratings. Due to the low ratings of after-sales services, the final indexes of services are rather low. The highest final index of services (HR2) was 80.8 and the lowest (SI2) was 44.6.

The results indicate that the model can show companies a general evaluation of each group of their services. The company can compare performances between groups of its services. It can also compare its results with other competitive companies. Such a comparison can give the company a good starting point for improving its services. From the results, the company can see which services it should emphasize to gain the largest benefit. AHP weights have a significant influence on the final ranking so they should be carefully performed. The model is also very appropriate for ranking the evaluated companies as it can perceive small differences between the evaluations. In conclusion, we can say that the model is suitable for determining the quality of services in furniture manufacturing companies and with small modifications it could also be used for assessment services in enterprises from other industries.

CONCLUSIONS

In the paper we presented a model that allows us to evaluate and analyze individual furniture manufacturing companies in terms of service provision. The model we developed is based on two methods, namely the method of multicriteria decision-making, AHP, and a fuzzy logic inference decision system. In a specific model for furniture companies all services that are important for potential customers were included in the decision tree. Then we determined parameters of membership functions and defined rules of decision (IF–THEN), which represent all needed data for FIS. We obtained the information for model testing from eight kitchen manufacturers from four European countries. It turned out that by using the model, we can accurately determine the performance of manufacturing companies in terms of service provision. At the same time, the model enables analysis of individual services. This means that it can also be used as a tool for strategy formulation for service activities in the company. The general model is not only usable in the furniture industry, but can be used in other industries as well. In future work, analysis of services regarding different groups of customers (Ahn & Sohn, 2009) and sensitivity analysis of parameters in the model could be carried out.

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Paper sent to revision: 08.03.2017.

Paper ready for publication: 26.07.2017.