FUZZY SETS
&
FUZZY LOGIC

MC-432

Application of Fuzzy Logic in Micro Economics

Analysis of Customer Services using Mamdani FIS

PROJECT REPORT

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Problem Statement

In an increasingly competitive market, companies must look for new ways to gain competitive advantage. One of these ways is the provision of **services**. Efficient *pre-sales* services, *sales* services and *after-sales* services are the key to customer retention. Many surveys and researches conducted in cities have confirmed that companies that meets the all-round service requirements of the customers results in long lasting relationship and hence the market size.

The **aim of this project** is to develop a model that will enable the measurement of performed services.

We have *analysed* the services delivered in Furniture market using *Mamdani Fuzzy Interface System*. The manufacturer can look into pre-sales, sales and after-sales services. We chose 4 furniture retail shops for our analysis.

In our Model, we have considered 9 parameters (services) that determines the over all customer satisfaction with services. On the basis of our analysis we have ranked the sample Shops. These results could be used in general retail stores in Indian market with required modification to boost their market size.

Motivation for the Study

In our daily life we find ourselves surrounded by tons of catchy ads. The presence of many 3rd party services and various articles on business expansions cultivated our curiosity towards services.

Introduction

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

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
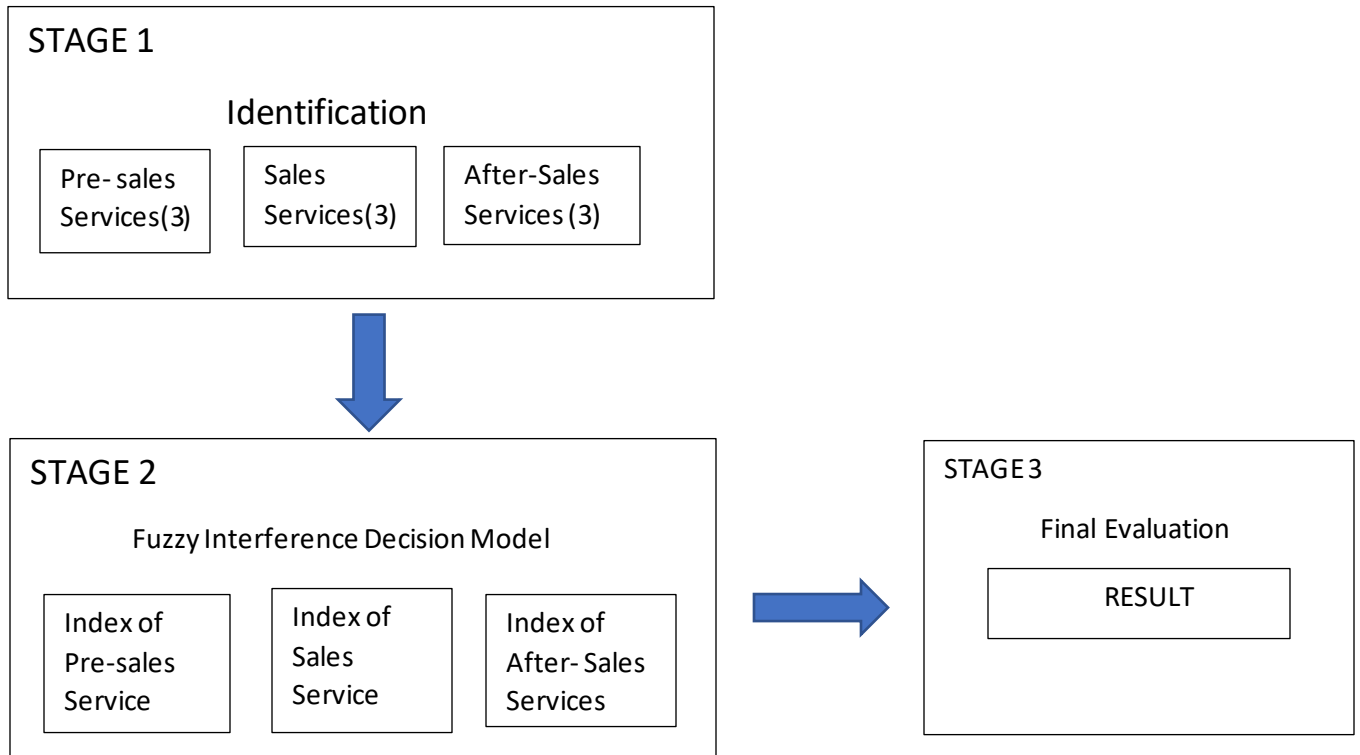
There are numerous options for measuring the performance of services used by a company to determine what bothers the customers and what could be improved, such as a book of comments and complaints, customer surveys, covert or comparison shopping for services and similar activities. However, none of these activities explicitly show how successful the company is when offering service activities. Service companies must develop creative ways to fund their distinctive advantages.

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 , 439 Leon Oblak - A fuzzy logic-based model for analysis and evaluation of services in a manufacturing company Journal of Applied Engineering Science 15(2017)3 260 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)

Earlier studies have been performed separately on pre- sale, sales and after – sales. Through this project our attempt is to inculcate the whole spectrum of pre-sales, sales and after-sales.

Methodology

STAGE 1

Identification

Pre-sales Services(3)	Sales Services(3)	After-Sales Services (3)

↓

STAGE 2

Fuzzy Interference Decision Model

Index of Pre-sales Service	Index of Sales Service	Index of After-Sales Services

→

STAGE 3

Final Evaluation

RESULT

[3 Stage model for service evaluation]

Fig1

Pre- Sales

Measurement at Home
Expert Advice
Design (3D)

Sales

Cash Discount
Interest - free Credit
Instalment Sale

After - Sales

Invoiced Delivery
Assembly
Waranty

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.

In the **Second Stage**, a fuzzy logic inference decision system (FIS) is applied to evaluate each group of services separately. FIS enables the modelling of complex and uncertain systems with soft data and imprecise information.

A FUZZY LOGIC APPROACH

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

A fuzzy logic inference system is a process from a given input of empirical values to an output including three main parts:

(1) membership functions; (2) fuzzy set operations; (3) IF-THEN inference rules. A Mamdani-type inference system is used in our model because of the more intuitive and human-like nature of its rules compared to other types.

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

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

For the purpose of this study, **trapezoidal membership functions** (Figure 2) are selected and presented as

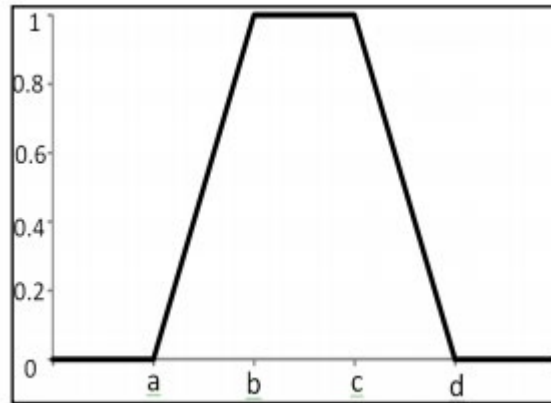$$\mu(x; a, b, c, d) = \min\left\{\frac{x-a}{b-a}, 1, \frac{d-x}{d-c}\right\}$$

Fig 2

Table 1: parameters of membership functions in the fuzzy interface system

Services	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)	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	20
Interest Free Credit	5	7	15	15	1	3	4	7	0	0	1	3				
Instalment Sale	0	0	3	9	1	3	4	6	18	24	48	48				
Invoiced Delivery	25	25	12	8	12	8	6	2	6	2	0	0				
Assembly	25	25	12	8	12	8	6	2	6	2	0	0				
Warranty	0	0	1	2	1	2	3	5	3	5	10	10				
Pre-Sales	0	0	10	30	10	30	40	60	40	60	70	90	70	90	100	100
Sales	0	0	10	30	10	30	40	60	40	60	70	90	70	90	100	100
After- Sales	0	0	10	30	10	30	40	60	40	60	70	90	70	90	100	100

Fuzzy inference systems (Mamdani)

To compute the output of this FIS given the inputs, one must go through six steps:

1. Determining a set of fuzzy rules

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

2. Fuzzifying the inputs using the input membership functions,
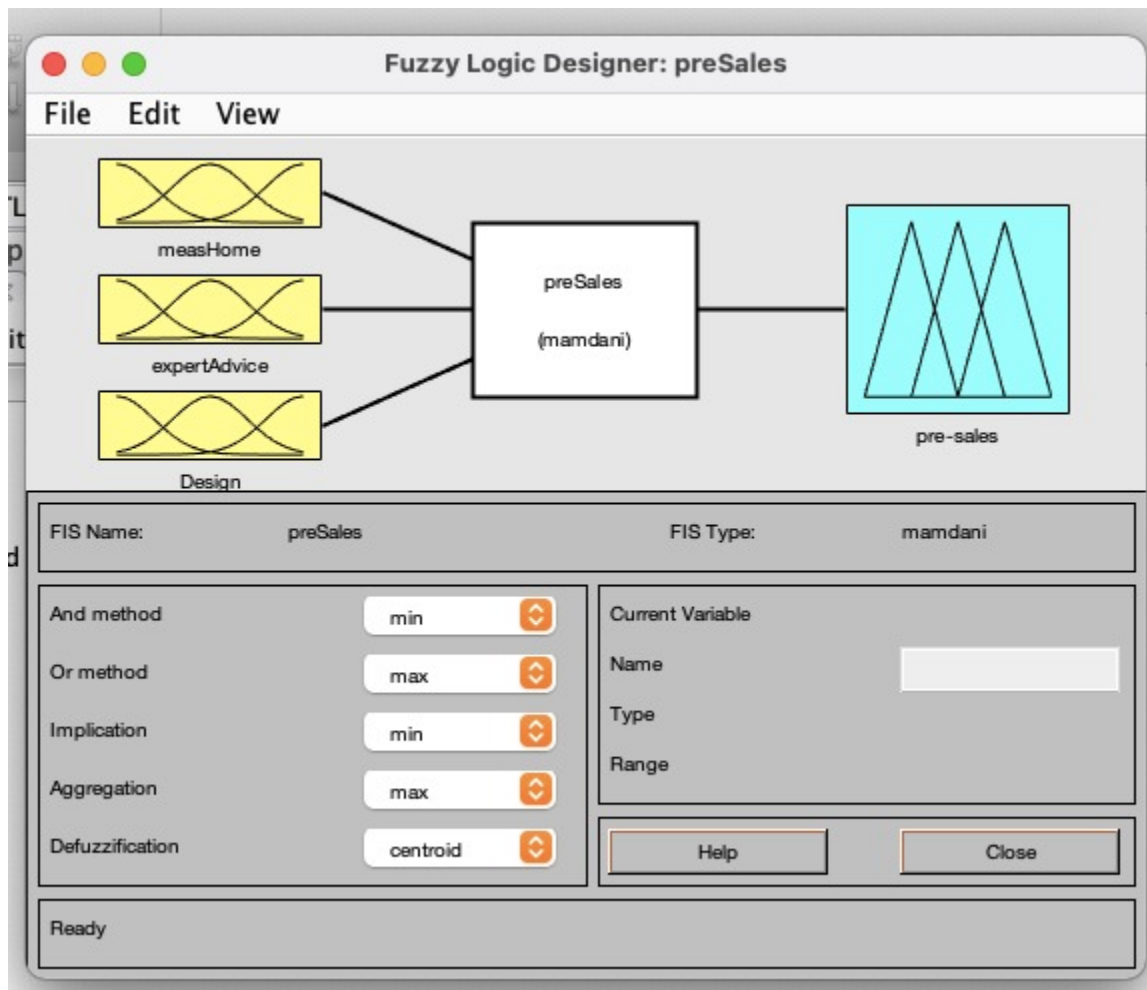

Fig 3

IF A… AND B…. AND C-----> THEN D

Implication: Minimum

Aggregation: Maximum

Defuzzification: Centroid Method

3. Combining the fuzzified inputs according to the fuzzy rules to establish a rule strength,

Parameters	S1	S2	S3	S4
Measurement at Home	0	3	2	2
Expert Advice	0	0	0	0
Design (3D)	0	0	2	0
Cash Discount	2	3	2	5
Interest - free Credit	0	2	1	0
Instalment Sale	6	12	12	0
Invoiced Delivery	10	0	5	10
Assembly	10	0	0	5
Warranty	3	3	5	5

Table 3

4. Finding the consequence of the rule by combining the rule strength and the output membership function,

5. Combining the consequences to get an output distribution, and

6. Defuzzifying the output distribution (this step is only if a crisp output (class) is needed).
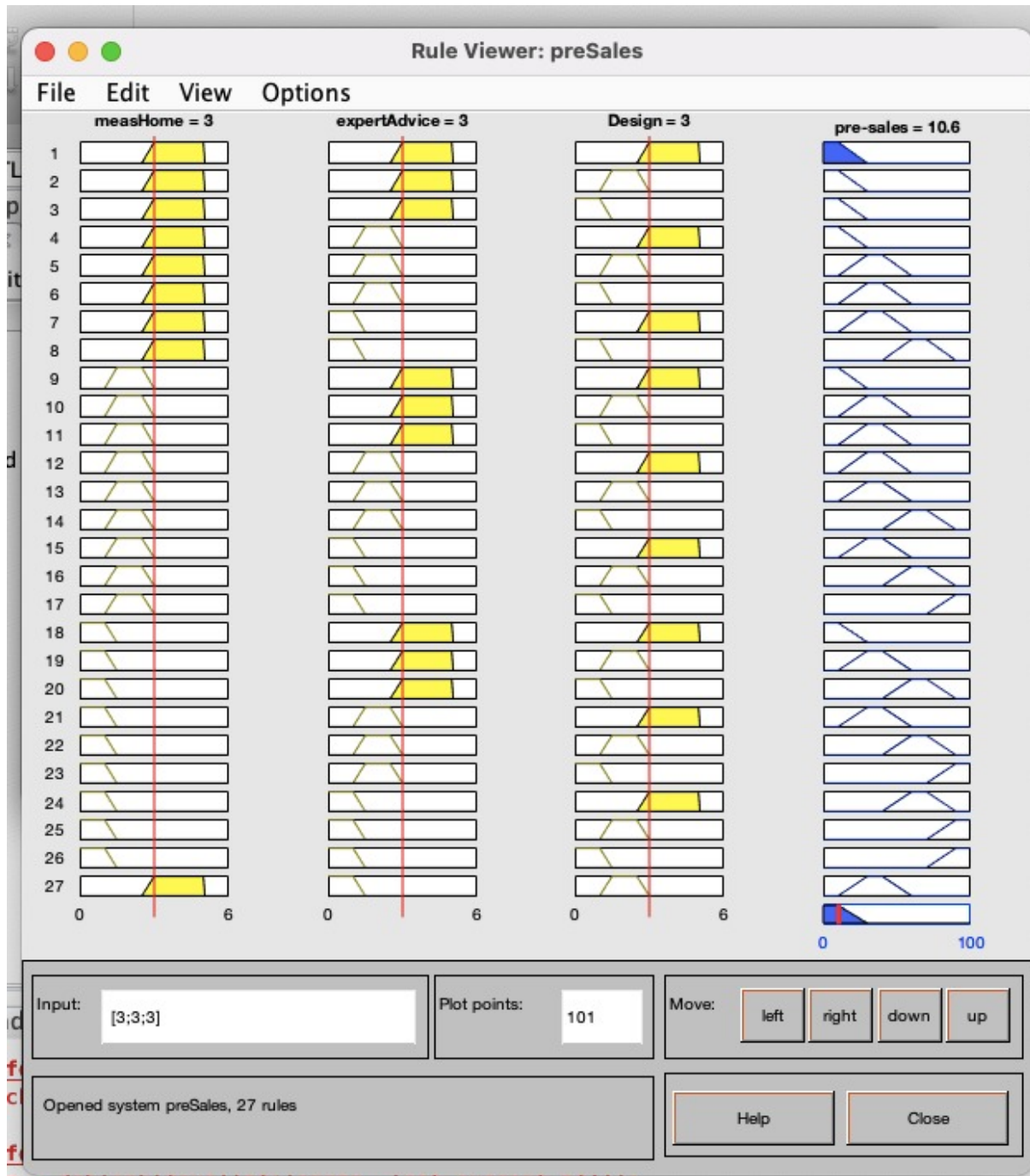
Fig 4

Similar process is to be followed for Sales and After- Sales.

Fig 5

Final Results

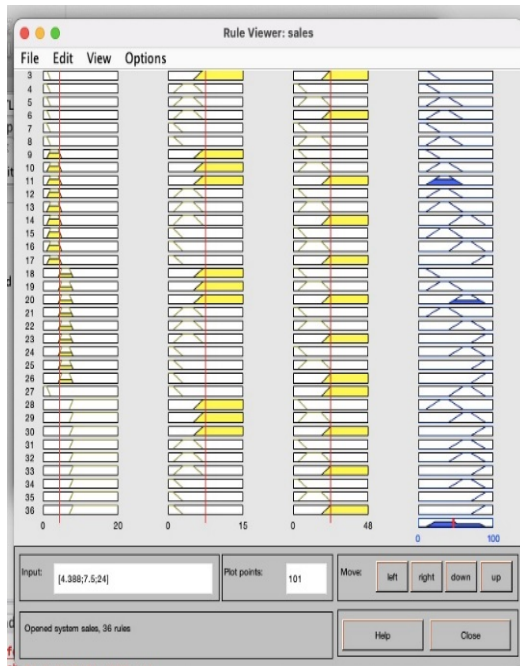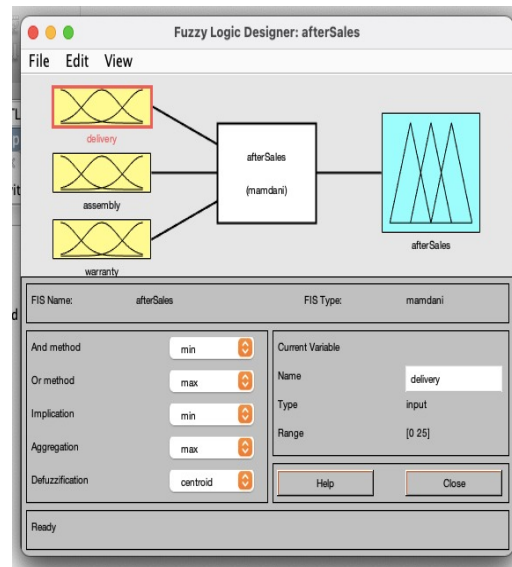|		S1	S2	S3	S4
Pre- Sales Services	0.4	89.4	65	65	89.4
Sales Services	0.3	27.3	50	56.7	10.6
After- Sales Service	0.3	27.3	89.4	88.6	54.4
		52.14	**67.82**	**69.59**	**55.26**
		4	2	1	3

Table 4

The Shop S3 is Top Performer in customer satisfaction.

Sales
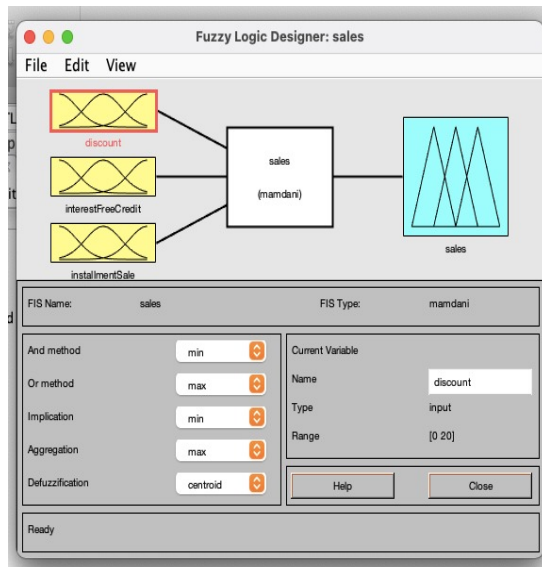
After- Sales
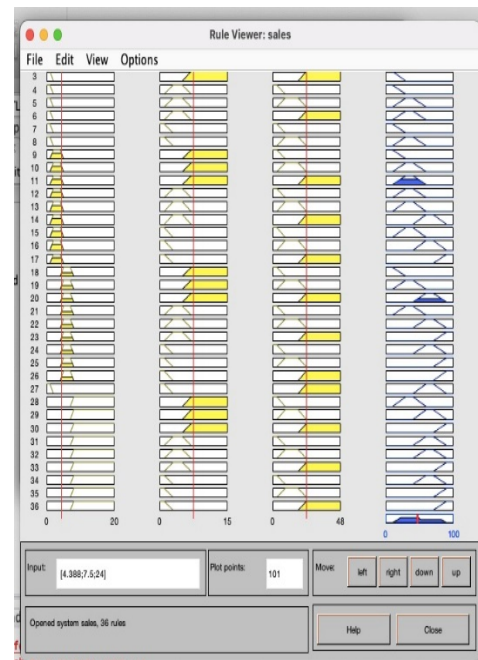
Conclusion & Future Prospects

The indexes for all groups of services for 4 Retain furniture stores, which are the results of FIS, are listed in Table 4.

Table 4 shows that the most important are Pre-sales services (Home Service, Expert advice, Design), sales services(Cash Discount, Interest Free Credit, Instalment Sale) and after sales services(Invoiced Delivery, Assembly, Warranty).Analysis of 4 retail shops showed that selected companies offer relatively good pre-sales services. Companies have achieved much worse ratings in terms of sales and after-sales services.

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.

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.

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