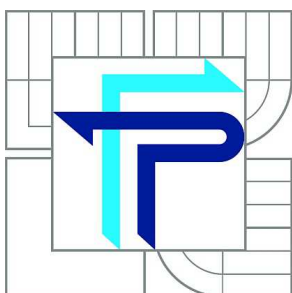# VYSOKÉ UČENÍ TECHNICKÉ V BRNĚ

BRNO UNIVERSITY OF TECHNOLOGY

FAKULTA PODNIKATELSKÁ
ÚSTAV EKONOMIKY

FACULTY OF BUSINESS AND MANAGEMENT
INSTITUTE OF ECONOMICS

THE APPLICATION OF FUZZY LOGIC FOR RATING OF SUPPLIERS FOR THE FIRM

APLIKACE FUZZY LOGIKY PRO VYHODNOCENÍ DODAVATELŮ FIRMY

DIPLOMOVÁ PRÁCE
MASTER'S THESIS

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MASTER'S THESIS ASSIGNMENT

Tomáš David, Ing.

European Business and Finance (6208T150)

Pursuant to Act. No. 111/1998 Coll., on Higher Education Institutions, and in accordance with the Rules for Studies and Examinations of the Brno University of Technology an Dean's Directive on Realization of Bachelor and Master Degree Programs, the director of the Institute of is submitting you a master's thesis of the following title:

The Application of Fuzzy Logic for Rating of Suppliers for the Firm

In the Czech language:

Aplikace fuzzy logiky pro vyhodnocení dodavatelů firmy

Instruction:

Theoretical Foundations
Current Situation Analysis
Proposals and Contribution
Conclusion
References
List of Appendices

List of literature:

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doc. Ing. Tomáš Meluzín, Ph.D.   doc. Ing. et Ing. Stanislav Škapa, Ph.D.
Director of the Institute   Dean of the Faculty

Brno, 11.09.2013

Abstract

The diploma thesis deals with the management of suppliers in the XY Company. There are few different software used for application of fuzzy logic methodology. First of all there are introduced main suppliers for the company in Asian region. Main attributes are picked up, which affects partnership between company and suppliers, and used such as inputs for fuzzy logic system. Fuzzy logic system after processing these inputs and based on them gives rating on the output. Output rating gives hint which supplier should be preferred.

Abstrakt

Tato diplomová práce pojednává o řízení dodavatelů firmy. Odlišné softwary jsou použity pro applikace fuzzy logiky. Nejprve jsou představeni dodavatelé firmy pro asijský region. Dále jsou vybrány hlavní parametry které vztahy s dodavateli ovlivňují a jsou použity jako vstupy pro fuzzy model. Fuzzy model poté na základě nastavených pravidel vyhodnotí vstupy a dává hodnotu na výstupu. Výstup je tedy hodnota, která vyjadřuje rating dodavatele a říká, který by měl být preferován.

Key words

Fuzzy logic, rating, supplier, company, input

Klíčová slova

Fuzzy logika, hodnocení, dodavatel, společnost, vstup

Bibliographic citation

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Statutory declaration

I declare that the submitted master's thesis is authentic and has been worked up independently. I also declare that citations are complete and copyrights haven't been violated (pursuant to Act. No. 121/2000 Coll., on copyright and on laws related to copyright Act.).

Brno, 31th August 2013

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Ing. David Tomáš

ACKNOWLEDGEMENT

Content

Main objectives

The main purpose of my diploma thesis is to build up model for ratting of the suppliers for XY Company based on fuzzy logic system. Based on the results to advice what supplier is most suitable for the company and with which suppliers should be relationship improved.

Introduction

All companies based on import and export needs to have profit, which is based on difference between price of bought items or service and price of sold items or service. To be able sell goods on the freedom market must company has competitive price and of course appropriate quality. If company wants to compete with competitors then is important to reduce expenses and of course price of bought items. Above mentioned means to have suppliers with good quality products and of course as low as possible price on the side of it to have service from suppliers which make business easier and smooth.

Each company has specific requirements for choosing suppliers. There are some important attributes such as price, quality, speed of production and due date payment. Of course there is also additional service which influent relationship between company and its suppliers. At same time company should has more suppliers to prevent against being dependent on one supplier only. That means company has to has more suppliers and manage them somehow.

Every company can choose own approach how to manage relationship with suppliers. Based on its approach choose most suitable supplier for the particular case. All these methods have common one thing and that is some criteria for choosing them and some rules which say how to pick right supplier up.

This diploma thesis deals with rating of suppliers and tries to find most suitable supplier and also may help to find particular areas which could be improved to get better rating for particular supplier.

1. Theoretical Foundation

1.1   MANAGEMENT OF PARTNERSHIP WITH SUPPLIERS

People communicating with each use the same expression for the transfer of information, but often the content of the information and its significance is different. In practice, it may cause many unpleasant situations in mutual communication, misunderstanding, but also economic losses. In an effort to reduce these misunderstandings is implement management partnerships with suppliers. This management involves evaluating the performance of suppliers, communication with suppliers, motivating suppliers, policy and strategy relationship with suppliers, joint planning with suppliers.[11]

1.1.1.   Evaluation and selection of suitable suppliers

Evaluation and selection of suppliers currently belongs to the standard activity in all types of organizations. Generally, procedures, selected range of criteria and demandingness of methods for evaluation of most suitable suppliers is different. Even thou, the reasons for the rating of the suppliers are more.

Reasons why to dedicate to the evaluation of suppliers are for example:
• Identification of long-term cooperation between the supplier and the customer
• promoting mutually effective cooperation
• The possibility to recognize a suitable supplier of potential partners

The scheme supplier selection is shown below, see fig. 3. Each customer creates a database of all available suppliers. Using a variety of tools to evaluation of suppliers, the company will decide on possible further cooperation with the most appropriate supplier. [11]
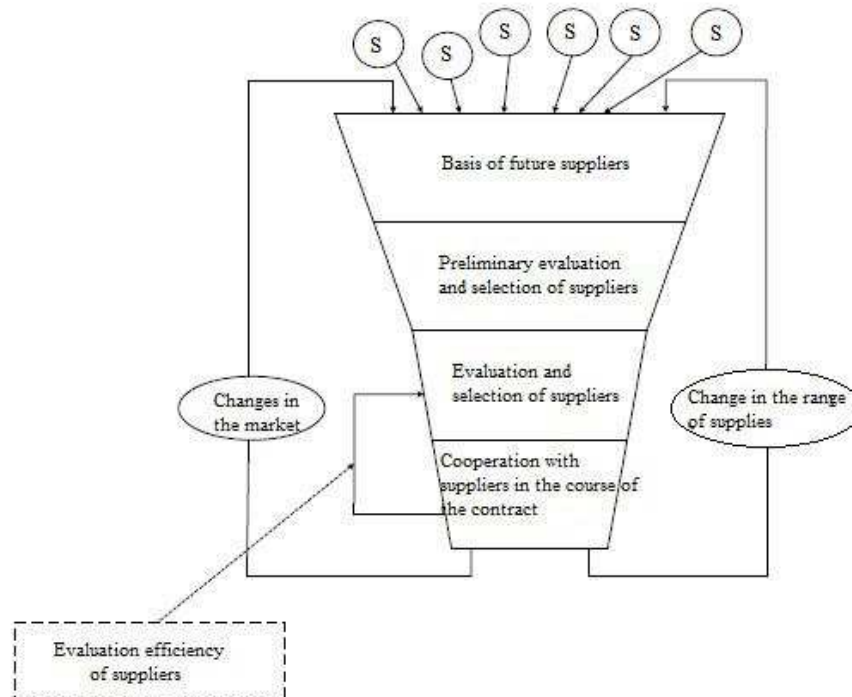
Picture 1: Rating of suppliers in a periodical cycle [11]

The phase of the preliminary assessment of possible future partner is the first step evaluation and selection of a large number of potential suppliers.

• Assessment of the first sample delivery

• assessing the maturity of the management system

• On their combination [11]

1.1.2.   Communication with suppliers

The next step, which occurs after selecting a suitable supplier is communication with the selected contractor. This communication should include the following:

• Announcement of selection procedure

• Comments on possible further increase in supplier evaluation

• Clarification of all details relating to future supply

• drawing up of all the conditions and elements that will be included in the official contract

• determine the conditions, rules and competences for everyday communication after closure contract with the supplier

The contract with the supplier is primarily a legal act and we must not forget any aspects of quality assurance of future supplies. In developing relationships is important adherence to all conditions contained in the trade agreement. It should not be in favor of one partner, but should ensure that the contract will be beneficial to both parties. [11]

1.1.3.   Evaluation efficiency of suppliers

The concept evaluation of efficiency can be imagine as a regularly repeated process in which we can find out immediate ability of suppliers to keep their commitments that are agreed in the contract. It is valid that customer buying certain materials, products, information or services from suppliers trying to maintain their consistently high productivity.

The basic elements by which can be judge the productivity of suppliers are quality supply, delivery times and costs associated with deliveries. The use of other elements of the evaluation is unusual. Other areas of evaluation may include a range of technical and information support provided by the supplier, the understandability of records, etc. [11]

1.1.4.   Motivation of suppliers

Picture 1 shows the main form to motivate the supplier. Motivation suppliers are divided into tangible and intangible, which can be further, divided into positive and negative. Tangible motivation has an effect on economic productivity supplier in revenues and expenses. Intangible motivation has an indirect impact on economic productivity.

Into the positive form of motivation may include all those that have stimulant sense to encourage better performance. To the negative mainly include motivation that causes concern, fear and uncertainty supplier.
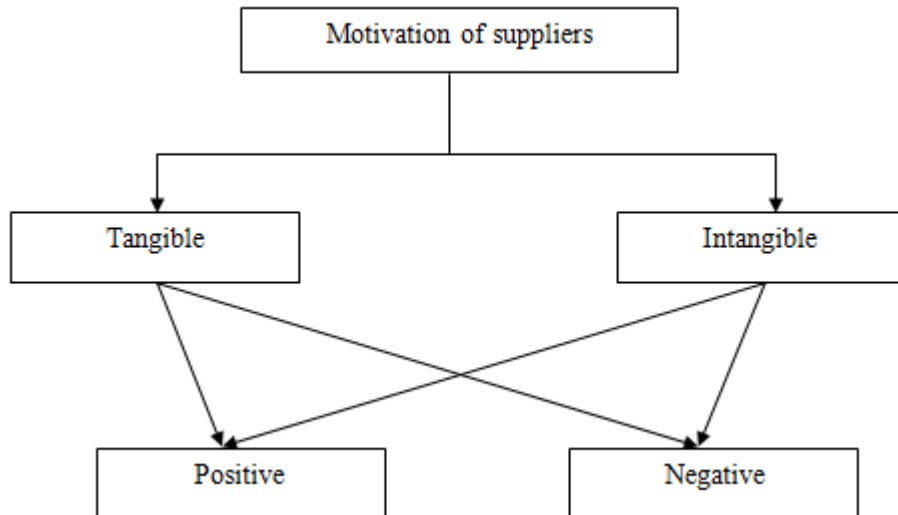
Picture 2: The main form to motivate the suppliers[11]

The following is a list of forms of motivation, from which we can tell if customer is interested in a supplier or not. Form of motivation can be divided into:

a) Tangible positive motivation

Some approaches applied by the customer:

• Long-term supply contracts and relationships, etc.

• Direct product sales employees selected suppliers for better prices compared to the market

• Long-term supply contracts and relationships, etc.

b) Tangible negative motivation

Some approaches applied by the customer:

• Termination of trade contracts

• Inclusion in the list of "sinners" and their disclosure, etc.

• Abuse of customers monopoly

c) Intangible positive motivation

Some approaches applied by the customer:

• Assistance in training and other forms learning contractor employees directly from suppliers

• Clear communication with the contractor during the term of the contract

• Joint planning with suppliers, etc.

d) Intangible negative motivation

Some approaches applied by the customer:

• Prerequisite is placed on the market through the main warehouses of customers

• storing very frequent audits on products, processes and management systems for suppliers

• publish the results of litigation with suppliers, etc. [11]

1.2   Fuzzy Logic

The term "fuzzy" is becoming popularity nowadays. What to closely imagine under the term is not always obvious. The use of fuzzy technology is increasingly asserting in commonly used devices around us. With the technology, you may encounter such as a camera with autofocus, ABS, engine management, idling and air conditioning (Honda, Nissan, Sabara), the palmtop designed for handwriting recognition, speech recognition and analysis of portfolio investment in the capital market. Fuzzy logic and fuzzy control can be used not only in production and technological processes, but "fuzzy stance" can be applied in quality management processes.

The aim of using fuzzy logic is also related to the process of continuous improvement, which is one of the fundamental obligations of each organization in the improvement of the quality required and strictly ISO / TS 16949. Among other things, these principles are recommended in the concept of TQM. Application of fuzzy logic significantly contributes to reducing costs in enterprises. Theoretical introduction of fuzzy logic and fuzzy control is described below in accordance with [2] [5] [13].

1.2.1. History of fuzzy logic

Fuzzy logic and set theory were published by Mr. Lotfi Zadeh in 1965. In 1965, Lotfi. A., who wasa professor at University of California at Berkeley, published an article [back, LA: Fuzzy sets. Inf & Control, 8, 1965, p. 338-353], which started the development of a modified set theory, fuzzy sets, which are tools for mathematical description of vague and imprecise terms. In 1966 L. A. Zadeh published an artickle about new trends in the analysis of complex systems [Zadeh, L. A.: Outline of a New Approach to the Analysis of Complex Systems and Decision Processes. IEEE Trans.Syst. Man. Cybern., 1, 1973, p. 28-44]. He formulated the principle of incompatibility which says:" If the growing complexity of the system then decreases our ability to formulate accurate and meaningful judgments about his behavior until a point beyond which the accuracy and relevance are practically almost mutually exclusive characteristics."[1]

The first one who practically used fuzzy logic was Abraham Mamdani in 1970 (the control system for the turbine). Fuzzy logic was initially very developed in the U.S., the enormous growth of interest in this technology began in Japan and today again appeared in the USA and Europe.

1.2.2. Set theory

The Set theory can be defined as the set of elements of certain properties. Element appertain into set or does not belong (0 or 1). There are only two states possible. L Zadech put into practice the theory of fuzzy sets and fuzzy logic, which is used to determine "how long" element belongs to the set or not (the variable x and its membership of a set is denoted $\mu(x)$ and is defined in the range 0-1; 0 means complete non-membership and 1 full membership). Use rate of membership is in a number of situations better than the use of conventional methods of assigning members to set according to the presence and absence. Fuzzy logic therefore examines certainty or uncertainty of membership in a set.

Using fuzzy logic can find a solution to the case of rules that have been defined for such cases. The method, using obscure sets (fuzzy) are among the methods that are used in the management of companies. In addition to applications of fuzzy logic, there are also combined systems, such as neural networks, the so-called neuron-fuzzy applications, etc.

1.2.3.   Process of fuzzy logic

Every fuzzy logic system contains three important sub-parts or let's say three steps. First step is fuzzification, second step is called fuzzy inference and last step is defuzzification.
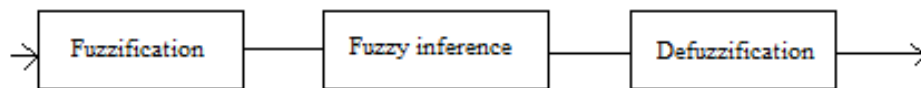
Picture 3: Process of fuzzy logic [2]

Very first step called fuzzification. Fuzzification is nothing else than translation of ordinary human language into numerical values which is easier to process. Let's see example. If we take variable risk, it can be expressed by human language such as no risk, very low risk, low risk, average risk, high risk and finally very high risk. Any variables have usually about two to eight attributes. Now, how much is input valuable participating in each group is mathematically expressed by membership function. We are using many shapes of membership functions. Most frequently used functions are called standard functions and they are called based on their look. For example there are functions S, Λ, and Z. But there is much more shapes of functions such as spline ones.

Second step is which is called fuzzy inference defines how should system behave. Behavior is sat up by rules such as IF, THEN and WITH. The conditional clutch makes these rules, which evaluates the input variables. These conditional clauses have the form of programming language.

$<IF>I_1$ is $mf_a<OR>$ I_2 is $mf_b...<OR>$ I_{N-1} is $mf_y<OR>I_N$ is $mf_z<THEN>O_1$ is $mfo_1<WITH>s$

The expression above could by described by words like:
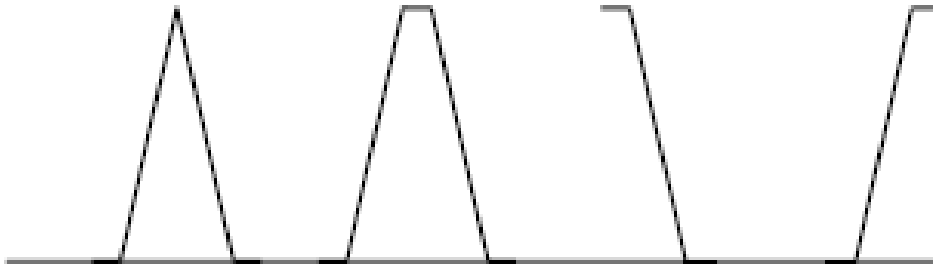
If the input I_1 is mf_a or I_2 is mf_b or.. I_{N-1} is mf_y or I_N is mf_z then O_1 is mfo_1 with weight s, where value s is in the range $<0-1>$. These rules must be set up and then they may be used for further processing.

The fuzzy rules represent the sophisticated expert systems. Each combination of variable inputs into system and occur in the condition IF, THEN and WITH represents one particular rule. Another step is to set up degree of support for each rule, which influence weight of rule for result output. It is possible to change the weight rules during the optimization process of the system. For the part of rules behind IF, it is necessary to find the corresponding attribute behind the part THEN. These rules are created by experts. The AND could be instead OR. These rules are created by user individually. These rules are:

$[a,b] + [d,e] = [a+d ,b+e]$, $[a,b] - [d,e] = [a-e ,b-d]$,

$[a,b] * [d,e] = [min (ad,ae,bd,be), max (ad,ae,bd,be)]$,

$[a,b] / [d,e] = [min (a/d,a/e,b/d,b/e), max (a/d,a/e,b/d,b/e)]$,

The very last step in fuzzy process is defuzzification. Result of defuzzification is linguistic expression. For example in case of risk can be no risk, very low risk, low risk, average risk, high risk and finally very high risk. Also could be result some kind of

decision or suggestion such as buy car or not to buy car. Third step is nothing else than just translation of numeric value into human words. Numeric values are always put into interval of values and each interval has linguistic expression. Let's say output value could be between 1 and 100. 1-50 means NOT to buy car and 51-100 to buy car. If output is 75 it is translated into to buy car based on interval 51 -100. [2]

1.2.4.   Development tools for fuzzy logic

Non-commercial tools:

Fuzzy COPE: SW environment for the Windows platform designed for researchers and teachers. Used to create and validate structures to create intelligent systems. Platform: MS Win 95/98 (Win32). It is possible to work with GUI (graphical user interface).

Fuzzy Logic inferencing Engine (FLIE) contains a simple inference, good teaching, but it is only compatible with the Macintosh platform. EFCLASS: This program is used for creating, testing, and training of neurons-fuzzy systems. [13]

Commercial tools:

Fuzzy Logic Development Environment for Embedded Systems (FLDE) runs under Windows platform.

Fuzzy Logic Toolkit inferencing (FLINT): a tool for the development of fuzzy expert systems and decision support systems (DSS). It offers more options Prolog. It is available for MS Win, DOS and Mac platform.

Fuzzy Logic Toolbox for MATLAB (J) provides tools for creating systems based on fuzzy logic, the recommended setting for those who are familiar with MATLAB software. It is provide for MS Windows, UNIX, Mac platform. However, the environment itself is required to work with MATLAB toolbox.

Fuzzy TECH: This program uses a combination of technologies fuzzy logic and neural networks. The environment is completely graphical model and based on ISO 9000 and IEC 1131-7 fuzzy logic standards. Its special version focuses on the financial and commercial applications. [13]

1.2.5.   Use of fuzzy technology

• Fuzzy control in the Japanese tube − automatic control station- increased stopping accuracy, smoother braking and especially lower energy consumption

• A camera with automatic search central point for focus (Minolta)

• ABS, engine management, idling and air conditioning (Honda, Nissan, Sabar)

• Management of elevators (Mitsubishi)

• Correcting errors in foundry equipment for plastic products (Omron)

• 3.5 "floppy drive (improvement headers exposure times of up to 30%)

• Palmtop Kanji designed for handwriting recognition

• Speech Recognition

• Fuzzy SQL (Omron)

• Assistance in finding and identifying offender profile systems (big, not too heavy, more or less old ...)

• Analysis of portfolio investment in the capital market [13]

1.3   SLEPT analysis

The SLEPT analysis is called as an instrument for analysis of changes in an environment. This analysis represents a complex view of the environment which the company exists in. The purpose is to provide overall summary of information from the social, legislative, economic, political and technological area. It is considered as a strategic analysis of the general company environment.

S – social factors

L – legislative factors

E – economic factors

P – Political factors

T – Technological factors

Before creating business plans or when evaluating existing ones it is important to 'scan' the external environment. This takes the form of a SLEPT analysis, i.e. an investigation of the Social, Legal, Economic, Political, and Technological influences on a business. In addition it is also important to be aware of the actions of your competitors. These forces are continually in a state of change. Social factors relate to pattern of behavior, tastes, and lifestyles. A major component of this is a change in consumer behavior resulting from changes in fashions and styles. The age structure of the population also alters over time (currently we have an ageing population). An understanding of social change gives business a better feel for the future market situation. Laws are continually being updated in a wide range of areas, e.g. consumer protection legislation, environmental legislation, health & safety and employment law, etc. Businesses need to take a pro-active approach and be ahead of these changes, rather than hurriedly making alterations to products and processes in a reactive way. Economic changes are closely related to social ones. The economy goes through a series of fluctuations associated with general booms and slumps in economic activity. In a boom nearly all businesses benefit and in a slump most lose out. Other economic changes that affect business include changes in the interest rate, wage rates, and the rate of inflation (i.e. general level of increase in prices). Businesses will be more encouraged to expand and take risks when economic conditions are right, e.g. low interest rates and rising

demand. Political changes relate to changes in government influence. In recent years these changes have been particularly significant because as members of the European Union we have to adopt directives and regulations created by the EU which then become part of UK law. Political changes are closely tied up with legal changes. Changes in technology have also become particularly significant in the post-millennium world. This is particularly true in terms of modern communication technologies. The creation of databases and electronic communications have enabled vast quantities of information to be shared and quickly distributed in a modern company enabling vast cost reductions, and often improvements in service. Organizations need to be aware of the latest relevant technologies for their business and to surf the wave of change.

All industries are influenced by SLEPT factors. For example, some of the SLEPT factors affecting the airline industry in recent years include:

Social: increased popularity of foreign travel leading to a boom in demand for air travel. However, this has been adversely affected by international terrorism.

Legal: there are increasingly tight rules about the materials that need to go into aircraft construction in order to make them safer and more resistant to fire hazards. This has had the impact of raising costs.
Economic: lower interest rates have meant that people have more disposable income to spend on luxuries like long distance air travel.

Political: the development of freedom of movement and trade in the European Union has led to greater levels of competition on European routes coupled with increased movement of people.

Technological: modern aircraft are safer and more economical to run than in the past making possible cheap air travel.

The interest rate is the cost of borrowing money. The interest rate is established each month by the Monetary Policy Committee, although there will be different interest rates for different types of credit, depending on such factors as risk and length of the

credit arrangement. [15]

1.4 SWOT analysis

SWOT analysis evaluates strengths, weaknesses, threats and opportunities of the company associated with the business plan, project, strategy and restructuring processes. Through the SWOT analysis we can recalculate the functioning of the company, find problems or new opportunities for growth. The analysis is part of a long-term strategic plan of the company. The SWOT analysis was developed by Albert Humphrey from Stanford University. In the 60th Humphrey led the research project which used data from 500 of most remarkable U.S. companies.

1.4.1. Description of the SWOT analysis

The analysis includes the analysis and evaluation of the current status of the company (internal environment) and the current situation around the company (external environment). In the internal environments searches and classifies strengths and weaknesses of the company. In the external environment looks and classify opportunities and threats for the company. For example, specified the particular strengths is used brainstorming with the management company and a specialist in the area where the SWOT analysis is concerned. After brainstorming is all sorts by relevance for intention to use SWOT, then starts quantified assessment of all the relevant items with all participants. After evaluating and calculating the balance of individual strengths with the entire team is ranked according to importance. After that it must run clear decision of management how to dispose with the results and what will be implemented.

The SWOT analysis is appropriate to seek synergy between strengths and weaknesses, opportunities and strengths, etc. These synergies can be used to determine the strategy and development of the company. [9]

1.4.2. Using SWOT analysis to determine strategy

The SWOT analysis can be used as a powerful tool for the identification and optimization strategy of a company, project or improvement of an existing condition or process. [9]

The SWOT analysis significantly contributes to the formulation of future strategy. Its main goal is to identify the current strategy of the company and its ability to deal with the threats and opportunities in the external surroundings. SWOT stands from English words - Strengths (strengths, weaknesses organization) Weaknesses (deficiencies, weaknesses of the organization), Opportunities (opportunities in the external environment) and Threats (threats from the external environment):

• The benefits are positive features of company that help gain a competitive advantage over other companies. It's a resource or capability that allows the company more competitive. This group includes access to better-quality materials, advanced technologies and distribution channels.

• Weaknesses are negative internal factors, which are due to lower organizational performance. The drawback for the company may be a bug in the development, disproportionate financial burden, obsolete machinery, etc.

• Opportunities are current or future conditions in an environment that is favorable to current or potential outcomes of the organization. Opportunities should be assessed not only in the current conditions, but also the long term. Among the opportunities we can embrace the growing number of customers, new technologies, etc.

• Threats are current or future conditions in the environment that may adversely affect the company's future. Under an unfriendly conditions can be considered a strong competitor to enter the market the decline in customers, legislative changes, etc.

From the complete SWOT analysis we can deduce the position of the organization. We can compare the external opportunities and threats with internal strengths and weaknesses. The strength of the company is quality goods and reasonable prices, and they can be used in the design of advertising.

SWOT analysis requires understanding the external environment and the ability to organization. It allows us a logical framework for the evaluation of current and future position of the company. With such an evaluation may suggest strategic alternatives. [9]

2. Current Situation Analysis

2.1   Company XY

Company XY is Czech company established in 1992, so just few years after velvet revolution. In 2005 has finished new own building. It is B2B orientated company which providing solutions on the field of marketing items. Company provides for many years customized items based on customer's needs and expectation. In present time after company started just with printed items such as posters, flyers and stickers. During all these years on the market, company opened new departments, such as parasol production facility in Boleradice and printing department also in Boleradice. In 2010 has started new facility near Brno where are refurbished refrigerators for Coca Cola company.

Main portfolio of the company
- Small marketing items called 3D.
- Marketing textile
- Green line products
- Point of sales product
- Glass
- Furniture
- Parasols
- Party tents
- Service of their products

So far, has the company sales place all over the Europe and Asia. Czech republic has headquarter and offices are placed in Slovakia, Norway, Italy, France, China, Hungary, Australia and Egypt. Company exports items into 50 countries all over the world.

Picture 5 : Offices of XY Company across the World [17]

Main customers are mostly drink companies, because these companies spending a lot of money for advertising.

Key customers

- Coca Cola
- Heineken
- Molson Coors
- Lobkowicz
- Sab Miller
- Google
- Autogrill

Organizational structure
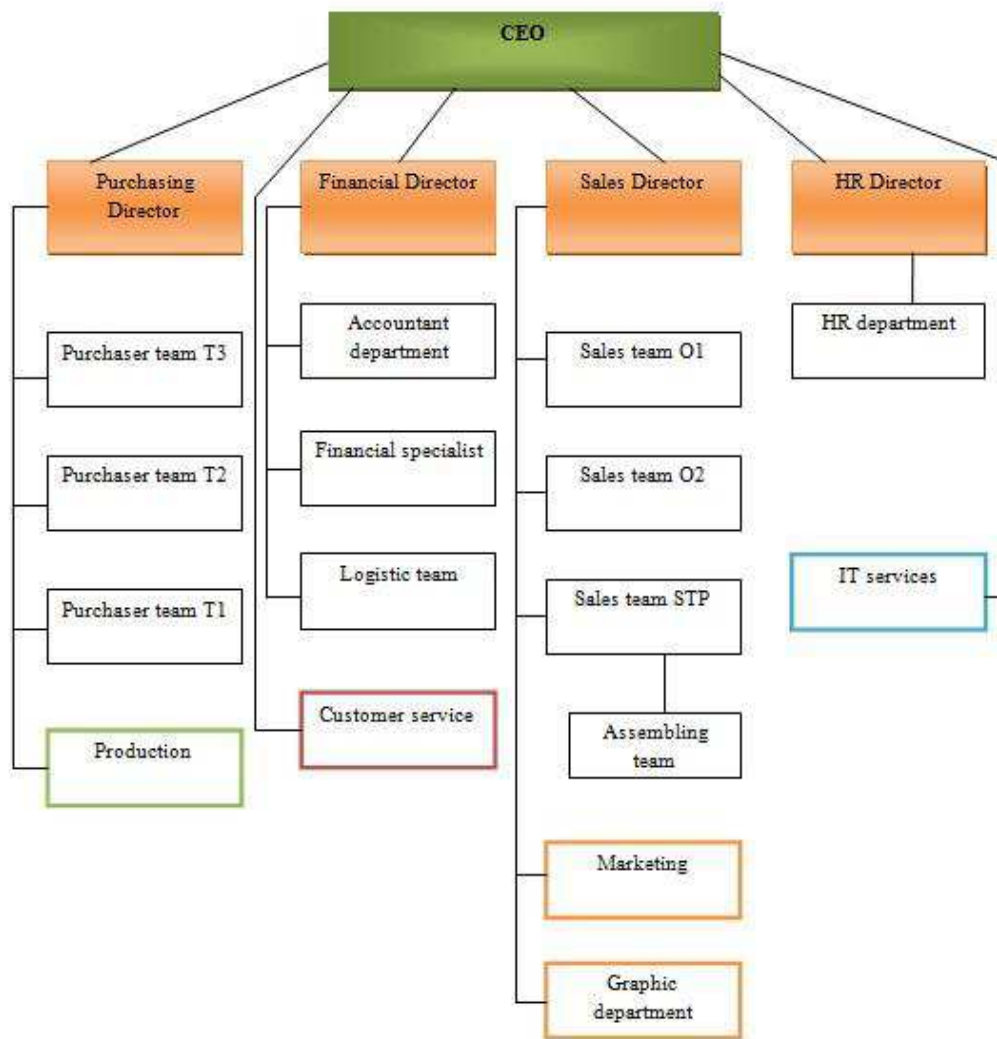
Picture 6: Organization structure in XY Company [17]

2.1.1. SWOT analysis

This part of diploma thesis summarizes all four parts of swot analysis strength, weakness, opportunities and threats for company. Theoretical background for swot analysis can be found in the first part of my diploma thesis.

Strength
- Wide range of products
- Strong service support
- Strong relationships with customers
- Good prices
- Strong relationships with suppliers
- Experienced people
- Innovations

Weakness
- Lack of native people abroad
- Access to cash
- Depended of experienced people
- Not able to win small tenders
- Depends on one type customers

Opportunities
- Expansion into fast growing regions
- Expansion into marketing organization events
- Finding new items
- Finding new suppliers
- Electronic expansion (smartphone applications)

Threats
- Economic crisis
- New trend of advertisement
- Anti-alcohol and sweet drinks campaign
- Coca Cola drinks scandal

2.1.2.   SLEPT analysis

Slept analysis is used for definition of environment and its changes, where the company operates. Slept analysis contains five points of view social factors, legislative factors, economic factors, political factors and technological factors.

Social factors:

- The company is located in a growth population stable region area, with connection to Asia and Russia.
- Europe is strongly developed society with spending for fun and culture, also Russia is.
- The inhabitants of the rural areas pride themselves on flower decoration of both public and private estates and buildings
- Good level of education makes easier access for good quality employees
- Infrastructure of media channels is developed and make it easier to offer services further in region

Legislative factors:

-Business law in all countries where company operates is developed and guaranteed by government.
- tax systems are stabilized and could be change just slightly
- Necessity of respect and unification of norms with EU
- law enforcement is guaranteed
- Healthy and safety standards must be passed

Economic factors:

- Minimum wage growth makes the company costs increasing
- Growth conditions of the area make potential gain
- Good bank infrastructure and service related
- Access to loans and cash
- Duty processes are strictly and clearly sat up

Political factors:

- Support for small enterprises in a form of state and EU subsidies
- Support for the company by local authority
- Contribution for development and pick-up in the environment
- Export and import restrictions such as duty tax
-pressure for keeping human rights
-International fairs for business support

Technological factors:

- Development of new forms of materials and cultivation of plants
- Good support of logistic infrastructure
- New production lines are implemented
- More precise technologies for production

2.2   Suppliers of XY Company

Because of company XY is exporting and importing goods and items for many countries on the World and at same time they processing hundreds of individual productions, they are mostly using agencies. Agencies are "middle men" who are connected directly to factories. After more than 20 years XY Company realized this is most effective way for production and also quite good protection against fraud. For example Company XY does not have to pre pay any order, because it is covered by agency Agencies are providing law services and also make sure that employees get regular salary etc. In my diploma thesis I have picked up five companies which are providing services in China. Unfortunately information are top secret so I am going to use fictive names for them. Suppliers will be named by letters A, B,C,D and E. Data about suppliers are taken from negotiating with them and also from last experience with them.

2.2.1. Supplier A

First supplier was established by Slovakian man 15 years ago. Because the agency is on the market for quite long time they have really good network of factories and quality of their products is priority number one. Also thanks to rich experience with business, they are able to solve any issue with order within one week. Prices are mostly average. Communication with company is very quick. Answer is usually delivered within 24 hours. Company also provides logistic service and insurance for transportation too. Only duty service has to be solved extra. Company also produce very accurate calculation of enquires and is able to send samples for small payment. Company has also good connection with audited factories and their items have always CE certificate, which means they are ready for sale in whole EU. Relatively small amount of orders (depends on article) is great for regular orders without troubles about cash flow. Only problem with company is due date which is maximum 30 days. If only transport by sea takes about 45 days you never know what you pay for.

2.2.2. Supplier B

The second chosen company has headquartered in Honk Kong. It is Chinese company with no western capital. Prices of items with this company are mostly lower than competition has. Sometimes can be problem solving issue with them. If production has some issue with material it can take about 2 weeks to sort it out which can make troubles with deadlines. Also variety of service is not that generous as others have. They do not offer transportation service and they do not give you CE certificate. CE certificate is guaranteed and it is usually condition within order, but they do not provide certificates. Communication can be also longer than necessary can take about 5 days to get answer on the other hand they provide samples for free and due date is 120 days which enable you to pay after delivery of your goods. Accuracy of calculations is definitely space for improvement where in average is accuracy of prices and deadlines about 70 percent. Minimum order quantity is one thousand to five thousand pieces depend on which product you would like to order.

2.2.3.   Supplier C

Another supplier marked as supplier C was found on international fair. Company was established in 2001 and has got quite low prices for products. The company does not provide best quality products, we can say average quality. The advantage of this supplier is quite fast respond in case of any issue with production, is able to react quickly. Because supplier has rich experience with smaller companies they are offering service which makes goods availability for new companies. Service such as shipping, insurance and duty service is provided. Due date is sat up between thirty to sixty days which could be longer, but right now they want to make several more businesses before they are ready to talk about longer due date terms. Company does not offer CE certificate service which can cause longer date of availability if goods in Europe. Communication is also quite fast and only holiday or time shift may cause slower communication. Company providing mostly pictures of sampling and that could be problem in case of more sophisticated items. On the other hand minimum order quantity which you can order is very low and sometimes starts on 1 pc.

2.2.4.   Supplier D

The fourth chosen company has headquartered in Honk Kong. It is Chinese company with western capital. Prices of items with this company are mostly very lower than competition has. Communication can be also longer than necessary can take about 3 days to get answer on the other hand they provide samples for free and due date is 150 days which enable you to pay after delivery of your goods. Sometimes can be problem solving issue with them. If production has some issue with material it can take about 2 weeks to sort it out which can make troubles with deadlines. Also variety of service is not that generous as others have. They do offer transportation service and they do give you CE certificate. CE certificate is guaranteed and it is usually condition within order and they do provide certificates. Minimum order quantity is five thousand plus pieces depend on which product you would like to order. Accuracy of calculations is definitely space for improvement where accuracy of prices and deadlines about 70 percent.

2.2.5.   Supplier E

Last chosen supplier was established by Polish business man 16 years ago. Because the agency is on the market for quite long time they have really good network of factories, but quality of their products is poor. Also thanks to rich experience with business, they are able to solve any issue with order within one week. Prices are mostly very low. Communication with company is very slow. Answer is usually delivered within more than 7 days. Company also does not provide logistic service and insurance for transportation too and also duty service has to be solved extra. Company also produce accurate calculation about 80% of enquires and is not able to send samples for small payment. Company has also good connection with audited factories and their items have always CE certificate guaranteed, which means they are ready for sale in whole EU. High volume of goods is not great for regular orders without troubles about cash flow. Only advantage with company is due date which is m180 days. If only transport by sea takes about 45 days you always know what you pay for.

3. Proposals and Contribution

For application of the Fuzzy logic methodology is necessary to determine input data. That means to determine which variable we are going to compare. It is necessary to pick up important variable which can influent our company. Each of these variables is necessary to evaluate for each supplier. I have picked up eleven attributes which I am going to evaluate. Let's look closer on the attributes I have picked up. Reliability is not used as a input, because in my opinion it is reflexed in inputs such as calculation accuracy, quality of goods, issue solving time and communication time.

3.1   Input attributes

Price – If prices are as company demanded how different they are and if they are compared with other companies. Based on last 5 enquires.

Quality of products – this attribute says about quality of molding, if parts fit together, smoothness of parts, functionality and etc. It is based on the five last productions.

Issue solving – how many times takes to solve issue. Days from complain to a solution agreement? It is based on last three complaints.

Shipping – Does company provide shipping service?

Insurance – Does company provide insurance of items during shipping?

Duty service – Does company provide duty services.

Due date – How many days for invoices to be paid for?

CE certificate service- Does company guarantee or provide CE certificates?
CE certificate enable to sell items in EU.

Communication- How many days it takes to get answer?? It is based on last fifty communications.

Calculation accuracy – how different is price from pre-calculation and from the reality?

Samples providing – If is possible to get sample of items.

Minimum order quantity – Quantity which must be ordered. It is based on the last ten orders.

All above mentioned input variables have different importance or let's say weight for final result of supplier valuation. All these above inputs have own scale on which we can evaluate inputs based on each supplier.

3.2   Scale of inputs

Price – Very low, low, modest, high, very high

Quality of products - Very good, good, medium, poor, and very poor.

Issue solving- 0-5 days, 6-10 days, 11-15 days, 16 -20 days.

Shipping- Yes, No.

Insurance - Yes, No.

Duty service - Yes, No.

Due date - 0-30 days, 30-60 days, 60-90 days, 90 -120 days, 120 - 150 days, 150 - 180 days

CE certificate service –Provide, guarantee, not guarantee.

Communication- 0-1 days, 2-3 days, 4-5 days, 6 -7 days

Calculation accuracy- 100 %, 90 %, 80 %, 70 %, 60 %, 50 %

Samples providing - Yes for free, yes for payment, pictures only, no

Minimum order quantity- 1-200 pcs, 201 – 1000 pcs, 1000 – 5000 pcs, 5001 + pcs.

3.3   Analyzed Suppliers

Following section shows how are suppliers integrated into valuation table. For each supplier is created the table which represents values belongs to particular supplier. Values are taken from negotiating with suppliers and also based on experience with them in the past.

price	quality of product	issue solving	shipping	insurance	duty service	due date in days	CE certificate service	commu-nication	calcula accur
Very low	Very good	0-5 days	YES	YES	YES	0-30	provide	0-1 days	100%
low	good	6-10 days	NO	NO	NO	30-60	guarantee	2-3 days	90%
modest	medium	11-15 days				60-90	not guarantee	4-5 days	80%
high	poor	16 -20 days				90 -120		6 -7 days	70%
very high	very poor					120 - 150			60%
						150 - 180			50%

Table 1: Valuation table

1. Supplier A

price	quality of product	issue solving	shipping	insurance	duty service	due date in days	CE certificate service	commu-nication	calcul accu
modest	Very good	6-10 days	YES	YES	YES	0-30 days	provide	0-1 days	90

Table 2 : Input values for supplier A

2. Supplier B

price	quality of product	issue solving	shipping	insurance	duty service	due date in days	CE certificate service	commu-nication	calcu accu
high	good	11-15 days	NO	NO	NO	90 -120	guarantee	4-5 days	70

Table 3 : Input values for supplier B

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3. Supplier C

price	quality of product	issue solving	shipping	insurance	duty service	due date in days	CE certificate service	commu-nication	calcu accu
low	medium	0-5 days	YES	YES	YES	30-60 days	not guarantee	2-3 days	90

Table 4 : Input values for supplier C

4. Supplier D

price	quality of product	issue solving	shipping	insurance	duty service	due date in days	CE certificate service	commu-nication	calcu accu
very high	good	11-15 days	YES	NO	YES	120 - 150	provide	2-3 days	60

Table 5 : Input values for supplier D

5. Supplier E

price	quality of product	issue solving	shipping	insurance	duty service	due date in days	CE certificate service	commu-nication	calcu acc
very low	poor	0-5 days	NO	NO	NO	150 - 180	guarantee	6 -7 days	8

Table 6 : Input values for supplier E

3.4 Software for processing results

There is plenty of software out there for fuzzy logic processing. There is even some software for free. For example is possible to use Microsoft Office excel, Matlab, Fuzzy COPE, Fuzzy TECH etc. I have picked up two of them. Microsoft Office Excel, because it is very popular software and most of people has MS Excel at home. The other choice is Matlab which is fully professional software.

3.4.1. MS Excel

"Microsoft Office Excel 2007 is a powerful tool you can use to create and format spreadsheets, and analyze and share information to make more informed decisions. With the Microsoft Office Fluent user interface, rich data visualization, and PivotTable views, professional-looking charts are easier to create and use. Office Excel 2007, combined with Excel Services, a new technology that will ship with Microsoft Office SharePoint Server 2007, provides significant improvements for sharing data with greater security. You can share sensitive business information more broadly with enhanced security with your coworkers, customers, and business partners. By sharing a spreadsheet using Office Excel 2007 and Excel Services, you can navigate, sort, filter, input parameters, and interact with PivotTable views directly on the Web browser."[12]

3.4.2. Matlab

"Fuzzy Logic Toolbox™ provides functions, apps, and a Simulink® block for analyzing, designing, and simulating systems based on fuzzy logic. The product guides you through the steps of designing fuzzy inference systems. Functions are provided for many common methods, including fuzzy clustering and adaptive neuro fuzzy learning. The toolbox lets you model complex system behaviors using simple logic rules, and then implement these rules in a fuzzy inference system. You can use it as a stand-alone fuzzy inference engine. Alternatively, you can use fuzzy inference blocks in Simulink and simulate the fuzzy systems within a comprehensive model of the entire dynamic system."[4]

3.4.3.   Excel vs. Matlab

Matlab		MS Excel	
sophisticated approach	+	well-arranged	+
easy management	+	easy management	+
expensive software	-	affordable software	+
necessary to learn new users	-	easy to understand	+
more complicated to set up rules	-	manageable graphic outputs	+
good quality of outputs	+	not fuzzy inference	-
possibility to solve more complex cases	+	not able to solve complex cases	-

Table 7 : Benefits and disadvantage of particular software

3.5   Solution in MS Excel

For using Microsoft Excel is necessary to define input matrix. Input status matrix contains data which are used for processing to get results. Based in input matrix is created transformation matrix. Transformation matrix translate input matrix into numbers, also is possible to say values. Values are determined by importance of particular attributes, which are set up by company. For example due date is more example than if company providing shipping service which can be provided by external logistic company. Importance of attributes is set up based on dialogs with XY company's employees and managers.

For each supplier is created one input status matrix which represents values of attributes. In tables are used words YES / NO which represents participation in the most suitable parameter of attribute. For MS Excel will be used number 1 for Yes value and 0 for value No.

To get rating of particular supplier is important to use scalar multiplication of transformation matrix and input data matrix. Let's see example of calculation for first supplier, therefore supplier A.

(900+1000+500+200+200+200+100+500+500+800+400+400) /7000 = 0,826

Because of rating should be showed in percentage it is important to multiply result by one hundred to get percentage indication.

0,826 * 100 = 82,6 %

Rounded up is rating 83 %.

price	quality of product	issue solving	shipping	insurance	duty service	due date in days	CE certificate service	commu-nication	calcula accur
Very low	Very good	0-5 days	YES	YES	YES	0-30	provide	0-1 days	100
low	good	6-10 days	NO	NO	NO	30-60	guarantee	2-3 days	90%
modest	medium	11-15 days				60-90	not guarantee	4-5 days	80%
high	poor	16 -20 days				90 -120		6 -7 days	70%
very high	very poor					120 - 150			60%
						150 - 180			50%

Table 8 : Description of transformation matrix

price	quality of product	issue solving	shipping	insurance	duty service	due date	CE certificate service	communication
1500	1000	700	200	200	200	100	500	500
1200	800	500	0	0	0	200	300	400
900	600	300				400	0	300
400	400	100				600		200
100	200					800		100
						1000		
1500	1000	700	200	200	200	1000	500	500
100	200	100	0	0	0	100	0	100

MIN	MAX	MAX-MIN
1000	7900	6900

Table 9 : Transformation matrix

Rating	Supplier rating
100 - 85 %	Very good
84 - 70 %	good
69 - 60 %	medium
59 - 50 %	poor
49 - 0 %	very poor

Table 10 : retransformation matrix

1. Supplier A

price	quality of product	issue solving	shipping	insurance	duty service	due date in days	CE certificate service	commu-nication	calcu accu
modest	Very good	6-10 days	YES	YES	NO	0-30 days	provide	0-1 days	90

Table 11 : Input values for supplier A

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price	quality of product	issue solving	shipping	insurance	duty service	due date in days	CE certificate service	commu-nication	calcula... accur...
NO	YES	NO	YES	YES	YES	YES	YES	YES	NO
NO	NO	YES	NO	NO	NO	NO	NO	NO	YES
YES	NO	NO				NO	NO	NO	NO
NO	NO	NO				NO		NO	NO
NO	NO					NO			NO
						NO			NO

Table 12: Transformation matrix for supplier A

price	quality of product	issue solving	shipping	insurance	duty service	due date in days	CE certificate service	commu-nication	calculation accuracy
0	1	0	1	1	1	1	1	1	0
0	0	1	0	0	0	0	0	0	1
1	0	0				0	0	0	0
0	0	0				0		0	0
0	0					0			0
						0			0
1	1	1	1	1	1	1	1	1	1

Table 13: State matrix for supplier A

Rating of supplier A:

Rating	83%
quality of supplier	good

Table 14: Retransformation table for supplier A

2. supplier B

price	quality of product	issue solving	shipping	insurance	duty service	due date in days	CE certificate service	commu-nication	calculati accurac
high	good	11-15 days	NO	NO	NO	90 -120	guarantee	4-5 days	70%

Table 15: Input values for supplier B

price	quality of product	issue solving	shipping	insurance	duty service	due date in days	CE certificate service	commu-nication	calculat accura
NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
NO	YES	NO	YES	YES	YES	NO	YES	NO	NO
NO	NO	YES				NO	NO	YES	NO
YES	NO	NO				YES		NO	YES
NO	NO					NO			NO
						NO			NO

Table 16: Transformation matrix for supplier B

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price	quality of product	issue solving	shipping	insurance	duty service	due date in days	CE certificate service	commu-nication	calculation accuracy	
0	0	0	0	0	0	0	0	0	0	
0	1	0	1	1	1	0	1	0	0	
0	0	1				0	0	1	0	
1	0	0				1		0	0	
0	0					0			1	
						0			0	
1	1	1	1	1	1	1	1	1	1	

Table 17: State matrix for supplier B

Rating of supplier B:

Rating	61%
quality of supplier	Medium

Table 18: Retransformation table for supplier B

3. supplier C

price	quality of product	issue solving	shipping	insurance	duty service	due date	CE certificate service	commu- nication	calcula accura
low	medium	0-5 days	YES	YES	YES	30-60 days	not guarantee	2-3 days	90%

Table 19: Input values for supplier C

price	quality of product	issue solving	shipping	insurance	duty service	due date in days	CE certificate service	commu- nication	calculat accura
NO	NO	YES	YES	YES	YES	NO	NO	NO	NO
YES	NO	NO	NO	NO	NO	YES	NO	YES	YES
NO	YES	NO				NO	YES	NO	NO
NO	NO	NO				NO		NO	NO
NO	NO					NO			NO
						NO			NO

Table 20: Transformation matrix for supplier C

price	quality of product	issue solving	shipping	insurance	duty service	due date in days	CE certificate service	commu-nication	calculation accuracy	
0	0	1	1	1	1	0	0	0	0	
1	0	0	0	0	0	1	0	1	1	
0	1	0				0	1	0	0	
0	0	0				0		0	0	
0	0					0			0	
						0			0	
1	1	1	1	1	1	1	1	1	1	

Table 21: State matrix for supplier C

Rating of supplier C:

Rating	75%
quality of supplier	good

Table 22: Retransformation table for supplier C

4. Supplier D

price	quality of product	issue solving	shipping	insurance	duty service	due date	CE certificate service	commu-nication	calculat accura
very high	good	11-15 days	YES	NO	YES	120 - 150 days	provide	2-3 days	60%

Table 23: Input values for supplier D

price	quality of product	issue solving	shipping	insurance	duty service	due date in days	CE certificate service	commu-nication	calculat accura
NO	NO	NO	YES	NO	YES	NO	YES	NO	NO
NO	YES	NO	NO	YES	NO	NO	NO	YES	NO
NO	NO	YES				NO	NO	NO	NO
NO	NO	NO				NO		NO	NO
YES	NO					YES			YES
						NO			NO

Table 24: Transformation matrix for supplier D

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price	quality of product	issue solving	shipping	insurance	duty service	due date in days	CE certificate service	commu- nication	calculation accuracy	
0	0	0	1	0	1	0	1	0	0	
0	1	0	0	1	0	0	0	1	0	
0	0	1				0	0	0	0	
0	0	0				0		0	0	
1	0					1			1	
						0			0	
1	1	1	1	1	1	1	1	1	1	

Table 25: State matrix for supplier D

Rating of supplier D:

Rating	
quality of supplier	59%
	poor

Table 26: Retransformation table for supplier D

5. Supplier E

price	quality of product	issue solving	shipping	insurance	duty service	due date	CE certificate service	communication	calculaccu
very low	poor	0-5 days	NO	NO	NO	150 - 180 days	guarantee	6 -7 days	80

Table 27: Input values for supplier E

price	quality of product	issue solving	shipping	insurance	duty service	due date in days	CE certificate service	communication	calculaaccur
YES	NO	YES	NO	NO	NO	NO	NO	NO	NO
NO	NO	NO	YES	YES	YES	NO	YES	NO	NO
NO	NO	NO				NO	NO	NO	YES
NO	YES	NO				NO		YES	NO
NO	NO					NO			NO
						YES			NO

Table 28: Transformation matrix for supplier E

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price	quality of product	issue solving	shipping	insurance	duty service	due date in days	CE certificate service	commu-nication	calculation accuracy	
1	0	1	0	0	0	0	0	0	0	
0	0	0	1	1	1	0	1	0	0	
0	0	0				0	0	0	1	
0	1	0				0		1	0	
0	0					0			0	
						1			0	
1	1	1	1	1	1	1	1	1	1	

Table 29: State matrix for supplier E

Rating of supplier E:

Rating	
quality of supplier	71% good

Table 30: Retransformation table for supplier

3.6   Solution in Matlab

Software I have chosen for rating calculation is Matlab. In use will be especially plugin Fuzzy Logic toolbox. Fuzzy logic toolbox contains complete user interface for comfortable using fuzzy logic calculations. Interface is called FIS (fuzzy inference system). There are two options how to set up fuzzy logic model. One possible way is GUI (Graphic user interface) where is seen all inputs and connections between them. The other way is just use CL (command line) and put commands in. For creating of fuzzy logic model is necessary to define input variables, output variables their intervals and also membership functions. GUI is great tool for editing and creating of fuzzy logic model. FIS contains all processes connected with inputs into regulator which we can configure as we need such as names, parameters and also outputs and their interpretation.

On the following picture is showed fuzzy regulator with inputs and one output. Into inputs are sent information about supplier. Fuzzy regulator after takes these values and processing them by sat up rules. Output is value which is in percentage indicator.
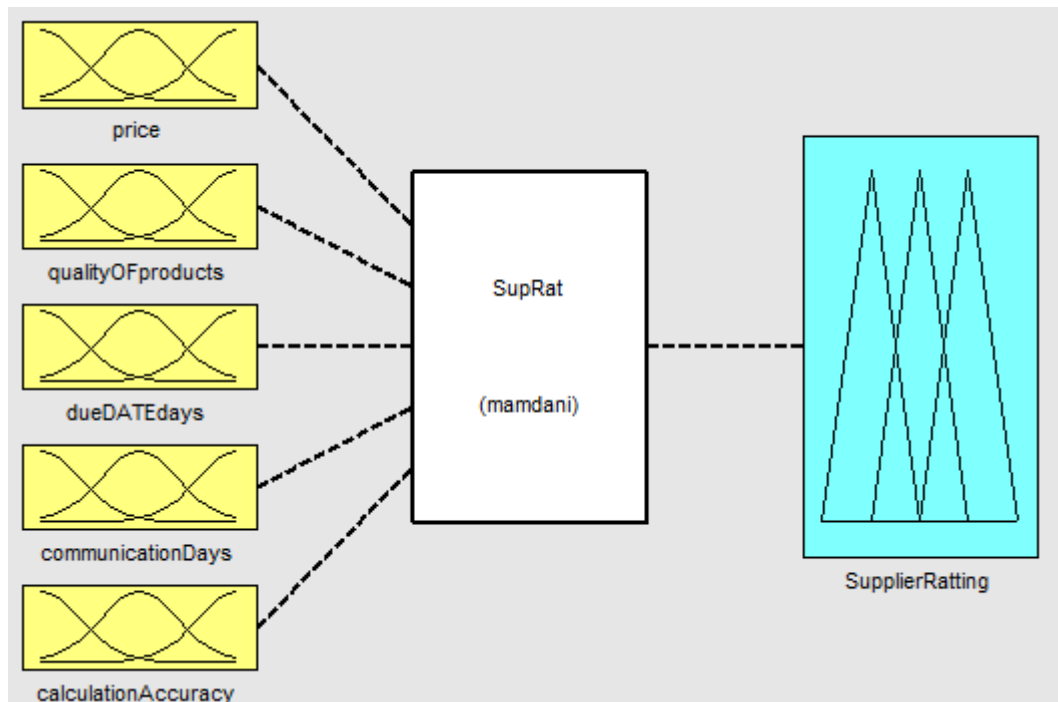
Picture 7 : Model processed in Matlab Software

Fuzzy inference system is composed of three different editors. Very first editor is called inference system fuzzy regulator (FIS editor) see picture above. The second editor is created for membership functions so Membership Function Editor where are set up membership intervals for inputs.
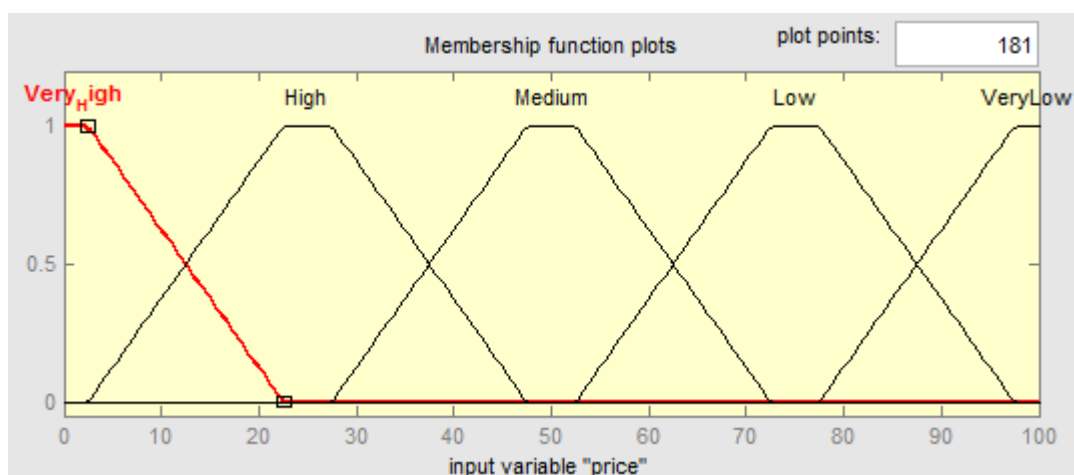
Picture 8: Membership functions of input Price

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Picture above is sat up input for price. There are sat up five levels according to variation of input values such very high, high, medium, low and very low price. Values copy levels based on weight of importance.

The very last important editor is called Rule Editor. In this Editor are rules between inputs and outputs made. When is clicked on button view and then rules you can see window with sub windows. Sub windows are inputs which are defined from before and also you can see output sub window. Basically I just always pick up one value from each input window and also one value from output sub window. After there are few options what is possible to do. When all input and outputs are picked up (they are lightened) you can press button add rule which create rule and add it into rule list. Rule list is just above these sub windows. After is possible to choose one rule and thanks to the other buttons we can change rule by change rule button or delete rule if needed.
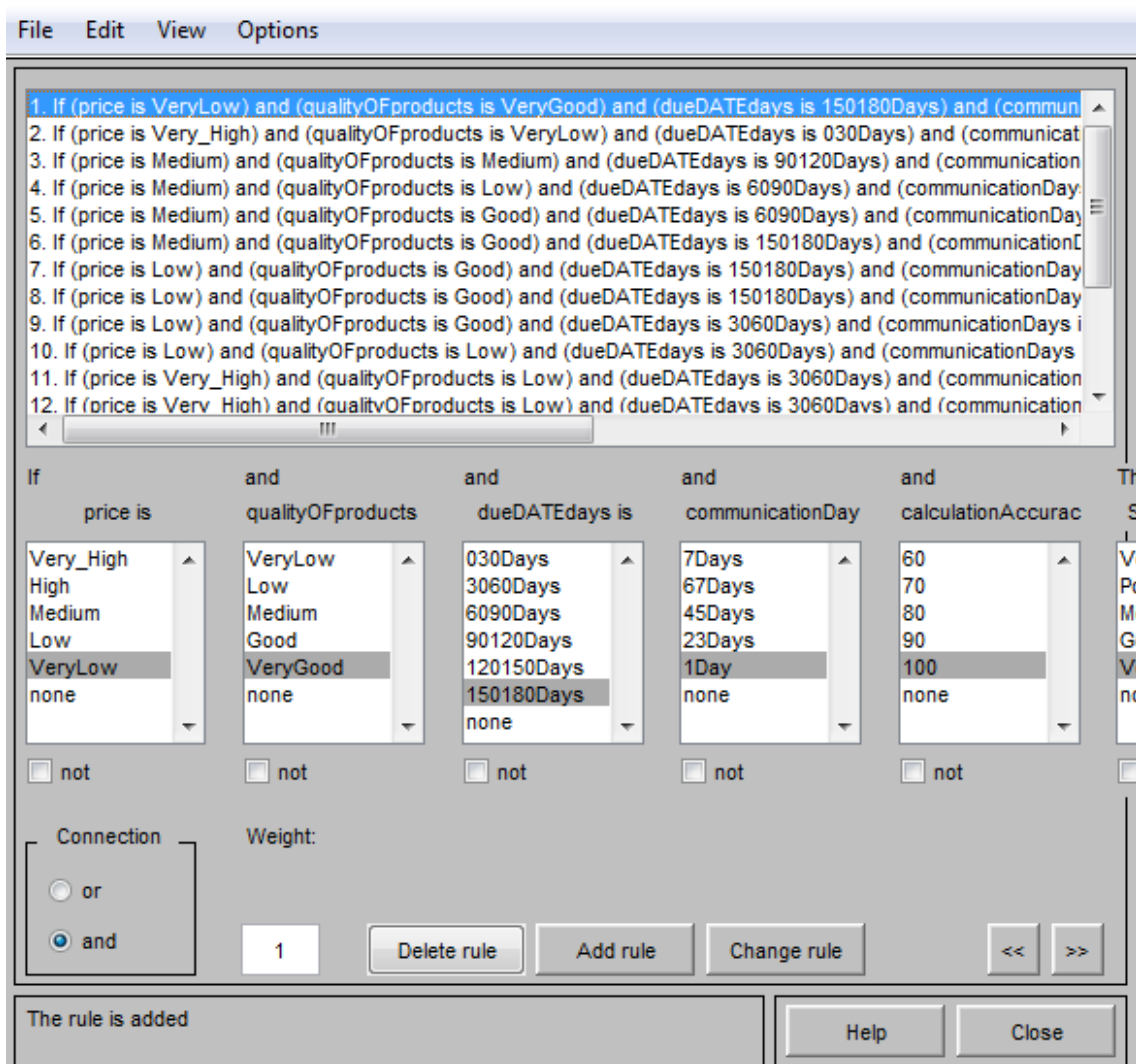
Picture 9: Sat up rules in Matlab software

As you can see picture above is the Rule editor with some rules sat up. Very first rule in the list represents following combination of inputs. Price is very Low, Quality of products is very good, due date of invoices are 150-180 days, wuick communication within 1 days and finally calculation of accuracy is close to 100 percent. Output for this combination of values is very good supplier.

Another way how to look on the rules sat up is Rule Viewer. See picture bellow. This viewer enables to see input and outputs of fuzzy logic model. When we look closer we can also see shapes of membership functions. Red vertical lines represent input values of supplier. In this case are sat up very high values for all inputs which makes very good output too. So again you can see price is very Low, Quality of products is very good, due date of invoices are 150-180 days, with communication within 1 days

and finally calculation of accuracy is close to 100 percent. Output for this combination of values is very good supplier.
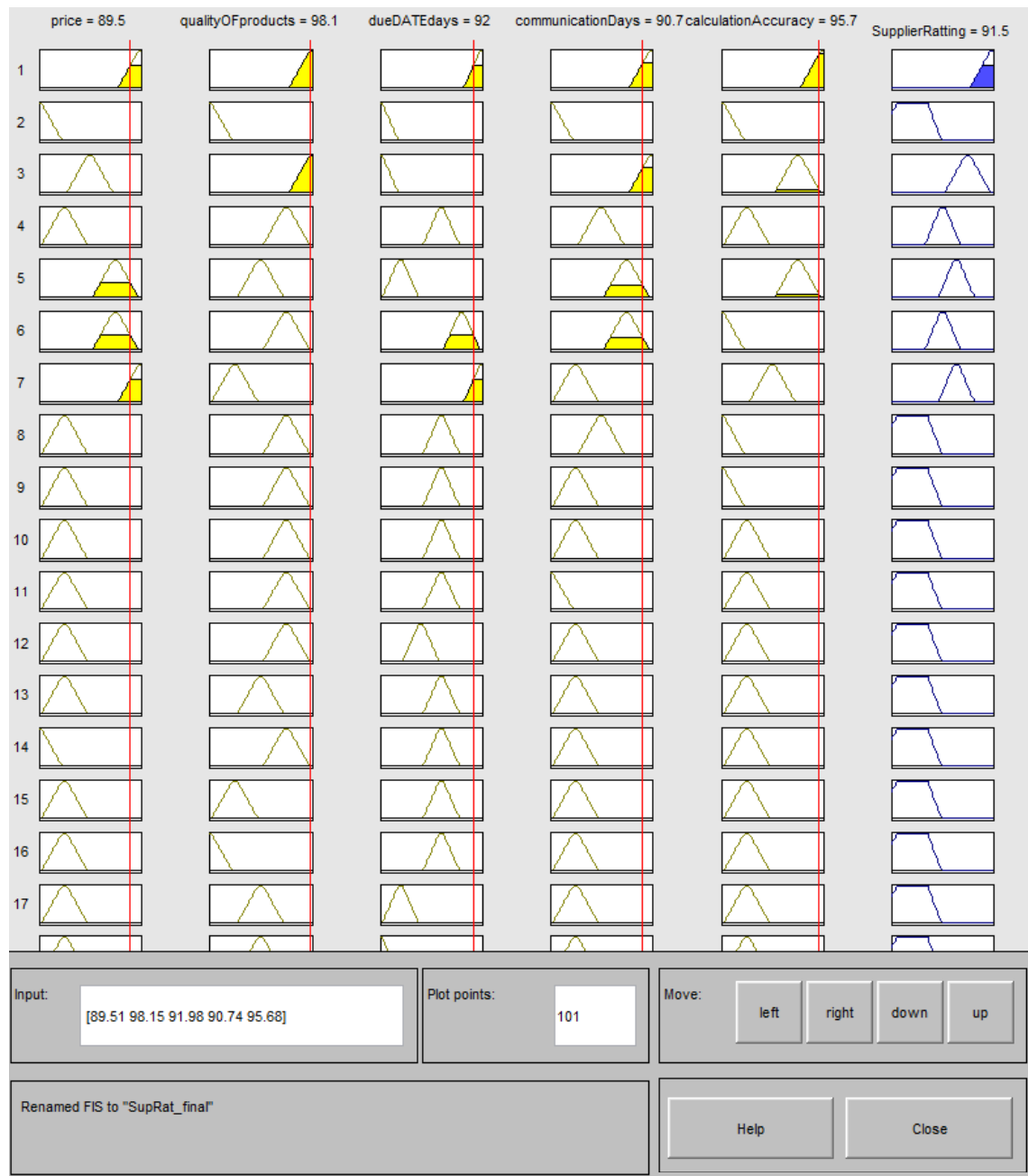
Picture 10: Visualization of rules in Matlab software

Also there is possibility to see relationships between individual inputs. For user friendly view on this is used graphics interface. See pictures below for relationship between quality of product and price of product under influence of other inputs. If price will be low and quality of product high we are getting highest score out of model.
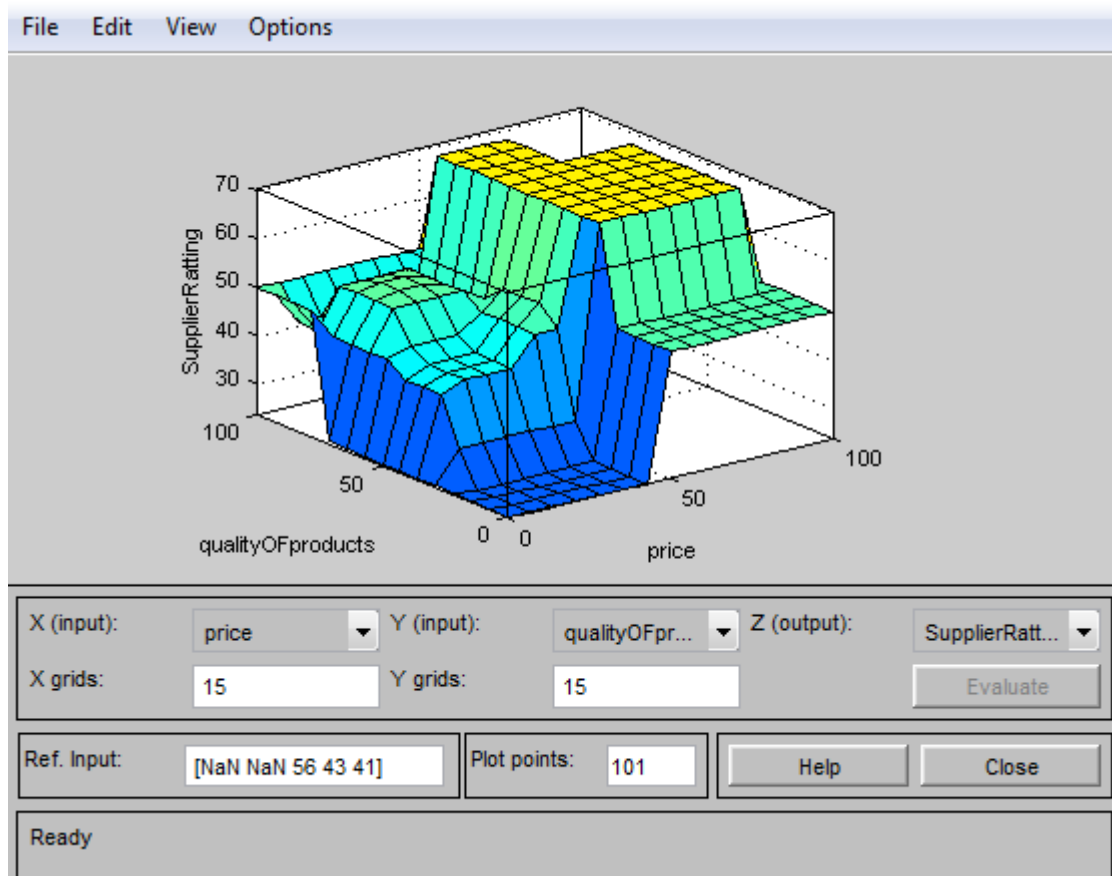
Picture 11: Dependence of the output on the values of inputs

Example: rating for supplier A by Matlab:
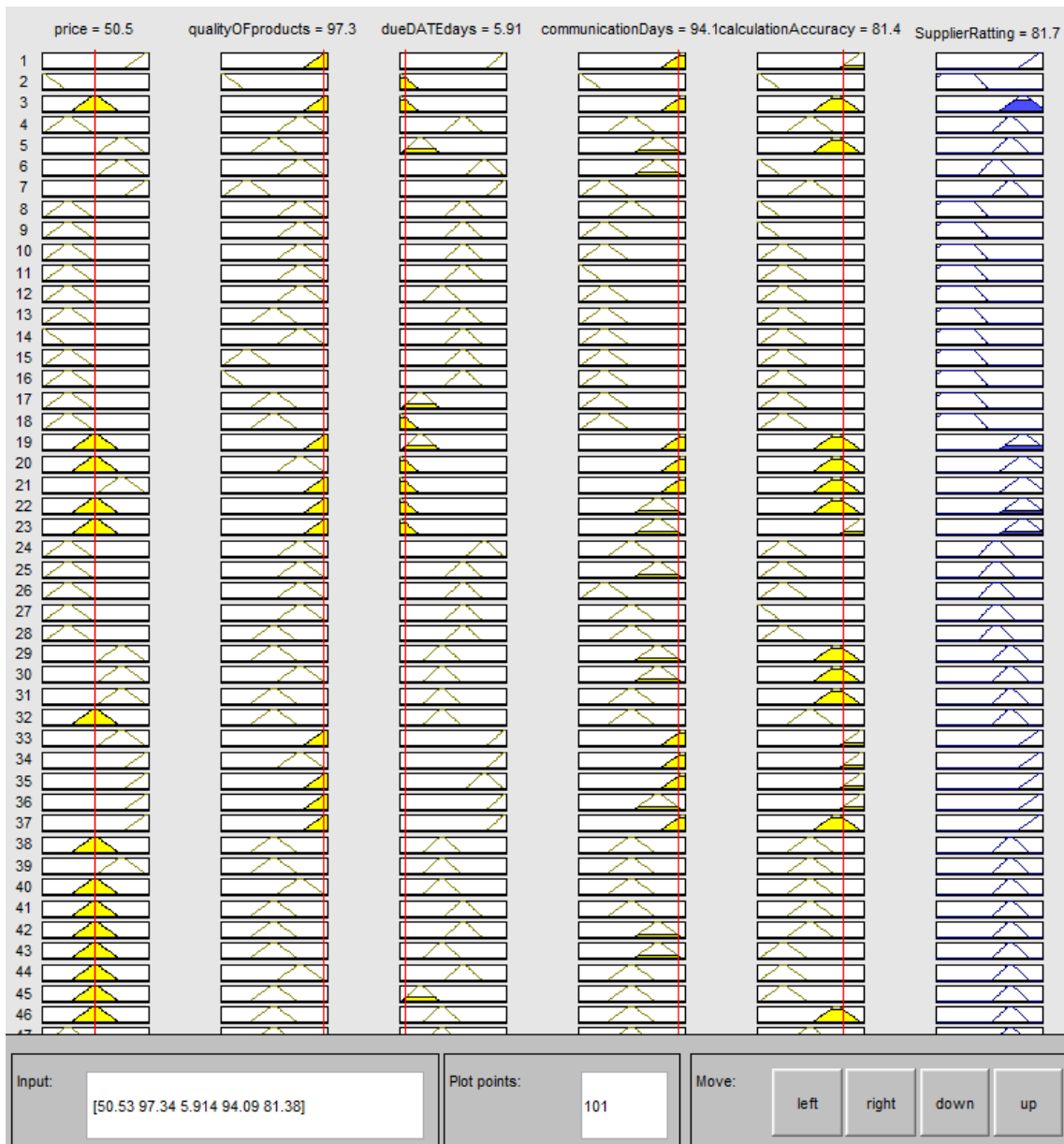
Picture 12: Input values for supplier A

On the picture above is screen shot for rating of supplier A. As input values are sat up price Excel - Medium (Matlab 50), Quality of product Excel – Very High (Matlab 97.3), due date Excel – 0-30 days (Matlab 5.91), communication Excel – 0-1 day (Matlab 94.1), calculation accuracy Excel – 90% (Matlab 81.4). These inputs give rating of supplier 81.7 percent.

Example: rating for supplier C by Matlab:
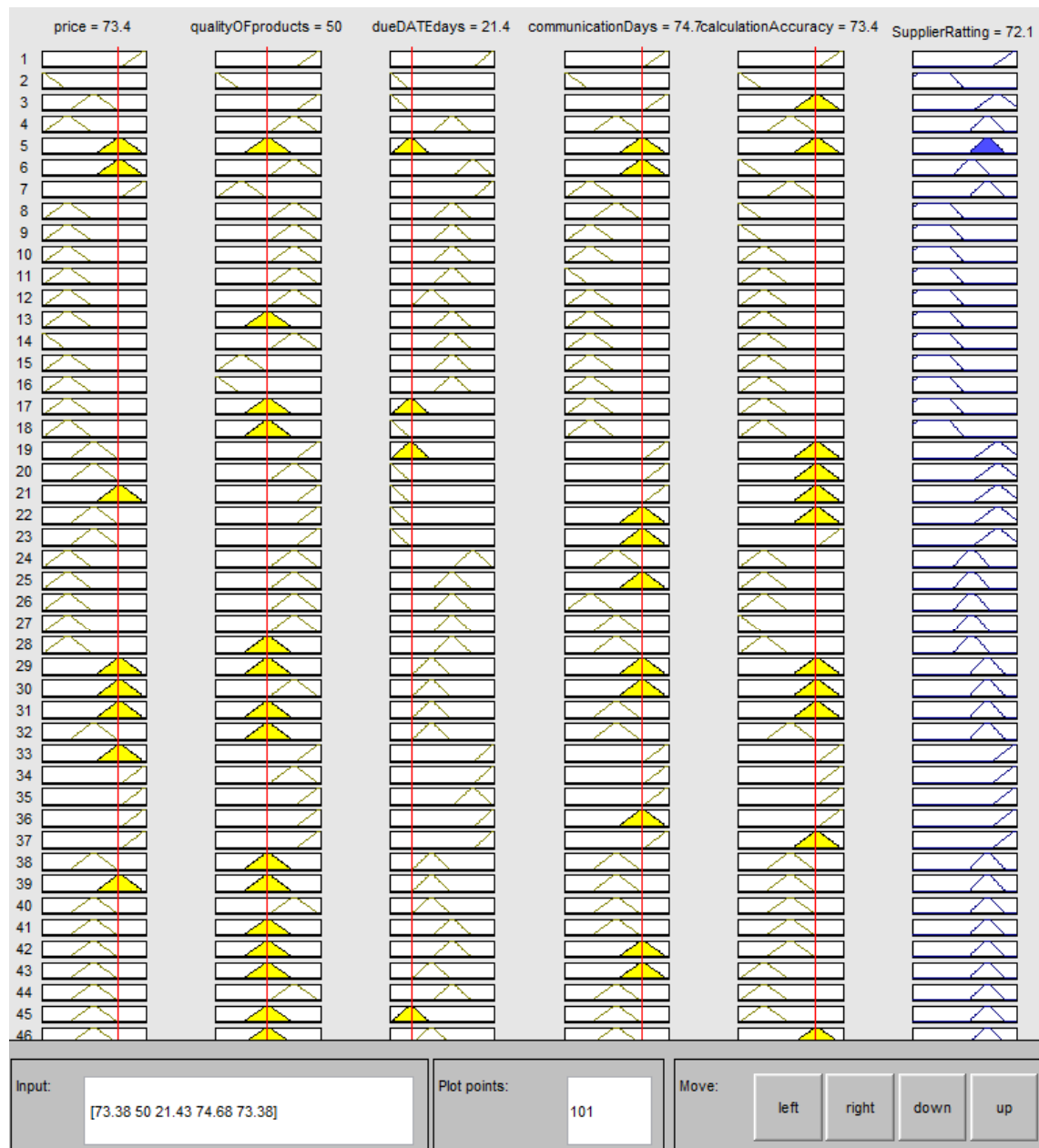
Picture 13: Input values for supplier C

On the picture above is screen shot for rating of supplier C. As input values are sat up price Excel - Low (Matlab 73,4), Quality of product Excel – Medium (Matlab 50), due date Excel – 30-60 days (Matlab 21.4), communication Excel – 2-3 days (Matlab 74.6), calculation accuracy Excel – 90% (Matlab 73,4). These inputs give rating of supplier 72,1 percent.

3.7   Summary

The rating of suppliers is processed by chosen criteria which are picked up by company's demands on suppliers. Most important criteria is price and quality of products. There are other criteria such as speed of communication, issue solving time, accuracy of calculations and services providing.

Rating of the suppliers

Based on mentioned criteria are suppliers rated by two type of software Microsoft Excel and Matlab R2012b. Intervals for final result were specified by following table. Following table also shows translation between percentage and word expression.

Rating	quality of product
100 - 85 %	Very good
84 - 70 %	good
69 - 60 %	medium
59 - 50 %	poor
49 - 0 %	very poor

Table 31: Retransformation matrix

Results based on Microsoft Excel software are:

Supplier	rating	word expression
A	83	Good
B	61	Medium
C	75	Good
D	59	Poor
E	71	Good

Table 32: Rating of suppliers in MS Excel

Results based on Microsoft Excel are displayed by column chart for better view.
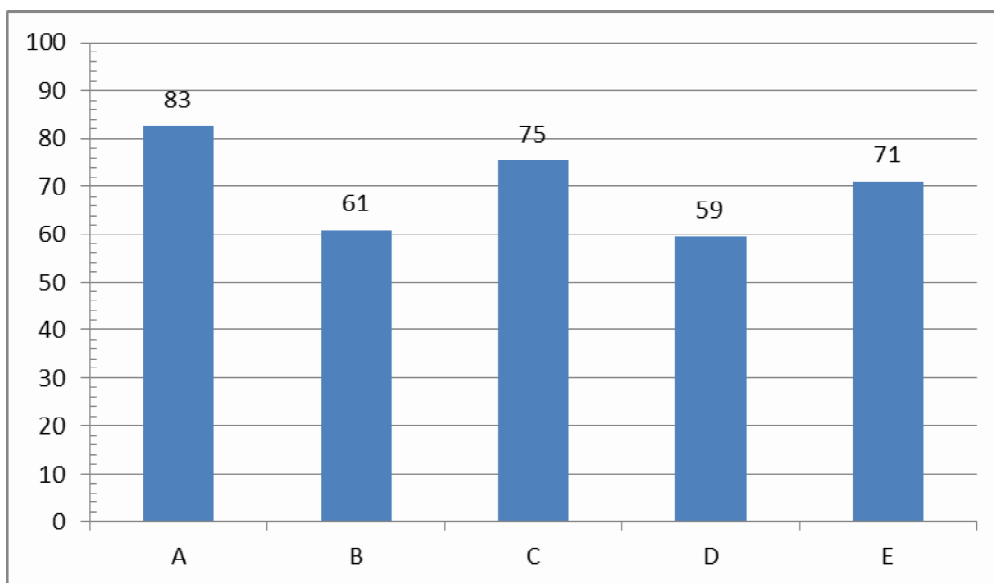
Figure 1: Results in MS Excel

After Excel software is used Matlab R2012r software, where were results similar to results in previous software.

Supplier	rating	word expression
A	82	Good
B	64	Medium
C	72	Good
D	57	Poor
E	75	Good

Table 33 : Rating of suppliers in Matlab software

Again, for gained results from Matlab software is used column chart which gives better view on the results.
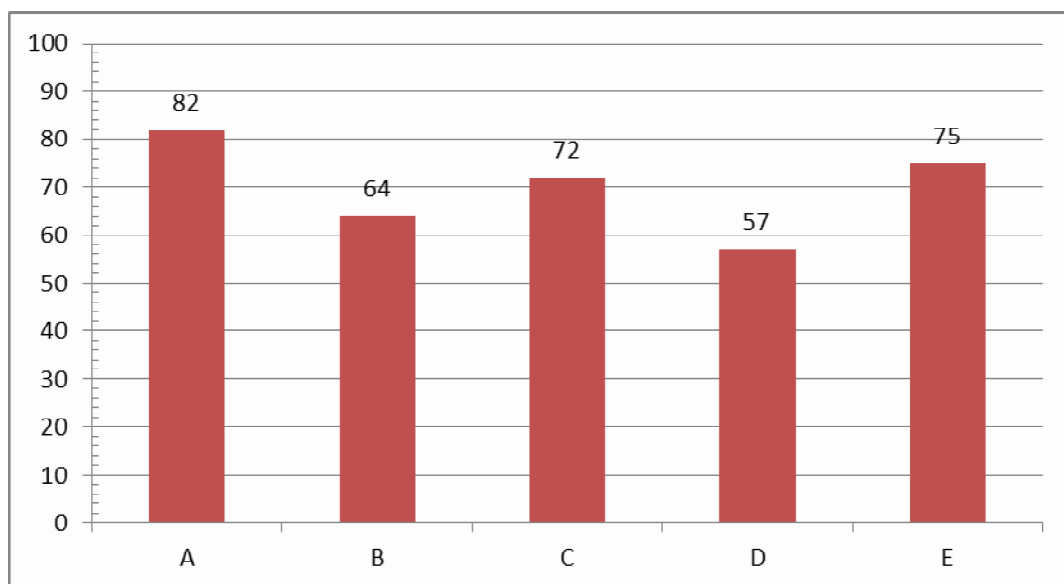
Figure 2 : Results in Matlab software

Comparison of results taken from Microsoft Excel software and Matlab software give us results which are very close to each other. Results are different just by few percent, which says that both models take us to same results. Results are also in order by rating which gives us clear view what supplier offer best service and quality.
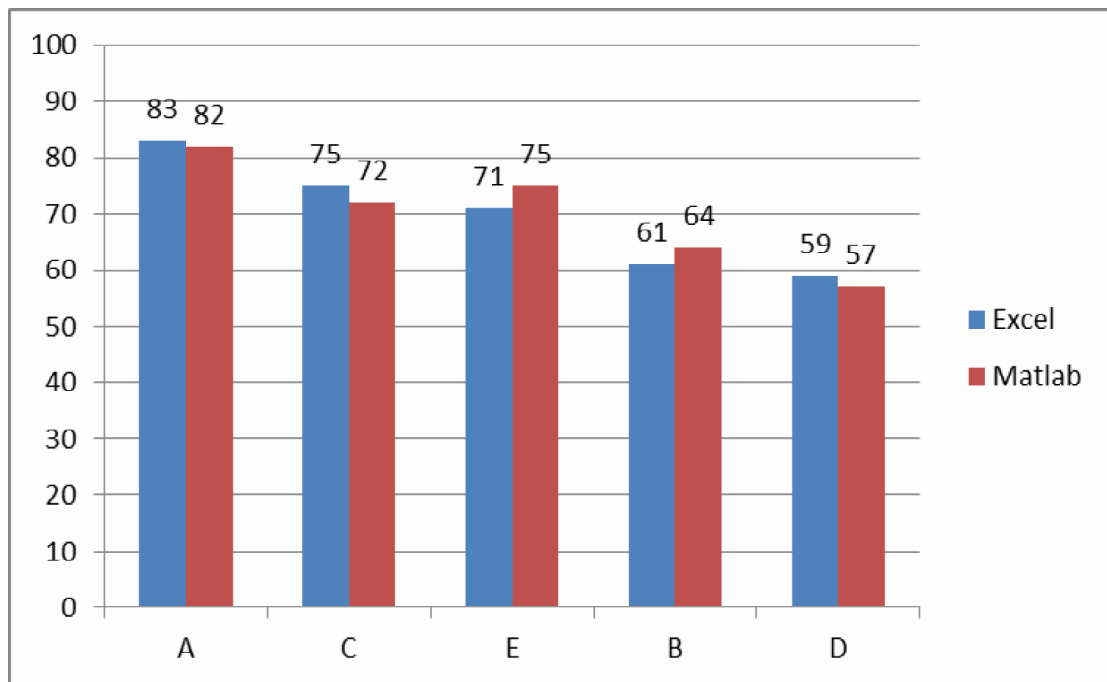
Figure 3 : MS Excel vs. Matlab results

Based on the result above is right now most preferred supplier A, Company should definitely keep good relationship with that supplier. Also supplier C and E has gotten good results even thou there is space for negotiating about better conditions. Supplier B and D have got pretty poor results and before starting another business should Company XY plan some meeting and try to improve conditions.

4. Conclusion

Controlling and rating of particular suppliers for trading company is one of the key success factors. There are many suppliers out there and they are offering many different services and also very wide range of quality products and of course for different prices. Even thou price is very important factor for choosing supplier. There are many others factors which may affect relationship between supplier and company. To be successful in long term run is important to have well known suppliers offering wide range of products and services. Appropriate approach for choosing suppliers should copy strategy of company.

The diploma thesis deals with rating of suppliers of XY Company. Company XY has more suppliers, but does not want to be dependent on one supplier only. In this diploma thesis are taken five biggest suppliers and they should be based on chosen criteria ordered by their quality. Fuzzy logic model is made by chosen inputs which were taken from company analysis and dialogs with company's workers. All input attributes have values taken from supplier's analysis. These values are sent into fuzzy logic system and processed. Application of fuzzy logic is made by Microsoft Excel software and also Matlab software. Both used software has shown very similar rating of a supplier which says that both models are sat up correctly.

Output rating of particular supplier helps to order suppliers by their quality and suitability for XY Company. Also based on results could be seen what attributes of suppliers should be improved in favor to get higher rating and what suppliers are not suppliers following XY companies business strategy. In this case Supplier A,C and E has gotten quite good rating, but suppliers B and D should be contacted and try to negotiate about values of attributes which were chosen in main body of diploma thesis.

Because of current fuzzy model copy current business strategy, company XY should once a time to check out if the model is still updated. There could be different weights between inputs and also some inputs could be erased and new could appear. For example if company will choose strategy of best quality products on the market then quality of product should have highest weight.

5. References

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6. List of shortcuts

SLEPT   -Social, Legal, Economic, Political, Technological factors

SWOT   - Strengths, Weaknesses, Opportunities, Threats

FR   - Fuzzy regulator

FLINT   - Fuzzy Logic Inferencing Toolkit

FLDE   - Fuzzy Logic Development Environment

GUI   - Graphic User Interface

CL   -Command Line

FIS   - Fuzzy Inference Systém

MS   -Microsoft Excel

7. List of Objects

7.1 Tables

7.2   Pictures

7.3   Charts

8. List of Appendices

Source code for Matlab software

```
[System]
Name='SupRat_final_final'
Type='mamdani'
Version=2.0
NumInputs=5
NumOutputs=1
NumRules=52
AndMethod='min'
OrMethod='max'
ImpMethod='min'
AggMethod='max'
DefuzzMethod='centroid'

[Input1]
Name='price'
Range=[0 100]
NumMFs=5
MF1='Very_High':'trapmf',[-22.5 -2.5 2.5 22.5]
MF2='High':'trapmf',[2.5 22.5 27.5 47.5]
MF3='Medium':'trapmf',[27.5 47.5 52.5 72.5]
MF4='Low':'trapmf',[52.5 72.5 77.5 97.5]
MF5='VeryLow':'trapmf',[77.5 97.5 102.5 122.5]

[Input2]
Name='qualityOFproducts'
Range=[0 100]
NumMFs=5
MF1='VeryLow':'trapmf',[-22.5 -2.5 2.5 22.5]
MF2='Low':'trapmf',[2.5 22.5 27.5 47.5]
MF3='Medium':'trapmf',[27.5 47.5 52.5 72.5]
MF4='Good':'trapmf',[52.5 72.5 77.5 97.5]
MF5='VeryGood':'trapmf',[77.5 97.5 102.5 122.5]

[Input3]
Name='dueDATEdays'
Range=[0 100]
NumMFs=6
MF1='030Days':'trapmf',[-18 -2 2 18]
MF2='3060Days':'trapmf',[2 18 22 38]
MF3='6090Days':'trapmf',[22 38 42 58]
MF4='90120Days':'trapmf',[42 58 62 78]
MF5='120150Days':'trapmf',[62 78 82 98]
MF6='150180Days':'trapmf',[82 98 102 118]
```

[Input4]
Name='communicationDays'
Range=[0 100]
NumMFs=5
MF1='7Days':'trapmf',[-22.5 -2.5 2.5 22.5]
MF2='67Days':'trapmf',[2.5 22.5 27.5 47.5]
MF3='45Days':'trapmf',[27.5 47.5 52.5 72.5]
MF4='23Days':'trapmf',[52.5 72.5 77.5 97.5]
MF5='1Day':'trapmf',[77.5 97.5 102.5 122.5]

[Input5]
Name='calculationAccuracy'
Range=[0 100]
NumMFs=5
MF1='60':'trapmf',[-22.5 -2.5 2.5 22.5]
MF2='70':'trapmf',[2.5 22.5 27.5 47.5]
MF3='80':'trapmf',[27.5 47.5 52.5 72.5]
MF4='90':'trapmf',[52.5 72.5 77.5 97.5]
MF5='100':'trapmf',[77.5 97.5 102.5 122.5]

[Output1]
Name='SupplierRatting'
Range=[0 100]
NumMFs=5
MF1='VeryPoor':'trapmf',[-16.9328542094456 6.26714579055441 35.7671457905544 49.6671457905544]
MF2='Poor':'trapmf',[39.449406175772 53.349406175772 60.459406175772 74.449406175772]
MF3='Medium':'trapmf',[52.8998812351544 67.8998812351544 72.8998812351544 87.8998812351544]
MF4='Good':'trapmf',[59.6063492063492 79.6063492063492 84.6063492063492 104.206349206349]
MF5='VeryGood':'trapmf',[77.3 97.3 102 122]

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2 4 3 2 2, 1 (1) : 1

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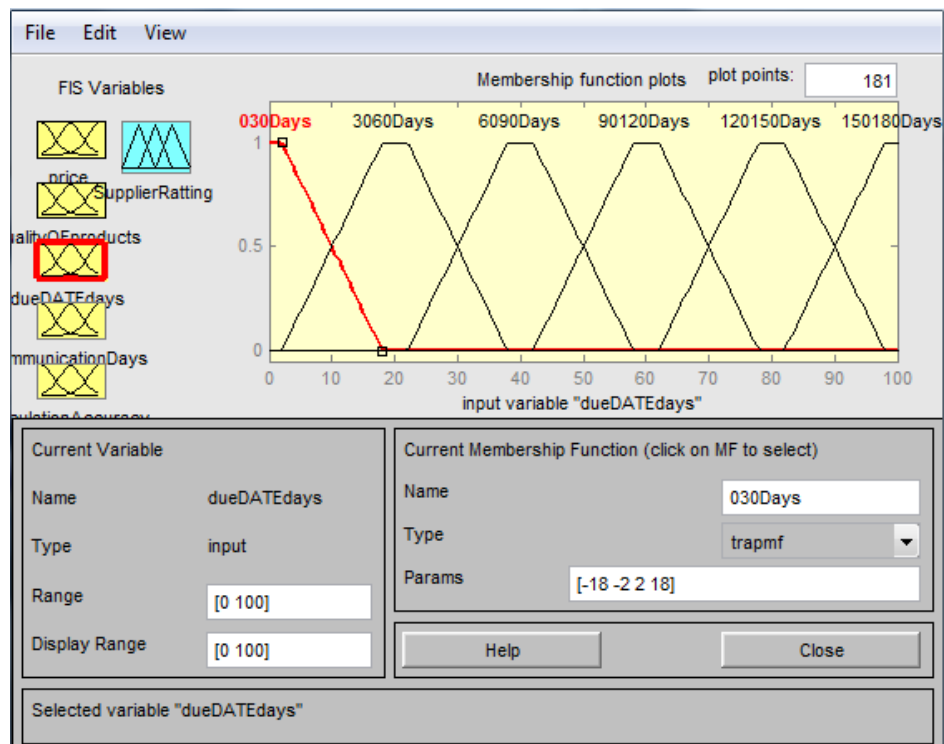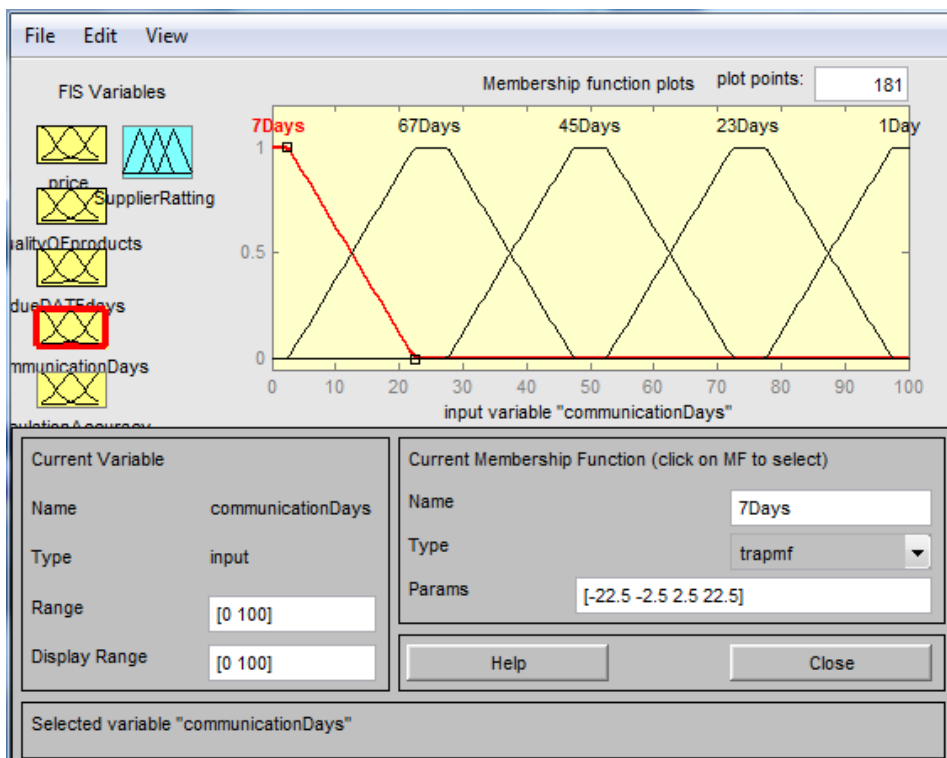
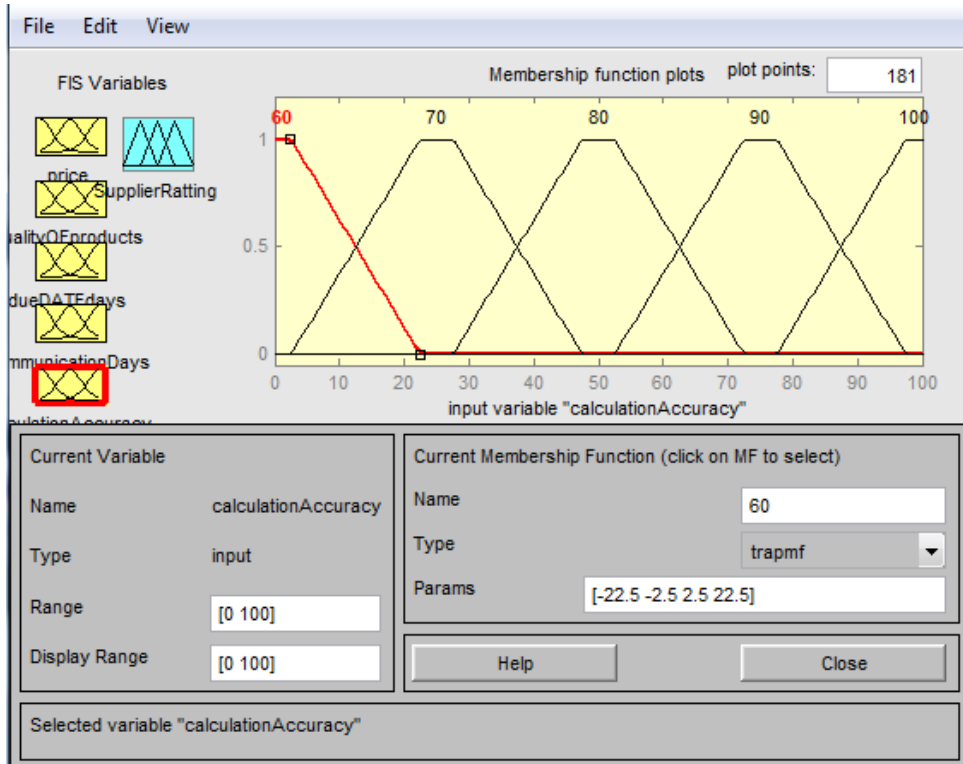**Input and output membership functions**

Price
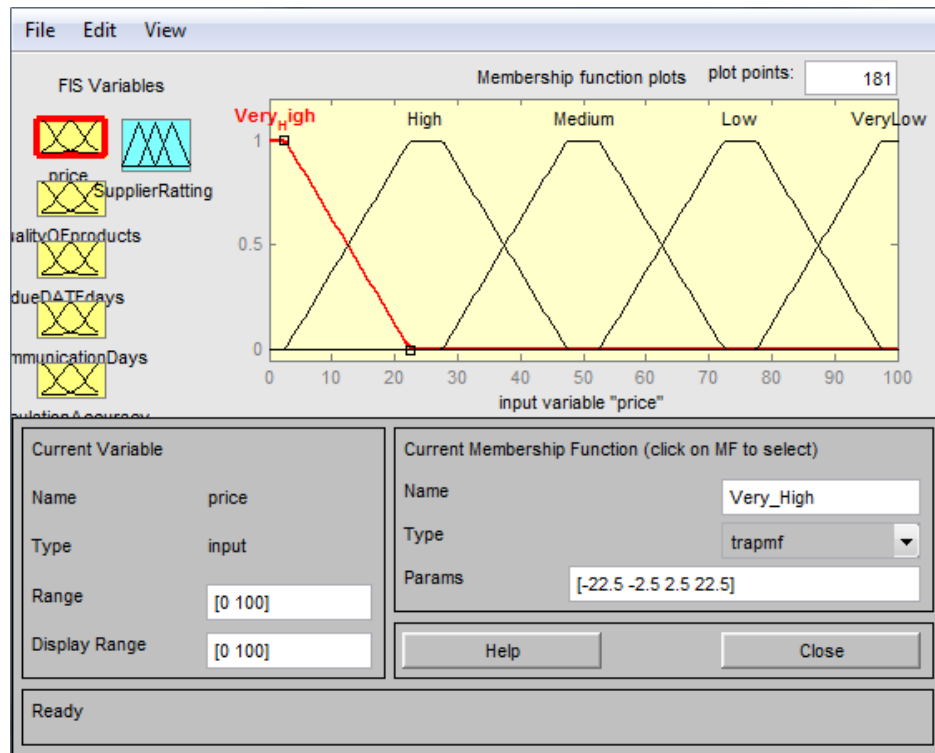
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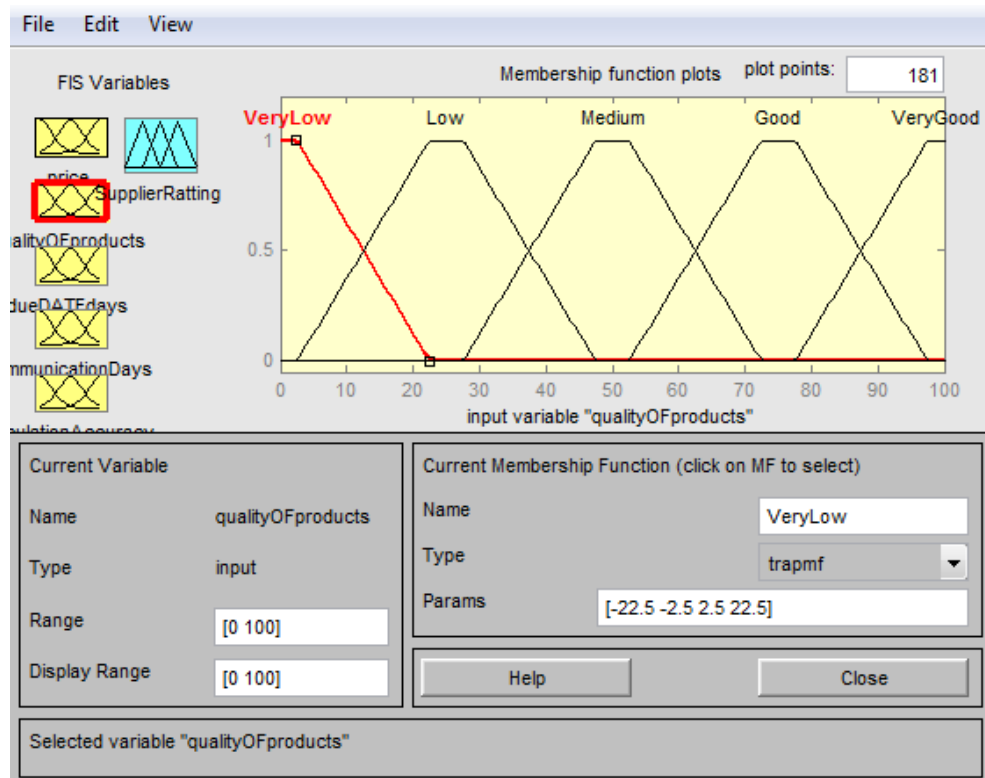
Due date

Communication

Calculation accuracy