# University of Pardubice

## Faculty of Economics and Administration

Modeling of SWOT Analysis Evaluation and Improvement of Weaknesses Using Fuzzy Aggregation and Case Based Reasoning

Dissertation

By: Ing. Meaza Birhane HAILE

Supervisor: doc. Ing. Jiří KŘUPKA, PhD.

Pardubice, September 2017

## Author's statement

I hereby declare:

This thesis was prepared separately. All the literary sources and the information I used in the thesis are listed in the bibliography. I got familiar with the fact that the rights and obligations arising from the Act No. 121/2000 Coll., Copyright Act, apply to my thesis, especially with the fact that the University of Pardubice has the right to enter into a license agreement for use of this thesis as a school work pursuant to § 60, Section 1 of the Copyright Act, and the fact that should this thesis be used by me or should a license be granted for the use to another entity, the University of Pardubice is authorized to claim a reasonable contribution from me to cover the costs incurred during making of the thesis, according to the circumstances up to the actual amount thereof.

I am aware that my thesis will be accessible to the public in the University Library and via the Digital Library of the University of Pardubice in agreement with the article 47b of the Act No. 111/1998 Coll., on Higher Education Institutions, and on the Amendment and Supplement to some other Acts (the Higher Education Act), as subsequently amended, and with the University Pardubice's directive no. 9/2012.

Pardubice 29.09.2017

## Acknowledgment

First of all I would like to thank my supervisor Jiří Křupka, for his unwavering advise and support beyond his obligations throughout my study. I would like to acknowledge Martin Mastalka, for his willingness to work with me, enormous support and expertise in the case studies that shaped this research work. I would also like to acknowledge Katerina Kantorova, for working with me despite the language barrier and for her valuable expert input. Finally I would like to thank my family for their continuous support.

This research was supported by the projects No. SGS_2016_023 'Economic and social development in private and public sector' and No. SGS_2017_019 'Models Synthesis and Analysis for Implementation Support of Smart Cities and Regions Concept' of the Ministry of Education, Youth and Sports of CR at the Faculty of Economics and Administration, University of Pardubice.

## Title

Modeling of SWOT Analysis Evaluation and Improvement of Weaknesses Using Fuzzy Aggregation and Case Based Reasoning


## Summary

*The Czech Republic and most of the EU member countries are developing their internal processes towards transparency and accountability. Where all stakeholders understand what was to be done, what have been done and what is not done, questions related to the strategic planning document. The main aim of this dissertation is the development of a model to measure progress of the local government in achieving the goals and objectives stated in the strategic document and to adopt systematic decision making in the public sector in solving problems.*



## Keywords

*Case based reasoning, Fuzzy aggregation, Multiple criteria decision making, SWOT analysis, Value chain*

## Contents

## List of abbreviations

AHP − Analytic Hierarchy Process

ANP − Analytic Network Process

ATM – Automated Teller Machine

CBR – Case Based Reasoning

CR − Czech Republic

EU − European Union

GDP − Gross Domestic Product

GVA − Gross Value Added

MCDM − Multiple Criteria Decision Making

R&D – Research and Development

RFSC − Reference Framework for European Sustainable Cities

SE – Strategy Evaluation

SP − Strategic Planning

SWOT − Strength, Weakness, Opportunity and Threats

TOPSIS − Technique for Order Preference by Similarity to Ideal Solution

VAT – Value Added Tax

WSAM – Weighted Sum Average Method

## List of figures

## List of tables

# 1. Introduction

The aim of the dissertation work was to create a method for analytically evaluating public organizations based on their strategic planning (SP) specifically using strategy evaluation method: strength, weakness, opportunity and threat (SWOT) analysis and multiple criteria decision making (MCDM). SP is a powerful and efficient tool for government on all levels to define and achieve goals- to design trails and activities that would lead to fulfil them. In early days strategy was seen mainly as a matter of the military. Military history is filled with stories about strategy, how leaders in a war used offensive and defensive strategy to defeat their enemies. In early 19s Henry Fayol suggested that planning should be used as a technique to improve effectiveness of a corporation's performance. However, a little attention was paid to a long term business planning until the end of World War II. SP was first introduced as a discipline in 1950s and 1960s. Although some authors put the beginnings of the SP in the public sector into the 80's in the Great Britain (Bryson & Alston, 2005), (Perlín & Bičík, 2006), there are some earlier notes, in the United States (Eadie, 1983). But the Eastern Europe had to wait for this tool for more than thirty years. Strategic planning can help leaders and managers of public and non-profit organizations think, learn, and act strategically (Bryson, 2011; Haile et al., 2016b).

The socialistic planning system was centralized system that had nothing in common with the modern attitudes used by Western governments. The social-political changes in the late 80's and the early 90's in the Eastern Europe brought not only new freedom but also new challenges for citizens, companies and the governance system as well. In the Czech Republic (CR) when the whole public sector was democratized; local power (and responsibility) was given to the local governments and at the beginning of the new millennium also to new-established regional bodies. The enthusiasm for freedom and defiance the strict socialistic planning led to resignation to planning at all. In some cities were the years when the only valid plans were the budget (1 year) and master plan (focused strictly to spatial division of functions in the city and restricting the building activities). Such a situation was not sustainable. Therefore cities started to use at least 3 years-budget and economy outlooks. In the late 90's the 3-year outlook became to be not good enough for planning the city development and the "new" tool - economic development plans – were adopted. But these documents were still focused to economic issues. As the end of

90’s of the 20th century were in the CR the years of rising economic and social problems there was the demand for new attitudes of governance (Haile et al., 2016b).

Different books define SP different ways; Kenneth comments that it is a pattern of decisions in a company that determines and reveals its objectives, purposes or goals, produces the principal policies and plans for achieving those goals, and defines the range of business the company is to pursue, the kind of economic and human organization it is or intends to be and the nature of the economic and non-economic contribution it intends to make to its shareholders, employee customers and communities (Kenneth, 1998).

Bryson define SP as a disciplined effort to produce fundamental decisions and actions that shape and guide what an organization (or other entity) is, what it does, and why it does it. At its best, SP requires broad-scale yet effective information gathering, clarification of the mission to be pursued and issues to be addressed along the way, development and exploration of strategic alternatives, and an emphasis on the future implications of present decisions. SP can facilitate communication and participation, accommodate divergent interests and values, foster wise and reasonably analytical decision making, and promote successful implementation and accountability (Bryson, 2004).

Abbass, in Management Formulation, Implementation and Control in a Dynamic Environment, also defines SP as the process of assessing the organization and its environment in order to meet the long term objectives of the organization. It refers to a series of decisions taken by management to determine the long term objectives of the organization and the means to achieve these objectives … Through SP, an organization can handle its mission at the same time assessing the relationship of the organization to its environment (Abbass, 2003).

In collective, SP is the comprehensive collection of on-going activities and processes that organizations use to systematically coordinate and align recourses and actions with mission, vision and strategy throughout the organization. It is the art and science of formulating, implementing and evaluating cross-functional decisions that enable an organization to achieve its objectives. SP has many advantages some are discussed below:

- Discharges board responsibility: discharges the responsibility of the board of directors

- Forces an objective assessment: strategic management provides a discipline that enables the board and senior management to actually take step back from day to day business to think about the future of the organization
- Provides a framework for decision making: provides a framework within which all staff can make day to day operational decision and understand that those decisions are all moving the organization in a single direction
- Competitive advantage: is the primary goal of strategic management
- Financial advantage: financial advantage is the result of various areas such as acquisition of cheaper resources, reducing production and focused market campaigns

SP is a successful system if all the necessary information is available and the steps are implemented properly. SP advantages are endless but there are numbers of limitations. The following are some of the limitations of SP:

- SP cannot provide a precise and detailed picture of the future
- The achievement of the SP often focuses on the planning
- Adverse effect may occur if people who planned the strategy are not involved in its implementation
- Lack knowledge of SP techniques
- Lack the necessary knowledge and information about SP and its advantages
- Expensive

Maintaining a perfect implementation of strategic plan for the local government is difficult since city governance is a complicated issue combining many different needs on many levels and in many fields. The local government is the one that is the closest to the public. In the central European perspectives, inhabitants know their mayor and municipality employees usually in person therefore the responsibility for the outputs and outcomes of the management and city development is much higher than on other levels of the governance. This close interaction of the local stakeholders is a positive contribution to the local development but include some threats as well. The group of the decision-makers faces the threat of the lock-in and not absorbing new ideas and impulse from the society. To prevent this situation the main goals of the local society

are expressed in the strategic development documents. These documents are created in cooperation between four main groups of actors in the city/region - local government plus public authorities, private companies, universities and the public. They set up the direction of the local development, define the goals and aim. The everyday work on the action level is up to the local government. As written above the local government has to balance many different needs and demands in the city. Not only the strategic goals but also the national and EU regulations, goals of their regional policies and of course there is a duty of ordinary city maintenance

In this dissertation the advantages of SP for the public sector and the steps of SP are discussed briefly and the evaluation of SP using strategy evaluation (SE) method specifically SWOT analysis, using MCDM and fuzzy aggregation methods are discussed in detail. The application of the proposed model for selecting projects at the local level and a solution for improving the success of public sector especially cities of the European Union (EU) member countries are also discussed.

This dissertation is organized in sections; introduction discussed above, goal of dissertation: explains the aim of the dissertation model of the dissertation work, material and methods section discusses material and methods and material researched for this work, in the discussion and results section case studies are presented, the CBR prototype developed in the dissertation work is also discussed in this section. Conclusion section presents the general achievements of the research. There are list of references and appendix, in the appendix a questionnaire used in this research and list of EU projects discussed in sections 4 and 5 are presented.

## 2. Goals of the dissertation

The aims of the dissertation work were to create analytic model of SE for public organisation that the results from the evaluation will reflect the current status of a public organisation and would easily be understood by stakeholders without further explanation. CBR was also proposed to improve public administration by sharing experience with other similar organizations.

The first step was to choose a SE method, SWOT analysis was chosen for this dissertation. The analysis was chosen for its simplicity, familiarity and that the success of all public and non-profit organizations as any other organization depends not only on the organizations internal quality but also on the surrounding environment.

The second step was to find a suitable multiple criteria decision making or fuzzy aggregation method to analytically evaluate the results of SWOT analysis in a way all stakeholders could understand. Different multiple criteria decision making methods such as Analytic Hierarchy Process (AHP), Analytic Network Process (ANP), Fuzzy AHP and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) were researched. Fuzzy aggregation methods such as fuzzy measure and fuzzy integrals were also researched and a decision was made to use the fuzzy aggregation methods Sugeno fuzzy lambda measure and Choquet fuzzy integral for the evaluation and the MCDM methods for analysing strategy options depending on the type of input data

These evaluation methods were also used for improving decision making process for the local government. A case study is also presented in section 4, on how to implement the methods discussed here for project selection, how the change in decision making could change based on weights were represented for local experts to show the advantage of contemporary decision making. The results were evaluated by experts.

The strategic planning process has been implemented into the local governance environment in the CR during last two decades. And the strategic goals that are expressed in the strategic development documents on the local level are the part that are to be fulfilled or solved by the local government. The CR and most of the EU member countries are developing their internal processes towards transparency and accountability. Where all stakeholders understand what was to be done, what have been done and what is missing. All this questions are related to the SP

document. Therefore local governments can use the proposed method to show the progress of the local government in achieving the SP goals. The model studied and proposed in this dissertation work is shown in the following figure (Fig. 1)

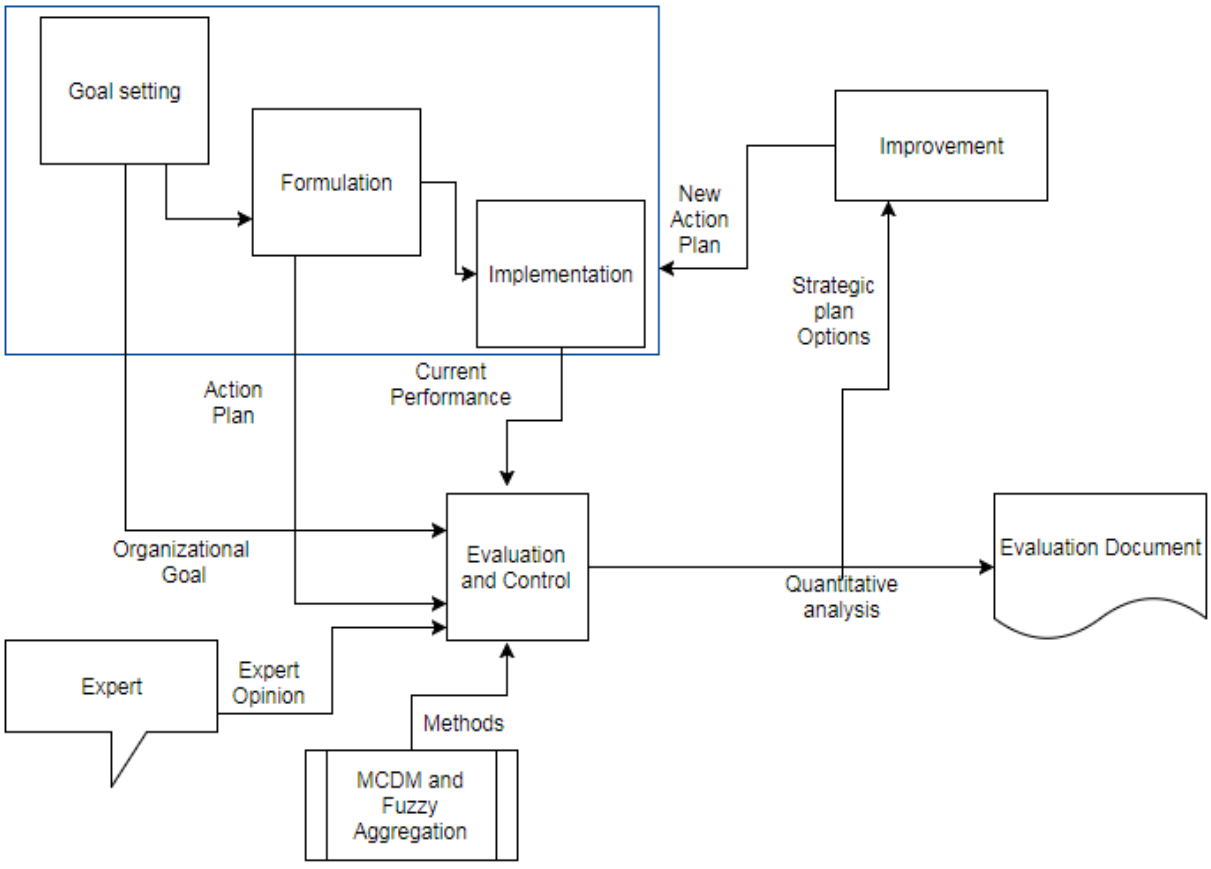



**Fig. 1 Output model**
Source: Author

Furthermore, the application of CBR for improving public organizations' weakness was researched since identifying and analysing a status of an organization with respect to its environment is only the first step in improving the success of the organization, in addition to the strategy option selection model designed. By using CBR method different cities of a country or cities of EU member countries could solve their problems using others experience. The possibility of different cities of EU member countries facing the same problem at the same or different point in time was researched.

The main benefit and out puts of the dissertation work are:

- To implement quantitative evaluation on SP of the public sector

- To test the proposed method for different organizations as to proof the feasibility of the method
- To use these quantitative methods to choose effective strategy
- To evaluate the proposed method using experts from relevant fields of study
- To introduce smart decision making in the public sector, to improve the success of SP
- To research if common threats in SP of EU cities exist
- To propose a method to share experience among EU cities to overcome threats and learn from one another in order to implement the EU goal in public administration

# 3. Methods and material

Scholars state that experience demonstrates that SP can be successfully used by public agencies, departments, or major organizational divisions, general-purpose governments, such as city, county, state, or tribal governments. Although measuring the performance of non-profit or governmental organization is different from measuring the success of business where assets, capital and market share could be used, Eldridge states that there are greater restraints on rewards and punishment in government systems; a government unit is subject to greater influence from changes in its leadership. Businesses normally use financial measures to measure performance, and the data for these measurements are readily available. Few government agencies are in a similar position. Governments find it difficult to establish yardsticks to measure performance on many programs that provide services, especially in the area of social programs. Measurement is a fundamental part of strategic control. Without measurement, there is no means for feedback and evaluation, and therefore strategies can become stagnant, decoupled from their intended effect (Kenneth, 1998; Barry 1997; Barry, 2001).

According to (Bryson, 2005, 2011) the benefits of strategic planning for public and nonprofit organization can be of many kinds, including:

- Promotion of strategic thinking, acting, and learning (e.g., understanding context, clarifying mission, figuring out what strategies are best, negotiating performance measures and standards, building needed coalitions of support)
- Improved decision making (e.g., making decisions tied to organizational purposes and in light of future strategic consequences)
- Enhanced organizational effectiveness, responsiveness, and resilience (e.g., meeting mandates, fulfilling mission, improved overall coordination and integration, better performance control, satisfying stakeholders according to their criteria, adapting to environmental changes)
- Enhanced effectiveness of broader societal systems (e.g., collaborating with others, often across sector boundaries, to address broad public problems)
- Improved organizational legitimacy (e.g., based on satisfying key stakeholders and creating real public value at reasonable cost)

- Direct benefits for the people involved (e.g., human and social capital building, improved morale, fulfillment of job responsibilities, improved competency, enhanced job prospects, reduced anxiety)

The activities of strategic planning vary from author to author, but the main step and the tasks are substantially consistent in each case:

- Goal setting: Review and update or prepare a Mission Statement for the organization. An organization will determine the factors that define its current state, list down the factors needed to reach its target state and then plan on how to fill the gap between the two states.
- Analysis: This is the step where all relevant data and information is collected and analyzed based on the goal, mission and vision. This includes identifying external factors that affect the success of the organization and internal strength and weakness. Morden (2007) defines this step as a process by which the enterprise examines its own internal or corporate characteristics and capabilities; and identifies the most important features of the external environment with in which it must operate.
- Strategy formulation: The first step in forming a strategy is to review the information from the analysis then organizations choose the most appropriate courses of action to achieve its defined goals. This step provides a framework for the actions that will lead to the expected results.
- Strategy implementation: this is where the action of the strategic planning process begins. Strategy implementation is the stage of strategic planning that involves the use of managerial and organizational tools to direct resources towards achieving strategic outcomes. Strategy implementation is accomplished through organizational design and structure. It is the action that converts strategy formulation into reality and accomplishment. Creating a climate and structure in the organization that forces planning and encourages participation is essential in the implementation process. Strategy implementation will depend on the nature of knowledge, technology and competence resources available to the organization. Creating a perfect strategic plan for an organization by itself does not guarantee success of an organization. It is important to structure the organization and allocate its resources efficiently based on the strategic plan.

- Evaluation and control: This process is ongoing through the existence of an organization. It answers such questions as: is the strategic plan appropriate? Is the plan being implemented properly? Is the plan guiding the organization to achieve its mission, vision, and goal? How is the organization performing? Does the plan need to be amended or changed? SE is not the same for public and non-profit organization as profit organizations since their success can be measured in terms of their change in capital, market share, and competitiveness with other organizations in the same industry.

For public and non-profit organizations, effective strategy must create public value at reasonable cost or serious consequences are likely to ensue. Increasingly, integrated use of human resources, information technology, and financial management are crucial elements of organizing, strengthening, protecting, and sustaining organizational capabilities for creating public value (Bryson, 2004). There are four commonly referred SE techniques:

- Gap analysis: is a performance analysis where actual performance is compared with potential analysis. In gap analysis, organizations identify their future state, current situation and identify way to bridge the gap between current situation and future state.
- Benchmarking: benchmarking is an effective approach towards improvement in productivity, quality and other dimensions of performance that are determinants of competitiveness. In order to determine the benchmark performance to be set it is essential to discover the special requirements for performing the main task.
- Political, Environmental, Social and Technological (PEST) analysis: Pest analysis is a scan of external macro-environment in which an organization exists. For example inflation rate, growth domestic product, political stability and culture of the environment where the organization operates. It can be used for evaluating market growth or decline, and such the position, potential and direction for a business. PEST analysis could address different environmental issues based on the organization and its product the following table shows factors we should consider for a product or service providing organization.
- SWOT analysis: is analysis of an organization with respect to the surrounding environment. SWOT analysis was chosen in this dissertation work since the success of public and non-profit organizations as any other organization depends not only on

the organizations internal quality (staff, economy or public relation) but on also on the surrounding environment (political interference, available fund or private sector). The primary aim of strategic planning is to bring an organization into balance with the external environment and to maintain that balance over time (Sackett et al., 2005). Organizations usually have multiple characteristics under each category of SWOT analysis.

## 3.1 SWOT analysis

While evaluating a strategy the main aspects that should be considered are evaluation of both internal and external factors that form the basis of the strategy and evaluation of its performance. SWOT analysis is used for identifying the importance of sub characteristics in order to choose the best strategy for an organization. However, this practice does not provide analytical means to evaluate importance of characteristics. Some authors have proposed methods to quantify results of a SWOT analysis: (Yuksel & Dagdeviren, 2007) used ANP to develop evaluation method for SWOT analysis. Chang and Huang (Chang & Huang, 2006) discussed application of a quantification SWOT analytical method and (Sevkli et al. 2012) applied fuzzy ANP, (Houben et al. 1999).

Businesses perform SWOT analysis when entering a new market, to evaluate their strategy or while launching a new product. SWOT stands for identifying organization's Strength, Weakness, Opportunity, and Threat (Humphrey, 2005, 2012). Strength and weakness are most often viewed from the organization's point of view whereas opportunities and threats are considered as external environmental factors. Strength is what an organization has or what it can offer that others of its type do not. Weakness in opposite is what an organization does not have or does not offer others of its type do. Opportunities are advantages in the environment that an organization could use. Threats are situations in an organization's environment that could compromise the organization's success. A number of other authors have contributed to its present form, who have tried different ways of its application. SWOT analysis is an excellent tool for coaching, which helps to identify the most notable activities, affecting the success of business.

SWOT analysis should include strategically important facts that are both realistic and valid in the range of about 6 months to 2 years. Within the SWOT analysis, it is also important to look at the interrelationships between strengths and weaknesses, opportunities and strengths.

This is mostly the case as part of the comparison of processed data. These synergies can be used to determine the company's strategy and development.

SWOT analysis can be used as a tool to determine and optimize a company's strategy, project, or decision-making to improve the current state of the organization or its individual processes. Based on the outcome of the comparison of the internal and external environment, it is possible to decide which basic strategy is most important for the investigated entity. SWOT analysis offers the following strategic options:

• MAX-MAX strategy - maximizing strengths - maximizing opportunities

• MIN-MAX strategy - minimizing weaknesses - maximizing opportunities

• MAX-MIN strategies - maximizing strengths - minimizing threats

• MIN-MIN strategy - minimizing weaknesses - minimizing threats

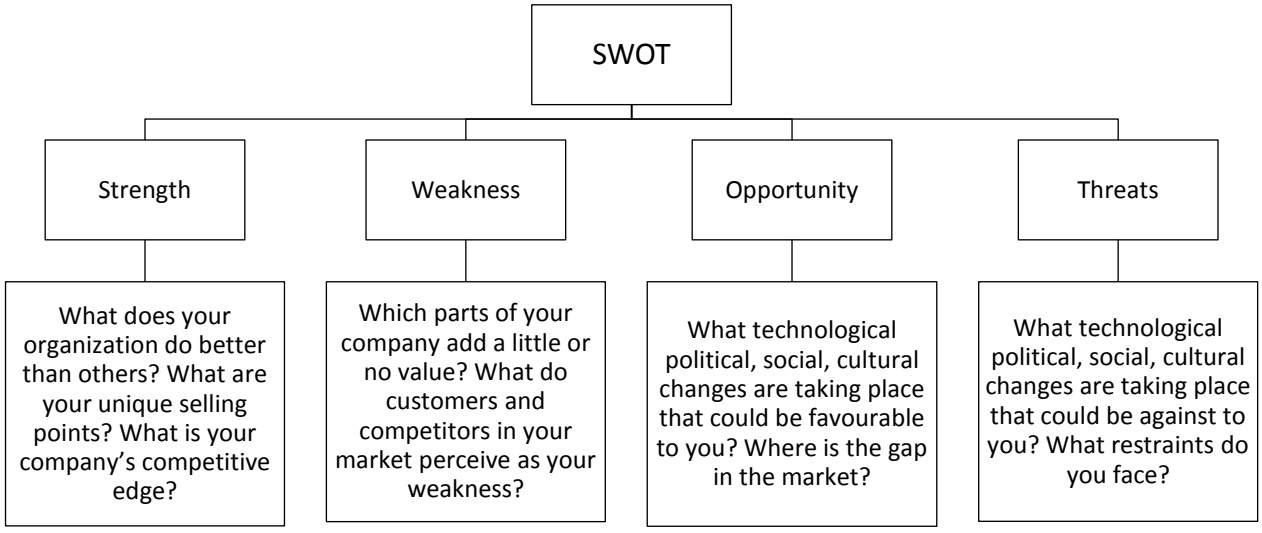



**Fig. 2 SWOT analysis and some questions its sub characteristics should address**
Source: process based on (Humphrey, 2005, 2012)

The SWOT analysis can also be used for non-profit organizations, governmental units and for individuals for decision-making situation when a desired objective has been defined (Scolozzi et al., 2014), (Amin et al., 2011) and (Haile & Krupka, 2016a). SWOT sub characteristics and their priorities are highly dependent on the type of organization (Humphrey, 2005, 2012), (Chang & Huang, 2006) and (Yuksel & Dagdeviren, 2007) the figure (Fig. 2) below shows the general description of SWOT characteristics in a hierarchical structure.

**Main steps in application SWOT analysis**

The SWOT analysis procedure should follow: The right procedure:

1. Specification for SWOT analysis
2. Assembling a team of specialists
3. Defining the internal and external environment and the environment
4. Specifying factors in the individual quadrants of a SWOT matrix
5. Proof of evidence to individual factors
6. Selection of the most important factors
7. Define key success factors / failures
8. Selection of the SWOT strategy (max-max, min-max, ...)
9. Creating a company strategy
10. Creating a plan to implement the strategy

In the dissertation work the SWOT analysis was also used as evaluation tool therefore the last step in (define SWOT strategy) is not discussed in some of the cases.

## 3.2 Multiple criteria decision making

MCDM is one branch of decision making that studies decision problems where the decision space is continues; there are many MCDM methods each has its own characteristics. There are many ways to classify these methods such as based on the data they use deterministic, stochastic or fuzzy or based on the number of decision maker involved (Panos, 2000).

There are many well-known multiple criteria decision making methods some of them are: the Weighted Sum Average Method (WSAM), AHP, ANP, Elimination and choice translating reality; English translation of the French original, ELimination Et Choix Traduisant la REalité (ELECTRE), TOPSIS.

WSAM: is probably the most commonly used approach, if there are m alternatives and n criteria then the best alternative is the one that satisfies most. The assumption that governs this model is the additive utility assumption. That is the total value of the alternative is equal to the sum of the products.

$$A_i^{WSM} = \sum_{j=1}^{n} w_j a_{ij}, for\ i = 1,2,3 \dots, m. \quad 3.1$$

Where $w_j$ denotes the relative weight of importance of the criterion and $a_{ij}$ is the performance value of alternative $A_i$ when it is evaluated in terms of criterion.

TOPSIS: was developed by Yoon and Hwang in 1980. TOPSIS calls for ordinal information on attributes of variants as well as the criteria preference expressed in weight vector. It is based on measuring distance from the ideal and negative-ideal solution. TOPSIS assumes that each attribute takes the monotonically increasing or decreasing utility. One approach is to take an alternative which has the weighted minimum Euclidean distance to the ideal solution (Panos, 2000).

Step 1: Transfer the cost criteria into the benefit criteria

$$x'_{ij} = 2\bar{x}_j - x_{ij} \tag{3.2}$$

Step 2: Construct the normalised decision matrix

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{p} x_{ij}^{\,2}}} \tag{3.3}$$

Step 3: Construct the weighted normalised decision matrix $W=\{w_{ij}\}=\{v_j r_{ij}\}$

$$W=\begin{bmatrix} v_1r_{11} & v_2r_{12} & \dots & v_nr_{1n} \\ v_1r_{21} & v_2r_{22} & \dots & v_nr_{2n} \\ \dots & \dots & \dots & \dots \\ v_1r_{m1} & v_2r_{m2} & \dots & v_nr_{mn} \end{bmatrix} \tag{3.4}$$

Step 4: Determine the ideal $H = (h_1,\dots,h_n)$ and negative-ideal $D = (d_1,\dots,d_n)$ solution

$$d_j = \min_{i=1}^{m}\left(w_{ij}\right),\ j = 1,\dots n$$
$$h_j = \max_{i=1}^{m}\left(w_{ij}\right),\ j = 1,\dots n \tag{3.5}$$

Step 5: Calculate the separation measures

from the ideal solution

$$d_i^{+} = \sqrt{\sum_{j=1}^{k}(w_{ij} - h_j)^2} \tag{3.6}$$

from the negative-ideal solution

$$d_i^- = \sqrt{\sum_{j=1}^{k} (w_{ij} - d_j)^2} \quad 3.7$$

Step 6: Calculate the relative proximity to the ideal solution

$$c_i = \frac{d_i^-}{d_i^+ + d_i^-} \quad 3.8$$

Step 7: Order the variants according to the $c_i$ where the highest value the better; $c_i = 1$ is ideal solution $c_i = 0$ is negative-ideal solution $c_i$ max compromise solution.

AHP: was originally developed by Prof. Thomas L. Saaty, it is a method that derives ratio scales from paired comparisons. Input for the method can be obtained from actual measurement such as price, weight, cost so on, or from subjective opinions such as preference; it allow some inconsistency in judgment. The ratio scales are derived from the principal Eigen vectors and the consistency index is derived from the principal Eigen value. AHP method consists three levels of hierarchy. The first hierarchy level is the goal of the decision making, the second level of hierarchy is how each of the existing criteria contributes to the goal achievement, and the last level of hierarchy is to find out how each of the alternatives contributes to each of the criteria. But the hierarchy could increase based on the type problem (Yu-Cheng, 2011).

Fuzzy AHP: is an extension on AHP proposed by Thomas L. Saaty in the 1980s. AHP has been successfully applied for a series of problems in the method decision makers preference is represented using exact numbers. However, it is usually impossible to assign exact number for judgment. Fuzzy scale is used in fuzzy AHP method to integrate an aggregation mechanism to allow expression of multiple points of views as shown in the following table (Yu-Cheng, 2011),

**Table 1. Fuzzy scale of relative preference**

| Linguistic scale | Triangular fuzzy scale |
|---|---|
| Just equal | (0,0,0) |
| Equal importance | (0,1,3) |
| Weakly importance | (1,3,5) |
| Strongly more importance | (3,5,7) |
| Very strongly more importance | (5,7,9) |
| Absolutely more importance | (7,9,9) |

Source: (Yu-Cheng, 2011)

ANP: was developed by Thomas L. Saaty as a generalization of AHP. AHP builds a hierarchy of decision items using comparisons between each pair of items expressed as a matrix. Paired comparisons produce weighting scores that measure how much importance items and criteria have with each other. In AHP dependency among sibling problems or characteristics and bidirectional dependency is not supported, which makes it less desirable to use where items are networked. ANP has been applied by different researchers for different purposed including for evaluation of SWOT analysis in combination with other methods and by itself (Diederik, 2007), (Yuksel & Dagdeviren, 2007), (Tramarico et al., 2015). ANP is a general theory of relative measurement used to derive composite priority ratio scales from individual ratio scales that represent relative measurements of the influence of elements that interact with respect to control criteria. A hierarchy is a linear top down structure; a network spreads out in all directions and involves cycles between clusters and loops within the same cluster (Saaty, 2001a, 2001b, 2005). ANP unlike AHP allows feedback and loop for decision problems by obtaining the composite weights through the development of a sub matrix. Super matrix is a partitioned matrix, where sub matrix is composed of a set of relationships between two components or clusters in a connection network structure (Bayazit, 2006). ANP process has two parts; the first part is a control hierarchy or network of criteria and sub criteria that controls the interaction. The second part consists of a network of influence among the elements and clusters (Saaty, 1996). The main steps of ANP process include: (1) identifying the elements and clusters; (2) create the model; (3) determine the interdependencies; (4) construct pairwise comparison matrices between the clusters and elements; (5) build super matrix (Gang et al., 2013). As an example of application of the ANP for software evaluation is discussed below, which shows the detail processes of the above five steps of the ANP model for choosing the best software product is discussed in detail (Haile, 2014).

Step 1: the first step was to identify relationships among different characteristics and sub characteristics, if relationship occurs among sub characteristics or if there exists a bidirectional relationship, it should be represented in a network otherwise in hierarchical structure. For instance if a developer wants to develop a software that needs sorting algorithm with fastest run time it is likely that a time space trade off should be done. Therefore, a software developer makes trade off of characteristics based on the stated user requirement.

**Table 2. The Saaty's 9-points rating scale**

| Intensity of importance | Definition | Explanation |
|---|---|---|
| 1 | Equal importance | Two activities contribute equally to the objective |
| 3 | Moderate importance | Experience and judgment slightly favor one activity over another |
| 5 | Strong importance | Experience and judgment strongly favor one activity over another |
| 7 | Very strong importance | An activity is strongly favored and its dominance demonstrated in practice |
| 9 | Absolute importance | The evidence favoring one activity over another is of the highest possible order of affirmation. |
| 2,4,6,8 | Intermediate values | When compromise is needed |
| Reciprocal of above non-zero numbers | If activity I has one of the above nonzero numbers assigned to it when compared with activity j, then j has the reciprocal value when compared with i. | |

Source: (Saaty, 1996)

After understanding, interdependencies and relationships among characteristics a survey should be conducted with experts to decide importance characteristics for a specific organization using Saaty's 9-points ratting scale of preference (Saaty, 1996) shown in the table above (Table 2.).

Step 2: is formulating interdependencies and performing pairwise comparisons among characteristics, sub characteristics and alternative solutions. The hierarchy and network model could be composed of any number of levels depending on the problem at hand where the first level is the best solution expected and the last level is alternative solutions. The software product evaluation model consists five levels. The first level is the best software product with highest quality. In the second level are quality models, internal, external and quality in use models, the third and the fourth level contains quality characteristics and sub characteristic, respectively. The last level is composed of alternative software products (Saaty, 1999, 2008). The matrix representation for the figure below shown in Fig. 3a is as follows:

$$W_h = \begin{array}{r} \text{Qualitysoftware} \\ \text{Quality model} \\ \text{Quality characteristics} \\ \text{Quality subc haracteristics} \\ \text{Alternative software} \end{array} \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ W_{21} & 0 & 0 & 0 & 0 \\ 0 & W_{32} & 0 & 0 & 0 \\ 0 & 0 & W_{43} & 0 & 0 \\ 0 & 0 & 0 & W_{54} & I \end{bmatrix} \quad 3.9$$

Where $W_{21}$ is a vector, which represents the impact of best quality software on quality models, $W_{32}$ represents the impact of quality models on quality characteristics, $W_{43}$ represents the influence of quality characteristics on quality sub characteristics, $W_{54}$ depicts the influence of sub characteristics on each alternative software solution, $I$ is the identity matrix, and zeros represent those elements having no influence.

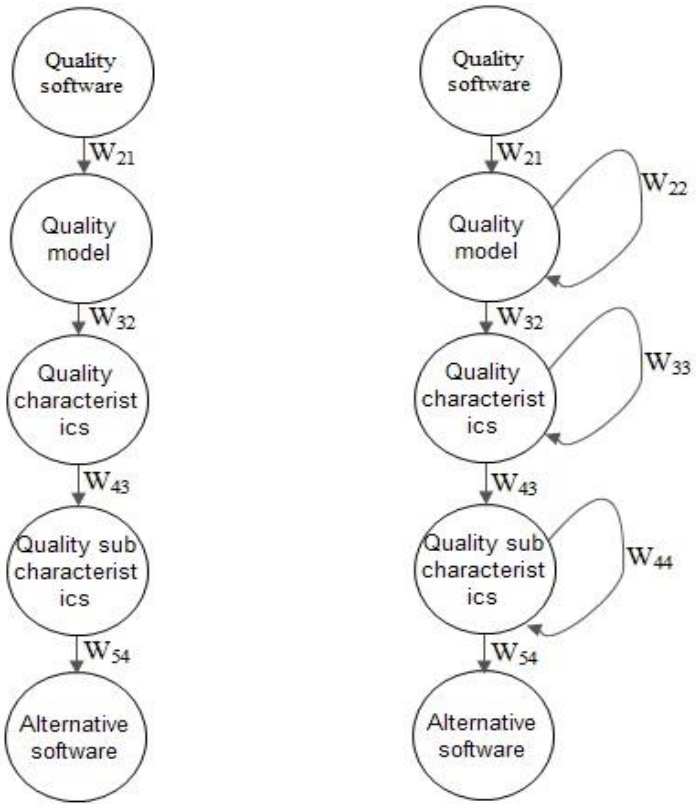



**Fig. 3 Hierarchy and Network structure Hierarchy (a) and Network (b)**
Source (Haile, 2014)

$$W_n = \begin{array}{r} \text{Qualitysoftware} \\ \text{Quality model} \\ \text{Quality characteristics} \\ \text{Quality subc haracteristics} \\ \text{Alternative software} \end{array} \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ W_{21} & W_{22} & 0 & 0 & 0 \\ 0 & W_{32} & W_{33} & 0 & 0 \\ 0 & 0 & W_{43} & W_{44} & 0 \\ 0 & 0 & 0 & W_{54} & I \end{bmatrix} \quad 3.10$$

The above matrix represents the network structure of quality model shown in the figure above, Fig. 2b, with the additional vectors $W_{22}$, $W_{33}$, and $W_{44}$. $W_{22}$ represents the interdependency among internal, external and quality in use quality measures; that is to show how internal quality affects external quality and how achieving quality in use depends on achieving these two quality measures. $W_{33}$ represents the effect and dependency among quality characteristics. Achieving one quality characteristics could guarantee achievement of other characteristics or result in a trade off with other characteristics the same is true for quality sub characteristics and this is represented by $W_{44}$.

Step 3: is to assume that there is no dependency among quality measures (internal, external and quality in use) and to determine their priorities with respect to the goal (Quality software) using pairwise comparison that is to calculate $W_{21}$. Pairwise comparison for the above matrix is performed the same way as AHP, using Saaty's matrix. The elements of this matrix are an estimation of importance of $i^{th}$ and $j^{th}$ criteria, using the above stated 1, 3,5,7,9 scale. This is a 'reciprocal matrix' that has all positive elements and has the reciprocal:

$$s_{ii} = s_{jj} = 1 \;\; i = 1,2, \dots, k; \; j = 1,2, \dots, k \tag{3.11}$$

$$s_{ji} = 1/s_{ij}\,, i, \tag{3.12}$$

The criteria weights or variant values are then normalized by geometrical mean of lines of matrix S (Saaty, 2008):

$$v_i = \frac{\left[\prod_{j=1}^{k} s_{ij}\right]^{1/k}}{\sum_{i=1}^{k}\left[\prod_{j=1}^{k} s_{ij}\right]^{1/k}} \quad i = 1,2,\dots,k \tag{3.13}$$

Step 4: Inner dependence among quality measures is then determined by the impact of each quality measure on every other using pairwise comparison. Since we established above in order to achieve quality in use achieving internal and external quality is prerequisite. Inner dependence among characteristics and sub characteristics is determined the same way. In this step the questions such as; what is the relative impact of internal quality compared with external quality for achieving quality in use, $W_{22}$? What is the relative importance of functional suitability, reliability, performance efficiency, operability, security, compatibility and portability on

achieving maintainability, $W_{33}$? And so on. Not all quality models, characteristics, and sub characteristics influence each other, in a matrix this is represented by zero.

Step 5: calculate interdependent priorities of quality model, *Qm*, characteristics, *ch* and sub characteristics *sch*; i.e. $W_{Qm} = W_{22} \times W_{21}$, $W_{Qch} = W_{33} \times W_{32}$, $W_{Qsch} = W_{44} \times W_{43}$.

Step 6: determine the global importance degrees of quality characteristics by multiplying interdependent priorities of quality model ($W_{Qm}$) with interdependent priorities of characteristics ($W_{Qchs}$) obtained in step five and global importance degrees of quality sub characteristics is then determined by multiplying this result with interdependent priorities of quality sub characteristics ($W_{Qsch}$).

Step 7: determine the importance of alternative software solution with respect to each quality sub characteristics using pairwise comparison, $W_{54}$.

Step 8: determine overall priorities of alternative software solution, reflecting the interrelationships with global importance degrees of software quality sub characteristic by multiplying global importance degrees of quality sub characteristics by $W_{54}$.

**Main steps in application of MCDM**

Panos describe the three steps in utilizing any decision-making technique involving numerical analysis of alternatives (Panos, 2000).

1. Determine the relevant criteria and alternatives
2. Attach numerical measures to the relative importance of the criteria and to the impacts of the alternative on these criteria
3. Process the numerical values to determine a ranking of each alternative

## 3.3 Fuzzy aggregation methods

Most of the MCDM focus more on the modeling of what could be called the choice procedure, rather than on the aggregation step. However, years ago in Japan the concept of fuzzy integral was proposed by Sugeno which in the discrete case is merely a kind of distorted mean. Although this was followed by a rather mathematically oriented research, far from application concerns, some Japanese researchers, including Sugeno himself, thought that fuzzy integrals could be applied to multiple criteria evaluation. Since 1985, papers have been published on the

application of the method. The distinguishing feature of a fuzzy integral is that it is able to represent a certain kind of interaction between criteria, ranging from redundancy (negative interaction) to synergy (positive interaction) (Grabisch, 1996).

**Fuzzy measures**

Measure in its classic definition uses additive property, but most real world problems cannot be measured using additive measures. In most of the cases fuzzy measures are considered as monotonic because it has applications in many fields such as data mining, image processing and so on, there are also non monotonic fuzzy measures which are defined as: Suppose that (X, P, $\mu$) is a measureable space, a fuzzy measure is a function $\mu$ : P$\rightarrow$[0,$\infty$] such that $\mu(\varnothing)$ = 0 is called non monotonic fuzzy measure. Every monotonic fuzzy measure is a non-monotonic fuzzy measure (Sugeno, 1974).

Fuzzy measure can be defined as:

Let X be a finite index set X = {1, ..., n}.

Definition: A fuzzy measure μ defined on X is a set function $\mu$ : P(X)$\rightarrow$[0,1] satisfying the following axioms (Grabisch et al., 2000) and (Sugeno, 1974): $\mu(\varnothing)$ =0, $\mu(X)$=1, and A$\subseteq$B $\Longrightarrow$ μ(A) $\leq \mu(B)$.

The P(X) indicates the power set of X, i.e. the set of all subsets of X.

A fuzzy measure on X needs $2^n$ coefficients to be defined, which are the values of $\mu$ for all the different subsets of X. Fuzzy integrals are integrals of a real function with respect to a fuzzy measure, by analogy with Lebesgue integral which is defined with respect to an ordinary (i.e. additive) measure. There are several definitions of fuzzy integrals, among which the most representatives are those of Sugeno fuzzy Integral (Sugeno 1974) and Choquet fuzzy Integral (Choquet, 1953).

Definition: Let $\lambda\epsilon(-1, \infty)$ and let X = $\{x_1, x_2, \ldots, x_n\}$ be a finite set. If (X, P(X)) is a measurable space and if set function $g_\lambda$:P(X)$\rightarrow$[0,1] satisfies the following conditions, then $g_\lambda$ is denoted by a Sugeno λ measure and $g_\lambda(\varnothing)$=0, $g_\lambda(X)$=1; A∩B=∅, A∪B≠X $g_\lambda(A\cap B)=g_\lambda(A)+g_\lambda(B)+\lambda g_\lambda(A)g_\lambda(B)$ that

$$\lambda + 1 = \prod_{i=1}^{n} (1 + \lambda g_\lambda(x_i)),\ \lambda > -1 \qquad 3.14$$

where $g_\lambda(x_i)$ is fuzzy measure.

**Fuzzy integrals**

Fuzzy integrals are interesting tools to summarize all the pieces of information provided by a function in a single value; this value could be a sort of average of the function, in terms of the underlying fuzzy measure. Fuzzy integrals permit the aggregation of information under different assumptions on the independence of the information sources. In particular, to model situations in which sources are independent as well as in situations in which such independence cannot be assured. Many authors have used fuzzy integrals, among are: (Yang, 2012), Measuring Software Product Quality with ISO Standards Based on Fuzzy Logic Technique. Authors in China have used fuzzy integrals for comprehensive framework for measuring the performance of an organization resource planning (Wei et al., 2008) and other researchers have used fuzzy integrals for handwritten signature verification (Singh et al., 2013) and many others (Torra & Narukawa, 2004), (Chang et al, 2008), and (Verkeyn et al., 2011).

***Sugeno fuzzy integral***

Sugeno integral is an integral based on fuzzy measure. Suppose that $\mu$ is a fuzzy measure on X, the Sugeno integral of a function $f$: X $\rightarrow$[0, 1] with respect to fuzzy measure $\mu$ is defined as (Sugeno, 1974):

$$\int f(x)d\mu = max\ (min\ (f(x_i),\ \mu(A_i))) \qquad 3.15$$

where { $f(x_1), f(x_2), f(x_3), \ldots\ldots, f(x_n)$} are the ranges and they are defined as $f(x_1) \leq f(x_2) \leq f(x_3)$ ……. $\leq f(x_n)$. Represented in the following figure Fig. 4 where $\alpha$, is a permutation of $f(x)$ and

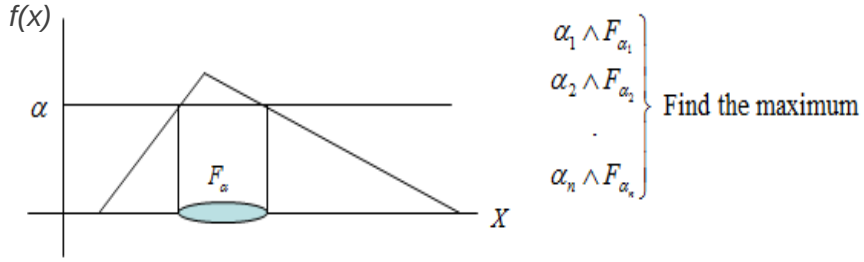



**Fig. 4 Sugeno fuzzy integral**
Source (Sugeno, 1974)

***Choquet fuzzy integral***

Fuzzy integrals are integrals of a real function with respect to a fuzzy measure, by analogy with Lebesgue integral which is defined with respect to an ordinary (i.e. additive) measure. There are several definitions of fuzzy integrals, among which the most representatives are those of Sugeno fuzzy Integral (Sugeno, 1974) and Choquet fuzzy Integral (Choquet, 1953).

Choquet Fuzzy integral is a fuzzy integral based on any fuzzy measure that provides alternative nonlinear computational scheme for aggregating input information unlike other fuzzy models. Choquet fuzzy integral is used in multiple criteria decision-making problems where the decision criteria are interactive: (Yang, 2012), (Wei et al., 2008) and by the authors of this research for analytical evaluation of SWOT analysis.

Choquet fuzzy integral was chosen over Sugeno fuzzy integral for this work since the Sugeno method is based on min and max, such integral calculation can only determine interval at which the measured values are possibly located, unlike Choquet fuzzy integral, which provides a unique solution. The following figure demonstrates the basic idea behind choquet integral (Choquet, 1953).

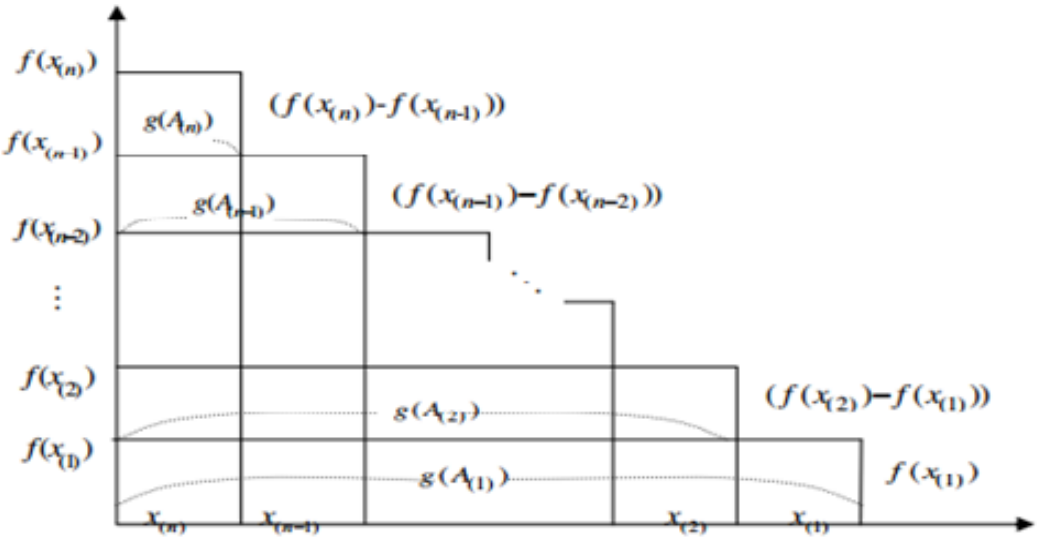



**Fig. 5 Choquet fuzzy integral**
Source: (Choquet, 1953)

Definition: Let μ be a fuzzy measure on X. The discrete Choquet fuzzy integral of a function f: $X \rightarrow IR^{+}$ with respect to $\mu$ is defined by

$$C_{\mu}(f(x_1), ..., f(x_n)) = \sum_{i=1}^{n} (f(x_1) - f(x_{i-1}))\mu(A_i) \qquad 3.16$$

Where i indicates that the indices have been permuted so that $f(0) \leq f(x_1) \leq \ldots \leq f(x_n) \leq f(1)$. Also $A_i = \{x_i, \ldots, x_n\}$, and $f(0) = 0$ (Choquet, 1954).

Definition: Let set function g: P(X)→[0,1] be a fuzzy measure on measurable space (X,P(X)), and $h$: X→[0,1] be a measurable function on X. If $h(x_1) \leq h(x_2) \leq \ldots \leq h(x_n)$, $A_i=\{x_i, x_{i+1}, \ldots, x_n\}$ then (Grabisch et al.,2000) , (Choquet, 1953)

$$E^{def} = \int h dg^{def} = h(x_1)g(A_1) + \sum_{i=2}^{n} \left(h(x_i) - h(x_{i-1})\right) g(A_i) \qquad 3.17$$

Where $E^{def}$ denotes the overall function $h(x_i)$ is viewed as the performance of sub characteristic $x_i$ of the organization at a specific time. $g(A_i)$, express the grade of importance for the subset $A_i$. The fuzzy integral *of* $h(x_i)$ with respect to g denotes the overall evaluation.

By using Eq. (3.17) the overall evaluation for each, Strength, Weakness, Opportunity and Threat is obtained. From these aggregated values, status of an organization with respect to its environment is determined. The organization can use the output for amending a strategy and/or for developing a new strategy based on the numbers obtained from the fuzzy aggregation. The method can also be used to compare different strategies.

However, the richness of fuzzy integrals has to be paid by the complexity of the model, since the number of coefficients involved in the fuzzy integral model grows exponentially with the number of criteria to be aggregated. The main difficulty is to identify all these coefficients, either by some learning data, or by questionnaire, or both (Grabisch, 1996). For this reason in order to apply these methods for SE it was important to prepare a questionnaire on the importance of characteristics and to divide Characteristics in to different categories. The problem in gathering opinions is the lack of certainty, in this study questionnaires were prepared to be answered using linguistic variables and transformed in to fuzzy membership functions.

**Fuzzy membership function**

Fuzzy sets were first introduced by Lotfi Zadeh in 1965, it was specifically developed to mathematically represent uncertainty and vagueness. It is impossible to represent these problems using the traditional crisp set. For example, while describing a person's height if John is 199cm tall we can easily say that John is tall; or if John is 150cm tall he is obviously short and he cannot belong to set tall; but if John is 175cm tall it is vague to say he belongs to the set tall the same way as someone with a height of 195cm or 200cm. Fuzzy set are sets whose elements, unlike

traditional crisp sets, can partially belong to the set, with a degree of membership. Degree of membership is defined through a membership function: $\mu_A(u)$: U→[0,1], where U is universe and A is the fuzzy subset of U. the values of this membership function are real numbers between 0 and 1 where 0 means the element does not belong to the set and 1 means the element completely belongs to the set. Fuzzy set A can be denoted in alternative ways depending on the universe U. if the universe U is discrete then the fuzzy set is denoted by:

$$A= \mu(x_1)/x_1 + \mu(x_2)/x_2 + \ldots + \mu(x_n)/x_n, \text{ or as } \quad A = \sum \mu_n/x_n \qquad 3.18$$

where $\sum$ and + sign stand for the union of membership grades and / symbol simply separates membership degrees $\mu(x_n)$ from members of the universe $x_n$ and does not imply division.

Let the elements of set X be $x_1, x_2, \ldots, x_n$ then the fuzzy set $A \subseteq$ X can be denoted by, $A= \{(x_1), \mu_A(x_1)), (x_2), \mu_A(x_2)), \ldots, (x_n), \mu_A(x_n))\}$ (Kasabov, 1996).

One of the most important steps in using fuzzy logic and fuzzy systems for problem solving is representing the problem in fuzzy term; the process is called conceptualization in fuzzy terms. Linguistic terms are often used for this process; for instance for the linguistic variable temperature we can use linguistic values such as "cold", "normal", and "hot". The process of representing linguistic variables into a set of linguistic values is called fuzzy quantization. These quantized linguistic values can be represented by standard fuzzy membership functions. The following are the standard, most favoured in fuzzy expert system design, types of fuzzy membership functions shown in the figure below.

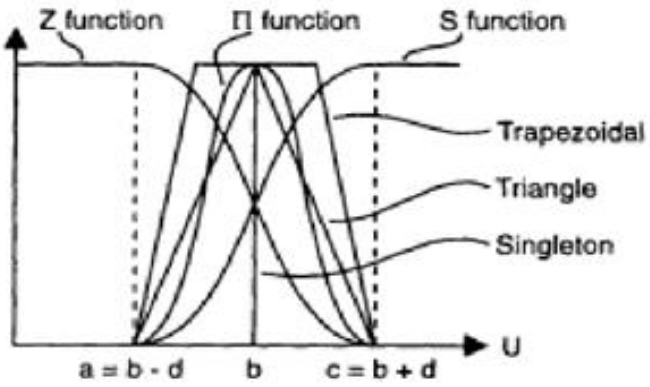



**Fig. 6 Fuzzy membership function**
Source: (Kasabov, 1996)

For the model, proposed in this study, fuzzy membership functions were used for presenting expert opinions in linguistic term. Since the result from the proposed model highly depends on

experts evaluation and it is difficult to use exact number for evaluations experts should use language to express their opinion.

**Yager's ranking method**

A popular way to carry out fuzzy arithmetic operations is by way of interval arithmetic. This is possible because any α -cut of a fuzzy number is always an interval. Any fuzzy number could be represented as a series of intervals (one interval for every α-cut). Ordering of fuzzy quantities may features a center of gravity, an area under the membership function, or various intersection points between fuzzy sets. Fuzzy ranking methods play an important role in fuzzy decision making; Yager's ranking method is one of the many known fuzzy ranking methods. Yager's ranking is the first centroid ranking approach. Based on the properties the fuzzy replacement problem can be transformed in to crisp replacement problem (Isabels & Uthra, 2012).

**Main steps in the application of the model**

The following are the main steps in evaluating strategy and its effectiveness:

1. Change the importance values from linguistic to fuzzy representation and find the interval and change the value to crisp number using centroid method discussed above
2. Change the performance values to decimal values between 0 and 1
3. Calculate for $\lambda$ for each level

$$\lambda + 1 = (1 + \lambda g_\lambda(S1))(1 + \lambda g_\lambda(S2))(1 + \lambda g_\lambda(S3)),\ \lambda > -1 \qquad 3.19$$

4. Calculate the combined effect of sub characteristics using the formula

$$g_\lambda(A, B) = g_\lambda(A) + g_\lambda(B) + \lambda g_\lambda(A) g_\lambda(B) \qquad 3.20$$

   and so on until all sub characteristics at this level are analysed
5. Calculate evaluation value for higher level using Choquet integral method discussed above.

The result from this analysis is aggregated performance of the strength of the organization; the same procedures are used to determine Weakness, Opportunity and Threats. Based on the result existing strategy could be evaluated.

However the application of any of the MCDM of fuzzy aggregation method is a complex task therefore better applied in a small list of criteria which might be impossible for larger organization where they have a long list of SWOT criteria. In this case it is important to divide the organization with respect to departments or processes. For this purpose value chain method

was applied in this dissertation work to divide organizations with respect to its task and the value the task is adding to the overall success of the organization.

## 3.4 Value chain

The main factor in performing SWOT analysis is selecting influential criteria. These criteria could be a long list and difficult to analyse depending on the organization. One way to analyse these criteria is to divide them in sub groups under strength, weakness, opportunity and threat. What is researched in this dissertation work is a value chain with different primary activities based on the organization, and to evaluate the each primary activity using SWOT analysis and the decision making methods discussed in sections 3.2 and 3.3. Since the aim is to evaluate each department and the value, it is adding to the final product and over all the success of an organization.

An organization is a system with interconnected departments. The success or failures of departments affect other departments and the overall success of the organization. When executives choose strategies, an organization's resources and capabilities should be examined alongside consideration of its value chain. A value chain charts the path by which products and services are created and eventually sold to customers. The term value chain reflects the fact that, as each step of this path is completed, the product becomes more valuable than it was at the previous step (Ketchen & Jeremy, 2011). By using the method discussed above in this section concentration of resources and focus of an organization could be assessed and determined if the strategy is working. The number of SWOT analysis for organizations could depend on the operations and departments of the organization.

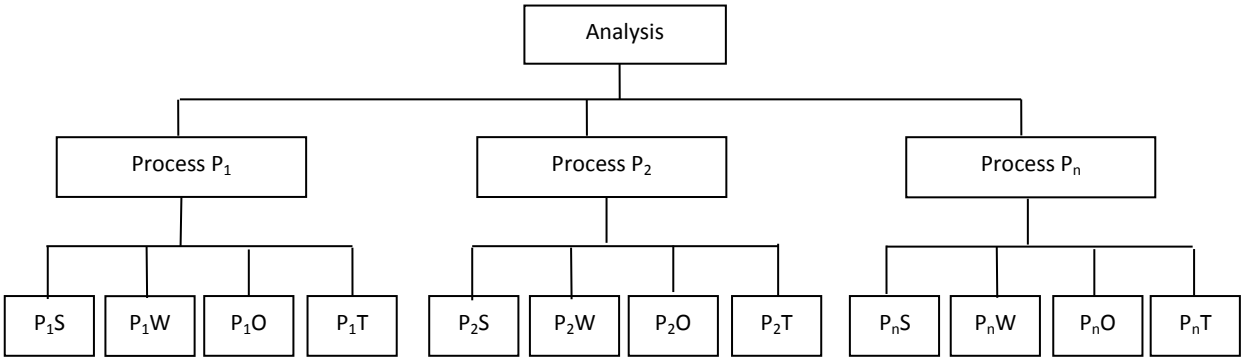



**Fig. 7 Hierarchical analysis of primary activities**
Source: (Ketchen & Short, 2011)

The term ‘Value Chain’ was used by Michael Porter in his book (1985), the term reflects the fact that, as each step of this path is completed, the product becomes more valuable than it was at the previous step. Value chain analysis describes the activities within and around an organization, and relates them to an analysis of the competitive strength of the organization. Therefore, it evaluates which value each particular activity adds to the organizations products or services. This idea was built upon the insight that an organization is more than a random compilation of machinery, equipment, people and money. Only if these things are arranged into systems and systematic activates it will become possible to produce something for which customers are willing to pay a price. Porter argues that the ability to perform particular activities and to manage the linkages between these activities is a source of competitive advantage.

Value chains include both primary and secondary activities. Primary activities are actions that are directly involved in creating and distributing goods and services. Consider a simple illustrative example: doughnut shops. Doughnut shops transform basic commodity products such as flour, sugar, butter, and grease into delectable treats. Value is added through this process because consumers are willing to pay much more for doughnuts than they would be willing to pay for the underlying ingredients (Ketchen & Short, 2011). According to porter (1985) primary activities include inbound logistics, operation, outbound logistics, marketing and sales and services. Secondary activities are infrastructure, human resource management, technology development and procurement. What is proposed in this research was value chain with different primary activities based on the organization, and to evaluate the each primary activity using SWOT analysis and MCDM to find the best strategy. Since the aim is to evaluate each department and the value it is adding to the final product and over all the success of the organization, secondary activities are not evaluated as a department.

**Main steps in the application of the model**

The main procedure in applying this method is:

1. Specification for value chain analysis
2. Assembling a team of specialists
3. Select primary and secondary departments
4. Identify the values added by each individual department
5. Identify the tasks in the primary department

## 3.5 Spearman's Correlation coefficient

More statistical characters are simultaneously observed in the real life and except of their properties we are interested in the tightness (greatness, power) of their mutual interaction. To understand Spearman's correlation it is necessary to know what a monotonic function is (Cliff, 1996). A monotonic function is one that either never increases or never decreases as its independent variable increases. The following graphs illustrate monotonic functions:

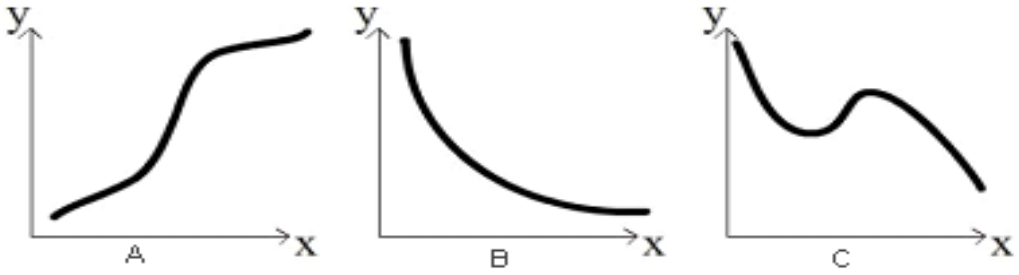



**Fig. 8 Monotonic functions**
Source: (Ruscio, 2008)

where A represents a monotonically increasing function, as the x variable increases the y variable never decreases, B represents a monotonically decreasing function, as the x variable increases the y variable never increases and C is a not monotonic function where the x variable increases the y variable sometimes decreases and sometimes increases.

Spearman's correlation coefficient is a statistical measure of the strength of a monotonic relationship between paired data. Spearman's rank correlation represented as $r_S$ is a nonparametric statistic that allows an investigator to describe the strength of an association between two variables X and Y without making the more restrictive assumptions of the Pearson product-moment correlation, *r* (Ruscio, 2008). In a sample, it is designed by constrained as $-1 \leq r_s \leq 1$.

$$r_s = 1 - \frac{6\sum_1^n d_i^2}{N(N^2-1)} \qquad 3.21$$

Where $d_i$ are the differences in the ranked scores on X and Y for each pair of cases and N is the sample size. Spearman's correlation could be used in situations where: both variables are measured in ordinal scale, if one of the variables is measured in ordinal scale but the other in interval or ratio scale, both variables are measured in interval or ration scale but the requirements for Pearson's correlation coefficient test are not met (Liwein, 2001).

In this model, Spearman's rank correlation was used to test the correlation of orders of alternatives from the different methods of MCDM, fuzzy aggregation.

However, identifying the status of an organization is only the first step in improving the organization. In the section below application of CBR method is proposed for improving the state of EU member country cities' by sharing experience with cities in the country or cities' of other members of EU.

## 3.6 Case based reasoning

The idea behind this terminology is to solve a problem by using previous experience. While solving a problem we refer to a similar problem that has already been solved and if the perfect solution is found it will be used otherwise, the solution will be modified to suit the current problem and the new solution will be stored in the case library for future reference. In case based reasoning terminology, a case usually denotes a problem situation previously experienced, which has been captured and learned in a way that it can be reused in the solving of future problems. In general, a case is composed of problem description, problem solution, and outcome (Kolonder, 1993).

The problem description essentially contains as much data about the problem and its context as necessary for an efficient and accurate case retrieval. Problem solution states the derived solution to that problem. Case based reasoning has the two main processes:

**Storing and organizing cases in the case library**

In order to solve problems using previously solved cases, there has to be an initial case memory that stores successful cases in indexed and organized way, which makes access efficient (Amodt & Plaza, 1994).

Indexing is identified with an accessibility problem that is, with the whole set of issues inherent in setting up the case base and its retrieval process so that the right cases are retrieved at the right time (Kolonder, 1993). Thus, case indexing involves assigning indices to cases to facilitate their retrieval. CBR researchers have proposed several guidelines on indexing; Indexes should be:

- Predictive of the case relevance
- Recognizable in the sense that it should be understandable why they are use

- Abstract enough to allow for widening the future use of the case base
- Discrete enough to facilitate efficient and accurate retrieval

Indices can be selected using manual and automatic methods. Choosing indices manually involves deciding the purpose of a case with respect to the aims of the user and deciding under which circumstances the case will be useful.

Another important factor is case organization; the case base should be organized into a manageable structure that supports efficient and accurate search and retrieval methods. Accurate retrieval guarantees that the best matching case will be retrieved, and efficient retrieval guarantees that cases will be retrieved fast enough for acceptable system response times.

**Retrieving the solution that best suits the current problem**

The Retrieve task starts with a (partial) problem description, and ends when a best matching previous case has been found. Its subtasks are referred to as Identify Features, Initially Match, Search, and Select, executed in that order. The identification task basically comes up with a set of relevant problem descriptors, the goal of the matching task is to return a set of cases that are sufficiently similar to the new case - given a similarity threshold of some kind, and the selection task works on this set of cases and chooses the best match (or at least a first case to try out) (Amodt & Plaza, 1994).

This step forms the basis for candidate solutions. In this step, a new case is entered into the system by the user; the system recalls cases that have relatively high similarity values, i.e., previous cases with similar indexes are retrieved. This process is called interpretation. Interpretation is the process of comparing the new situation to recalled experiences. When problem situations are interpreted, they are compared and contrasted to old problem situations. The result is an interpretation of the new situation, the addition of inferred knowledge about the new situation, or a classification of the situation. Different methods can be used to search cases. The most well-known retrieval method is nearest neighbour retrieval method.

Nearest-neighbour retrieval is a simple approach that computes the similarity between stored cases and new input case based on weight features. A typical evaluation function is used to compute nearest-neighbour matching (Kolodner, 1993). Nearest-neighbour evaluation function:

$$Similarity(Case_1, Case_R) = \frac{\sum_{i=1}^{n} w_i \times sim(f_i^1, f_i^R)}{\sum_{i=1}^{n} w_i} \quad 3.22$$

where $w_i$ is the importance weight of a feature, *sim* is the similarity function of features, and $f_i^I$ and $f_i^R$ are the values for feature *i* in the input and retrieved cases respectively.

Another important process in this step is adaptation. Adaption is the process of fixing up an old solution to meet the demands of the new situation. There are different methods that can be used to insert something new into an old solution, to delete something, or to make a substitution (Kolonder, 1992).

Last, the solution has to be stored for future reference. Before storing the solution, it is important that the user evaluate the solution, make the necessary modification and correct if necessary. Case-based reasoning has been applied by researchers since the 90's for different fields recent applications include business failure prediction (Li & Sun, 2011), eco-innovation product design (Cheng & Jahau, 2014). The following figure is the basic cycle of case-based reasoning (Amodt & Plaza, 1994).

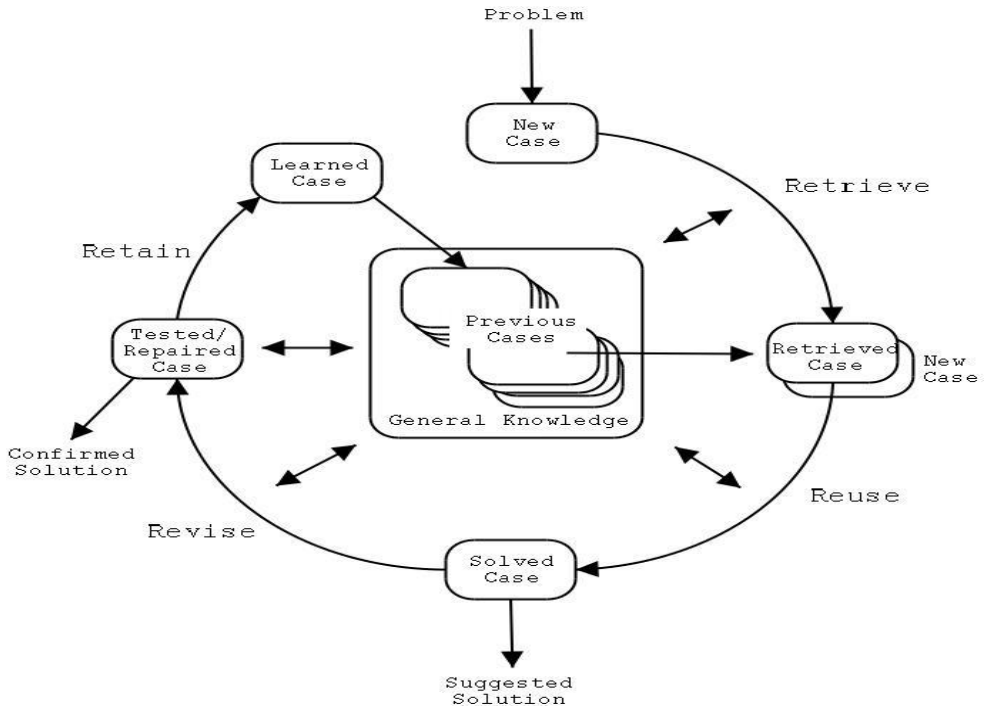



**Fig. 9 Case based reasoning**
Source: (Amodt & Plaza, 1994)

**Application of model in the public sector**

Analyzing the status of an organization only helps to identify problems in an organization. Identifying problems and their effect on an organization is the most important step but this is by no means the last step for improving the organization. Therefore, the author further proposed the application of case based reasoning method for solving specific problems especially for European Union member countries, since it is encouraged for the EU member countries to share experience.

As mentioned in the introduction strategic planning is on-going process and needs a constant monitoring and fix to improve success of public organization. For that reason case based reasoning system that records all the problems or weaknesses faced by EU member cities and their solution so that solutions could be adopted by other cities in the future. This will create relation among cities in sharing experience, avoids redundancy and saves a city's cost.

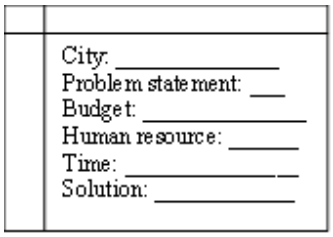



**Fig. 10 Case description in a case base**
Source: Author

While solving any problem cities consider solutions that are implementable on their capacity and structure. Capacity includes fund, human resource, time limit, the city the problem was solved in, and so on, which are considered as case attributes. Therefore, in case representation each case contains these attributes, problem statement, and solution.

The advantage of the proposed method over existing tools include: providing a way to adapt solution for a specific problem instead of a strategy, but still provides cities the final say, like other tools and frameworks. Cost effective since the proposed system does most of the heavy lifting, time effective by avoiding time consumption in proposing alternate solution. Solving these specific problems improve the overall success of a strategy; provides cities with options and freedom to choose a detailed solution for a specific problem based on their capacity without going through strategies of other cities; it provides a bottom up approach where cities can solve their weakness.

Two-step retrieval method is proposed, the first step is to use text parser to find similar cases that is to compare the new case with the problem statements in the case base. Once these cases with similar problem statement are found Choquet fuzzy integral method will be used to choose the best-suited case for the current problem based on the comparison of case attributes shown in the figure (Fig. 11).

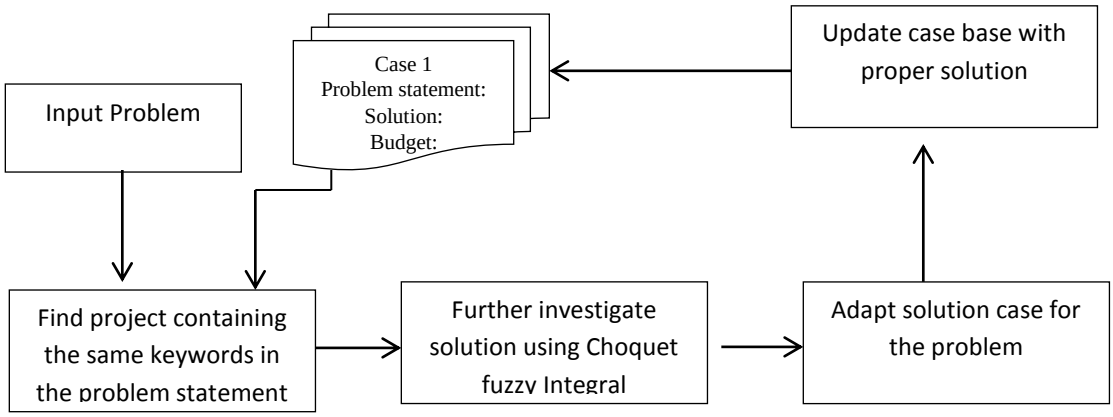



**Fig. 11 Process flow of case based reasoning**
Source: Author

In the first step of the case retrieval process the problem statement of the new case is compared with cases and the cases that match the new case are chosen. These will limit the number of candidate cases but there could be more than one case with the same problem. To further eliminate candidate cases Choquet fuzzy integral method is used. From the selected cases with similar problem statement cities would choose the ones that are applicable to the city searching for solution based on the attributes mentioned above. For instance cities with smaller population would prefer solutions generated in cities with similar population size, similar culture growth rate based on the type of the problem the city is facing; furthermore the solution has to be implementable with affordable resources. These criteria could be implemented using multiple criteria decision-making methods such as analytic hierarchy process, Choquet fuzzy integral. For this research, fuzzy integral method is chosen to avoid dependency issues among characteristics (Choquet, 1953).

If a case that satisfies the given characteristics is found then the solution will be adapted and implemented by the city, the adaption process highly depends on knowledge and experience of the experts the city has. After the adaption and implementation process the new solution will be

stored in the case base for future reference. If there is no such a case that satisfies the given criteria a new case will be created, implemented by the city and stored in the case base.

For instance as discussed above, the cities of Prague and Vienna face the same problems, if one of these cities want to solve those problems, using the proposed method, the city specifies the problem, and the characteristics the expected solution has to fulfill. Since it is unlikely to find case that fulfill all required characteristics the characteristics has to be assigned with priorities. Then search the case base for proper solution, if a solution is found in the case base adopt the solution, implement, properly index and update the case base. If the problem has not been faced by, another city in the past, create a solution and update the case base.


**Fig. 12 Flow chart for Choquet fuzzy integral based case based reasoning**
Source: Author

## 3.7 COLIBRI Studio

COLIBRI is an open source platform for the development of CBR systems. It supports the development of different families of specialized CBR systems: from Textual CBR to Knowledge Intensive applications. The project was supported by Spanish Ministry of Science & Education, Madrid Education Council and UCM and the Spanish Ministry of Economy and Competitiveness.

Once COLIBRI Studio is installed, the COLIBRI perspective organizes all the provided tools like means of creating the New CBR Project Wizards. In the process of creating new project, the wizard provides a way to select libraries, design case structure, similarity measure and persistence of cases. This wizard generates a complete k Nearest Neighbors system. Users must configure the case structure, similarity and persistence and the wizard generates a fully functional system. The configuration is performed by means of the dialogs used in the previous wizard. Then, the tools in the perspective can be used to modify the configuration and generate the source code of an application with basic methods like set and get (GIA, 2008).

Also retrieving items, Conversational Systems also may invite or allow the user to refine his/her current preferences, typically based on the recommended items. Iterated Preference Elicitation might be done by allowing the user to select and critique a recommended item thereby producing a modified query, which requires that one or more retrieved items be displayed. Alternatively, it might be done by asking the user a further question or questions thereby refining the query, in which case the retrieved items might be displayed every time or might be displayed only when some criterion is satisfied.

**Retrieval in COLIBRI Studio**

Since the studio is focusing on case-based recommender systems (and related memory-based recommenders including collaborative filters), Retrieval is common to all recommender systems. Retrieval is a complex task, with many alternative decompositions. The choice of decomposition is, of course, not independent of the choice of decomposition for One-Off Preference Elicitation and Iterated Preference Elicitation. For example, if One-Off Preference Elicitation delivers a ratings profile, then the method chosen for achieving the Retrieval task must be some form of collaborative recommendation (GIA, 2008).

In all ways of achieving Retrieval, a scoring process is followed by a selection process. For example, in similarity-based retrieval (k-NN), items are scored by their similarity to the user's preferences and then the k highest-scoring items are selected for display; in diversity-enhanced similarity-based retrieval, items are scored in the same way and then a diverse set is selected from the highest-scoring items; and so on. Note also that there are alternative decompositions of the Retrieval task that would not have this two-step character. For example, filter-based retrieval, where the user's preferences are treated as hard constraints, conventionally does not decompose into two such steps. On the other hand, there are recommender systems in which Retrieval decomposes into more than two steps. For example, in some forms of Navigation-by-Proposing, first a set of items that satisfy the user's critique is obtained by filter-based retrieval, then these are scored for similarity to the user's selected item, and finally a subset is chosen for display to the user.

# 4. Discussion and result

The main aim of this dissertation work was to introduce a model for analytical evaluation of performance of public organizations with respect to their strategic plan. However evaluation of a strategy is only the first part of improving the organization the main task is how to implement strategies without diverting from the objectives and goal but also adopting to situations unforeseen during strategy panning phase. Therefore a research was also conducted on project selection using decision making methods and way to adopt other projects to solve specific problem or weaknesses. The outcomes of this research work can be divided in two completely different outcomes:

1. **Model for analytical evaluation of performance of public organizations with respect to their strategic plan goals and objectives.**
2. **Prototype of case based reasoning system to find projects to solve problems occur during SP implementation phase, based on other cities or regions experience.**

The development of the first model for this dissertation work can be divided in four phases (quantitative evaluation of SWOT analysis, applying fuzzy membership function, defuzzification of input data using Yager's ranking method, dividing the list in Strength, Weakness, Opportunity and Threat in to categories of processes based on value chain principle). The first phase of the dissertation work was to study Choquet fuzzy integral methods, MCDM and strategy evaluation tools including SWOT analysis to evaluate the performance of an organization. However collecting accurate numerical data was difficult even impossible for experts to assign therefore the second phase was to find a method to collect the data in linguistic variable such as very good, very bad and so on and to interpret such data fuzzy membership function method was adopted. The next phase was to defuzzify data from the fuzzy membership function Yager's ranking method was applied. Last, value chain method was used to divide large organization's evaluation criteria in to categories to provide a more detailed solution of strategic options and to simplify the application of the model. The following figure (Fig. 13) shows the phases in developing the first model in this dissertation work. The first main problem the dissertation work to solve was to provide a quantitative SWOT analysis for success report of an organization that shows the Strength, Weakness, Opportunity and Threat of the organization in percentage. Percentage result is more understandable by stakeholders and precise explanation of status. This approach of report

could increase the accountability in the public sector. For instance if a major's office was to provide the public with a report with indicators like the improvement of housing this year, the number of research and development projects, this may tell the public what was done this year even improvements from last year but does not depict the whole picture of was this necessary investment in the city, was this enough with respect to the resources available for the public office to utilize, does the new housing have problems and so on. But in using SWOT analysis the public could see precisely the strength of the work the city has done, the resources available, the weakness and threats.

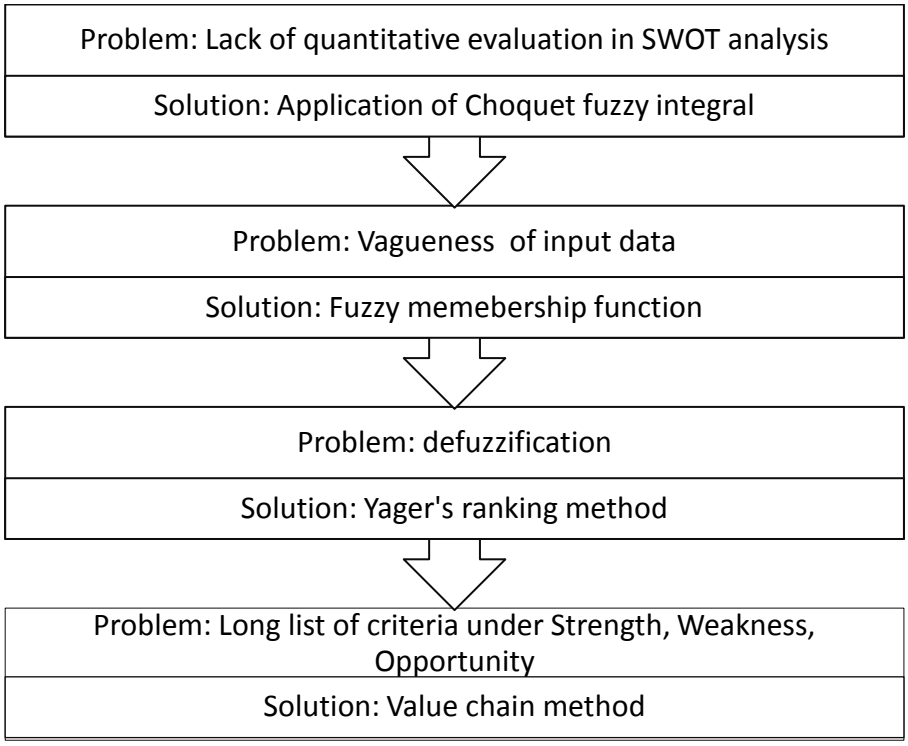



**Fig. 13 Phases of output model**
Source: Author

The first step in this model is to set deterministic criteria for SP analysis. The second step is to categorize these criteria as Strength, Weakness, Opportunity and Threat. However, if the list of these criteria is long analytical could be complex to avoid this the criteria will be divided by primary departments/processes using value chain method. For instance in evaluating an organization with two main departments, ($D_1$ and $D_2$), first the list of criteria for the SWOT analysis would be identified based on experts, if the list of this criteria is long then the organization will be divided in to departments that are primary in the organization. The

departments, in this case $D_1$ and $D_2$ will then be evaluated using Choquet fuzzy integral and SWOT analysis; the result from this evaluation is a percentage on the Strength, S, Weakness, W, Opportunity, O, and Threat, T of each department in the organization with respect to their internal and external environment. Based on this evaluation the organization can choose future strategies ($SD_1OD_1$, $SD_2OD_2$, …, $SD_2TD_2$, $WD_1OD_1$, $WD_2TD_2$). The model can be represented in the figure below (fig. 14 ).

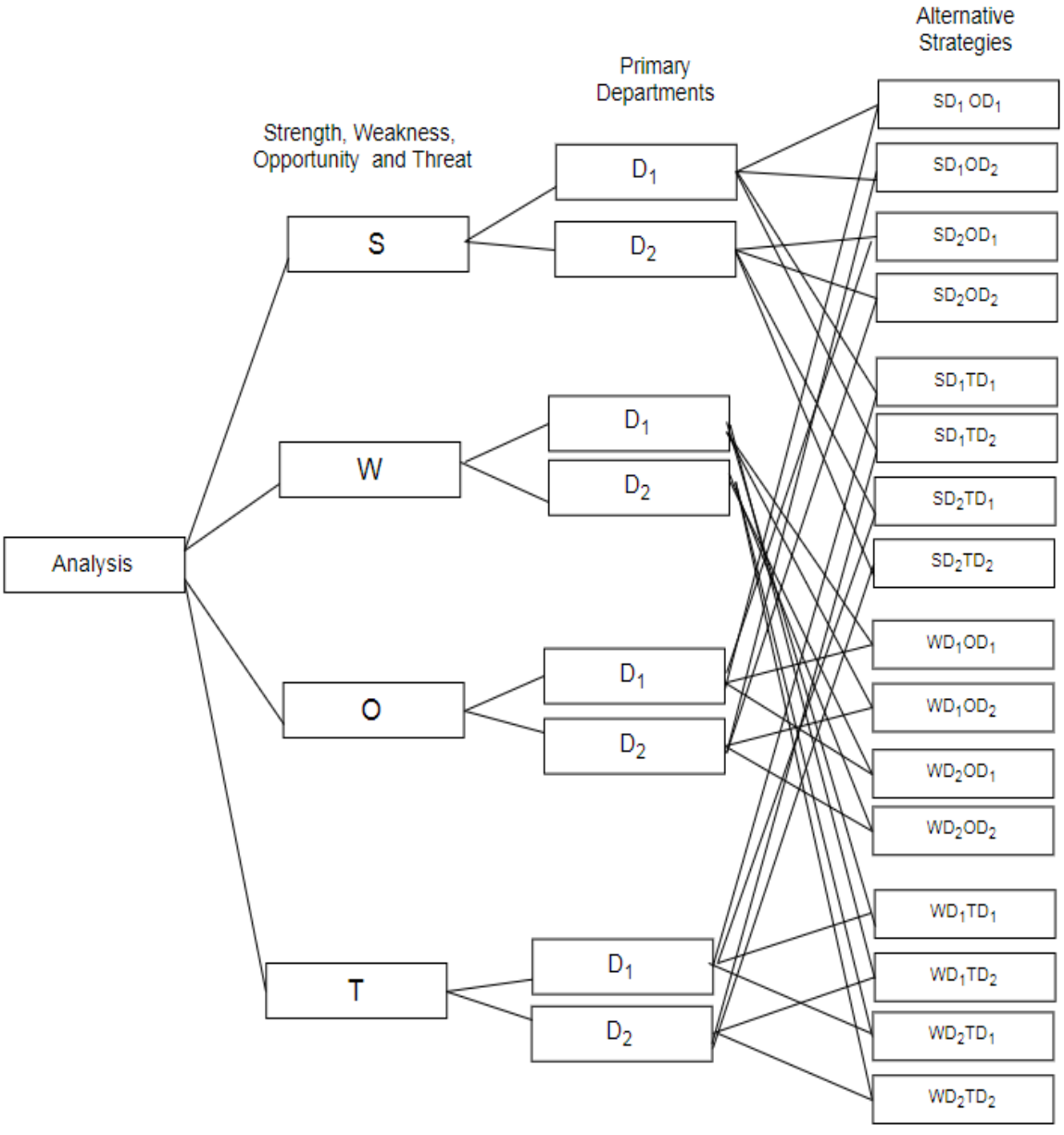



**Fig. 14 Output model application for strategy selection**
Source Author

Analysis of method and methodology is a main factor in effectively analyzing SP or/and any other research topic. Therefore, it is important to test a new method or existing one for the feasibility of the method in a specific area. The model in this dissertation work was evaluated using two main ways: **by comparing results with other methods and gathering expert opinion on the results from case studies**.

By comparing results with results from other methods: As discussed in the above sections representing a result of a study or analysis in the public sector is difficult since quantitative measures like asset, capital and market share are not available. To evaluate the accuracy of results of the proposed model, studies were performed on two private sectors. The results of the model for a specific private sector were then compared with other known methods to see the consistency of results.

The first step for identifying efficient MCDM, a research was conducted on application of ANP, for evaluation process specifically on evaluation of software based on ISO (ISO/IEC 25000:2014) as discussed above the problem with applying ANP is that it is complicated to use when networks, loops, or cycles exist in the problem representation. The first case study (case study 1) was conducted for a business to proof the results from the model using Sugeno lambda measure and Choquet fuzzy integral for one branch of an **exchange office**, which was a small branch of a business hence the results were easy to verify. The second case study (case study 2) was on the evaluation of the SWOT analysis of **Prague city**. The methods used for this case study were fuzzy membership function, Yager's ranking, Sugeno lambda measure and Choquet fuzzy integral. Case study 3 is the analysis of the city of **Pardubice** this case study also used the same methods as case study two. The other organization the model in the dissertation was used for **Atemit plc.** which is discussed in case study 4.

The execution of the strategic plan may vary from the original intension, and the environment expected in the strategy formulation phase may also change. The implementation is the process where things could change. Therefore it is important to closely control and evaluate every action taken in the strategy implementation phase. Projects and programs that organizations pursue in order to achieve the desired goal of SP are the main actions in the strategy implementation phase. Projects have direct effect in the successful implementation of SP, which is why in this dissertation work project selection methods and models are discussed.

Case study 5 discusses the application of MCDM and fuzzy aggregation method for project selection of mid-sized city in the CR specifically **Hradec Kralove**, where the consistency of results from different method is discussed. The final case study (case study 6) is the application of CBR for solving problems of EU cities using projects developed by other cities in the Europe.

### 4.1 Case study 1: Exchange office

There are many currency exchange offices in Prague some of these offices buy and sell foreign currencies for a small difference and they make their profit by buying and selling a large amount of foreign currencies per day while others make a better profit from each unit of currency they buy and sell and make significantly less amount of transaction. The currency exchange company, studied here, uses the second method and has more than five offices each making a small amount of transaction a day.

The data shown in the following table (Table 3.) was gathered from one of these currency exchange offices. This data was used only as an empirical example to clarify the application of the discussed methods. The SWOT sub characteristics were selected and assigned importance and performance (weight) value by the staff of the company based on their experience in that office and in comparison of their other exchange offices located in Prague (Haile & Krupka, 2016a).

The sub characteristics are defined by the following way: S1 is Location, S2 is Customer service and S3 is Promotion for Strength; W1 is the presence of too many people around the entrance of the exchange office, W2 is Reserved money in the office and W3 is that the area is Not a tourist center for Weakness. O1 is there is a Restaurant nearby, O2 is No direct value added tax (VAT) and O3 is Hotels and hostels around for Opportunity. T1 is changing to euro, T2 is automated teller machine (ATM) and T3 is Two more other exchange offices on the same street for Threats. The following table contains the data after it was transformed in to [0,1] scale.

As shown in the table below (Table 3.), strength of this company is the location, customer service and promotion. The importance of a location of an exchange office is evaluated to be 0.6 out of 1and the location of this particular exchange is very good since it is located on the building right next to a traffic light, 0.9 out of 1. They also have a good customer service, which they believe is 0.9 out of 1 and the importance of good customer service for the success of the

exchange is evaluated to be 0.4. The importance of promotion is also 0.4 for exchange and they have a Very good promotion. It is important to note that this experiment was only done for one branch of the exchange company to explain the application of the method.

The step by step procedure to evaluate the SWOT analysis performed for the exchange office is shown below

1. $\lambda$ was calculated for each level using equation Eq.3.14

$\lambda+1=(1+\lambda g_{\lambda}(S1))(1+\lambda g_{\lambda}(S2))(1+\lambda g_{\lambda}(S3)),\ \lambda>-1\ \lambda+1=(1+0.6\lambda))(1+0.4\lambda)(1+0.4\lambda),\ \lambda>-1$ for Strength (S)

2. The data was arranged according to $h(x_1) \leq h(x_2) \leq \ldots \leq h(x_n)$
3. Combined effect of sub characteristics was calculated using fuzzy measure

The same procedure is used for W, O and T

4. The aggregated value for each characteristics was calculated using Eq. 3.17

**Table 3. Input data from experts and calculated $\lambda$**

| Characteristics | Importance | Weight | $\lambda$ |
|---|---|---|---|
| S1 | 0.6 | 0.9 | -0.69 |
| S2 | 0.4 | 0.9 | |
| S3 | 0.4 | 1 | |
| W1 | 0.2 | 0.2 | -0.46 |
| W2 | 0.5 | 0.7 | |
| W3 | 0.5 | 0.8 | |
| O1 | 0.6 | 0.4 | -0.97 |
| O2 | 0.2 | 0.7 | |
| O3 | 0.7 | 0.9 | |
| T1 | 0.8 | 0.3 | -0.92 |
| T2 | 0.5 | 0.4 | |
| T3 | 0.5 | 0.5 | |

Source: (Haile & Krupka, 2016a)

**Table 4. Evaluated value for strength, weakness, opportunity and threat**

| Strength | Weakness | Opportunity | Threat |
|---|---|---|---|
| 0.94 | 0.25 | 0.54 | 0.44 |

Source: (Haile & Krupka, 2016a)

The same procedure is used to find the values for the rest of the characters. The result of the evaluation is shown in the table above (Table 4.).

Based on these results over all the company has good strength but they also have weakness they could improve their weakness more by reserving more money and they could change their offices to a more tourist center since the combined effect of these two sub characteristics is significant. The opportunity at their disposal is 0.54, these are the factors the company could not control, but in the future they could choose a place in an area where there are more hostels and restaurants in order to increase their success. Finally the threat is that they worry about the country changing the currency to Euro and that makes them cautious to invest more in the business and that many people are using credit cards, unfortunately they cannot do anything about that.

## 4.2 Case study 2: The city of Prague

SWOT analysis was first used in Prague in 1994; the results of this SWOT analysis were released and updated during preparation of strategic plan and follow up regional programming documents for EU. The current form of the SWOT analysis is the result of the last update from 2004-2008. The document (Strategy, 2008) contains seven categories of SWOT analysis, one characteristic was chosen from the categories that could be used to evaluate activities of the city. These categories include infrastructure, safety and security, city resilience and city management and administration. A questionnaire shown in the index of this dissertation was prepared for experts to evaluate the chosen characteristics of Prague (Haile et al., 2016b).

The weight and performance were assigned by five experts from different fields of public administration familiar with strategic planning, urban planning, social studies and regional economy.

Weight is the importance of the characteristics for the success of the city on the scale 0 to 1. The third column of the table (Table 5.) is the current performance of the city on the listed characteristics, the value for the performances were collected using linguistic variables.

Based on the evaluation of experts sufficient capacity of elementary and secondary educational facilities has 0.574 importance out of 1 and currently the city has satisfactory capacity.

**Table 5. Characteristics SWOT analysis of Prague – part Strength**

| Characteristics | Weight | Performance | $\lambda$ |
|---|---|---|---|
| Sufficient capacity of elementary secondary educational facilities | 0.57 | 5.5 | -0.989 |
| Well-functioning public transport system | 0.82 | 9.5 | |
| Implementation of comprehensive flood protection systems | 0.5 | 5.5 | |
| Gradual renewal and development of energy networks | 0.54 | 1.5 | |
| Size and strength of the city economy | 0.58 | 5.5 | |

Source: (Haile et al., 2016b)

Prague has a very well-functioning public transport system (8, is very satisfactory) which experts believe is very important to the success of the city (0.82). The fourth characteristic, gradual renewal and development of energy networks has 0.5424 importance but the city's performance to on the gradual renewal and development of energy networks is not satisfactory. The linguistic variables from the performance column were presented using trapezoidal membership function (Fig. 15).

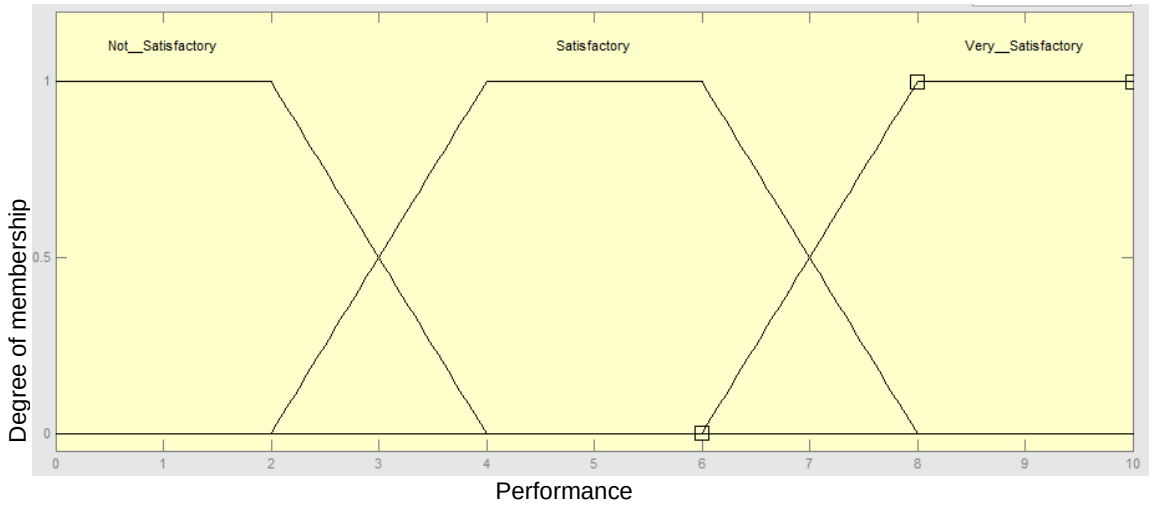



**Fig. 15 Trapezoidal membership function of fuzzy sets for linquistic variables**
Source: Author

Determining membership function is highly subjective on what is not acceptable, acceptable and very good performance for a specific organization. In this case study the membership function was chosen by expert opinion. If the city's performance on a characteristic is less than

or equal to 2 out of 10 then it is completely unacceptable (not satisfactory) and above 2 to 4 is not satisfactory but with degree less than 1

**Table 6. Characteristics SWOT analysis of Prague – part Weakness**

| Characteristics | Weight | Performance | $\lambda$ |
|---|---|---|---|
| Poor coordination with public sector | 0.58 | 5.5 | -0.971 |
| Weak crime fighting and drug protection | 0.58 | 1.5 | |
| Hypertrophied and complicated system of public administration | 0.48 | 5.5 | |
| Ineffective utilization of housing fund | 0.54 | 5.5 | |
| Insufficient effectiveness and, consequently, lower capacity of the central wastewater treatment plant | 0.5 | 5.5 | |

Source: (Haile et al., 2016b)

. If the performance is between 2 and 8 it is satisfactory with degree. Performance between 8 and 10 is very satisfactory with a complete belonging to the set. Then Yager's ranking indices was used to transform performance to crisp values (Isabels & Uthra, 2012).

The same membership functions were used for other characteristics of SWOT analysis (means Weakness, Opportunity and Threats), these characteristics are defined by the same way as Table 5, are in Table 6 to 8.

**Table 7. Characteristics SWOT analysis of Prague – part Opportunity**

| Characteristics | Weight | Performance | $\lambda$ |
|---|---|---|---|
| Support from EU | 0.46 | 5.5 | -0.980 |
| Position heart of Europe | 0.44 | 5.5 | |
| Well-developed and diverse telecommunications networks suitable for multimedia communication | 0.5 | 5.5 | |
| Greater range of tourist destinations within and outside Prague's Heritage Conservation Area of the city | 0.48 | 1.5 | |
| Balanced social structure | 0.76 | 1.5 | |

Source: (Haile et al., 2016b)

**Table 8. SWOT analysis of characteristics of Prague – part Threats**

| Characteristics | Weight | Performance | $\lambda$ |
|---|---|---|---|
| Loss of citizens interest for public affair | 0.58 | 5.5 | -0.985 |
| Competition of other cities | 0.56 | 1.5 | |
| Loss of Prague's international standing as a unique heritage site | 0.42 | 5.5 | |
| Lack of financial resources for the development of modern educational programs and comprehensive social services | 0.6228 | 5.5 | |
| Growing xenophobia and expression of racism and extremism | 0.74 | 5.5 | |

Source: (Haile et al., 2016b)

The aggregated quantized SWOT analysis was calculated based on the evaluation of experts, using Sugeno λ-measure and Choquet Fuzzy Integral. The numbers in the following table (Table 9.) show how strong is the city's strength, how weak is its weakness, how effective are the opportunities at the city's disposal and how well are they being exploited and how bad is the threat the city is facing and how eminent it is. Small percentage result for strength could happen for two reasons; if importance of the characteristics the city administration considered as the strength are not very important or the characteristics the city consider as strength are not that strong meaning the city is not performing on the characteristics as well as the administration believed. Acceptable Strength, weakness, opportunity or threat is subjective, depends on different factors such as economy of the city, region, history and so on.

**Table 9. Evaluation value for S,W, O and T (in %)**

| Strength | Weakness | Opportunity | Threat |
|---|---|---|---|
| 87.53 | 53.84 | 49.31 | 54.53 |

Source: (Haile et al., 2016b)

Based on the result from the above table (Table 9.) the strength of the city is 87.53% where the perfect record is 100%. The city has more strength than weakness 53.84%. The city is currently exploiting opportunities 49.31% and is facing a threat 54.53% that affects the success of the city in a perfect world the city should be facing zero threats. Lack of financial resources for the development of modern educational programs and comprehensive social services and Growing xenophobia and expression of racism and extremism in the threat table have 0.6228 and 0.74 out of 1, which is the reason that the arrogated threat is significant in the result table.

To improve the success of the city the authorities have to consider utilizing their opportunities more and focus on strengthening their weaknesses with higher priority. These methods could also be used to compare alternative strategies.

### 4.3 Case study 3: The city of Pardubice

Pardubice region is among the smallest region of the CR, both of area or population, which is reflected in its economic performance, which moves among average, below average or mild zones in comparison with other regions. For example, the formation of the National Gross domestic product Pardubice region accounts for only 4%, which is the third lowest contribution in CR. On the gross value added (GVA) to the region's central role in industry, whose share in GVA in 2011 amounted to 36.9% (which is about 25% more than the national average). Many factors contribute to this result; processing and manufacture, followed by sub-sectors of the services sector (service sector contributes more than half the total mostly on the structure of GVA). Among the services are outstanding logistics services - transport, storage, and communications followed by trade and repair of motor vehicles and products. The region has excellent export performance, contributing 7.7% to the total export of CR (4th place among the regions). Pardubice region has diversified and managed to keep a relatively strong industrial base. Regional innovation and research system of the region in the CR is on the average level (Grabisch et al., 2000), (Pardubice, 2016), (Haile & Krupka, 2016c).

The aggregated quantized SWOT analysis was calculated based on the evaluation of experts' opinion and using Sugeno λ-measure Choquet fuzzy integral. The experts opinion is used to determine how strong is the region's strength, how weak is its weakness, how effective are the opportunities at the region's disposal and how well are they being exploited and how bad is the Threat the region is facing and how eminent it is.

The sub characteristics are defined by the following way: S1 is the industrial tradition and proportion of manufacturing industry in the creation of GDP, , S2 is Share of exports of medium and high-tech industries from the region, S3 is The share of innovative enterprises in the manufacturing industry, S4 is Activity of regional innovative companies in the use of public programs to support research and development (R&D) (purpose and infrastructure, e.g. the TIP, Alpha and Prosperity program), and S5 is Simplification of administrative burden for recipients of public support for R & D (Public Procurement Act, etc.) for the Strength. For the Weakness:

W1 is Level of gross fixed capital formation (i.e. low investment activity entities in the region, …), W2 is Innovative infrastructure, W3 is Interest of key actors in R&D and regional and local political representation on the implementation of existing RIS and promote the knowledge economy, W4 is Barriers to the development of cooperation between the public and private sectors, W5 is Participation in FP7 in comparison to other regions but significantly below average in international comparison with EU15. The data is shown in the table below.

**Table 10. Input data from experts**

| Characteristics | Importance | Weight | $\lambda$ |
|---|---|---|---|
| S1 | 0.8 | 0.95 | -0.989 |
| S2 | 0.5 | 0.95 | |
| S3 | 0.6 | 0.55 | |
| S4 | 0.6 | 0.55 | |
| S5 | 0.4 | 0.95 | |
| W1 | 0.5 | 0.55 | -0.946 |
| W2 | 0.6 | 0.15 | |
| W3 | 0.4 | 0.55 | |
| W4 | 0.5 | 0.95 | |
| W5 | 0.3 | 0.55 | |
| O1 | 0.5 | 0.55 | -0.963 |
| O2 | 0.5 | 0.15 | |
| O3 | 0.6 | 0.95 | |
| O4 | 0.4 | 0.55 | |
| O5 | 0.5 | 0.55 | |
| T1 | 0.5 | 0.15 | -0.933 |
| T2 | 0.6 | 0.55 | |
| T3 | 0.3 | 0.95 | |
| T4 | 0.4 | 0.55 | |
| T5 | 0.4 | 0.55 | |

Source: (Haile & Krupka, 2016c)

For the Opportunity: O1 is Geographical location and transportation access, O2 is Process preparation of SF 2014+ that will lead to an open partnership and cooperation between different actors in R&D and regional and local authorities, O3 is The attractiveness of the region for foreign direct investment in medium and high-tech manufacturing industries O4 is Use of capacity of the research centers in other regions for innovative businesses, and O5 is New

technologies in education and popularization of Science, Technology, Engineering and Mathematics. For the Threats: T1 is Continued disinterest in the issue of R&D in relation to strengthening the competitiveness of the region within the framework of regional and local authorities, T2 is Key manufacturing industries and spending during economic crisis, T3 is The aging population and the impact on the labor market, social network and educational system, T4 is the largest foreign direct investment in high-tech medium tech manufacturing industries and largest employers in this sector, and T5 is Positions of many companies (mostly SMEs) in the Global value chains (Haile & Krupka, 2016c).

Importance is the importance of characteristics for the success of the city on the scale 0 to 1. The values for the current performance of the city on the listed characteristics were collected using linguistic variables. The linguistic variables from the weight column were presented using trapezoidal membership function; which were then transformed to crisp values using Yager's ranking indices (Isabels & Uthra, 2012). The same membership functions were used for Weakness, Opportunity and Threat.

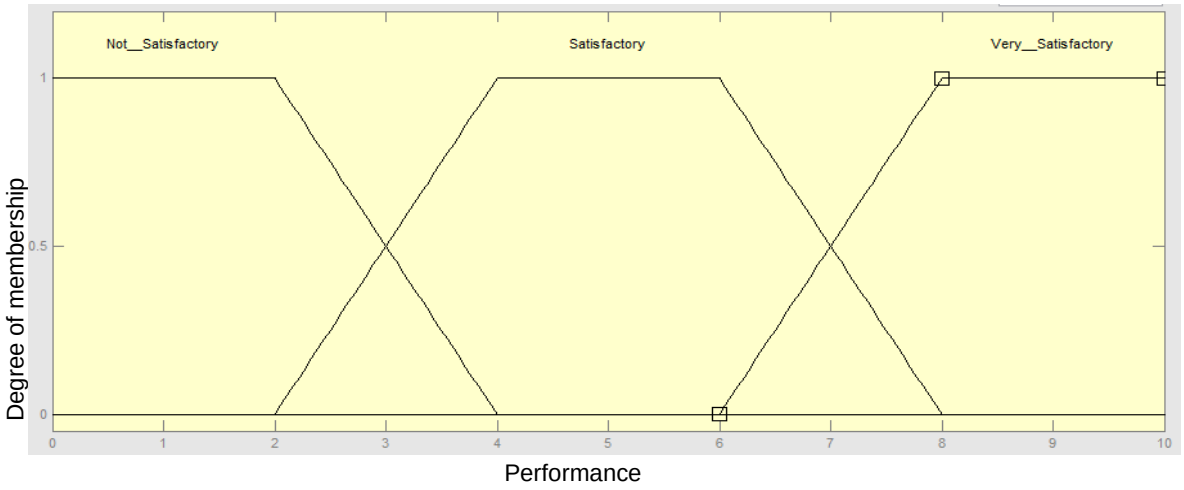



**Fig. 16 Trapezoidal membership function representing the linguistic values of performance variable**
Source: Author

**Table 11. Evaluated value for strength, weakness, opportunity and threat**

| Strength | Weakness | Opportunity | Threat |
|---|---|---|---|
| 0.93 | 0.72 | 0.77 | 0.64 |

Source: (Haile & Krupka, 2016c)

Using the same steps as discussed in the previous cases the overall performance of Strength, Weakness, Opportunity, and Threat. The results are presented in the table (Table 11.).

Based on the results in the table above (Table 11.) Strength of Pardubice city on the economic characteristics discussed in this section is 93 percent which, could be considered a success. The weakness of the city is 72 percent which is not good for the city, the opportunity the city is currently exploiting is 77 percent and the threat the city is facing is 64 percent. These results show that even though the city has a really good strength but the all opportunities are not being exploited and the weakness and the treats need to be eliminated, at least the ones with high importance in order to increase the success of the city.

### 4.4 Case study 4: Atemit private limited company

The surveyed enterprise Atemit plc. offers services in industrial markets. It mainly focuses on wall covering and laying of floor coverings. Operates on a saturated market. It is the exclusive representative of Densit (extremely resistant cast floor). It offers its services in the building industry, the food industry and in the engineering industry. The number of employees ranges from 25 to 49. The company is very successful. It reaches high turnover, belongs to the top 10% of companies in the CR. In the last two periods, the company has stagnated year-on-year. Two people have been replaced in the course of their career.

The enterprise was analyzed for the purposes of this case study in 2015. It has been found to have well-engineered internal guidelines and standards, actively using communication mix tools, and building long-term relationships with customers. It primarily uses personal sales, sales promotion, and advertising. The company did not work with an analytical apparatus that would give it a wider view of the overall situation within the business with the link to its surroundings.

SWOT analysis for the company was performed by an external experts based on the assessment of the internal staff. The first step was to identify all the internal and external characteristics of the company. Then these factors were classified in to Strength, Weakness, Opportunity and Threat based on the values provided by experts. However, the problem raised in at this point was the long list of criteria in each SWOT category. As the number of criteria to be analyzed roses the analytical analysis gets more difficult to map. To solve this problem I was

necessary to divide the enterprise in a systematic approach. Using Porter's value chain the enterprise was divided in to three primary departments shown in the figure below:

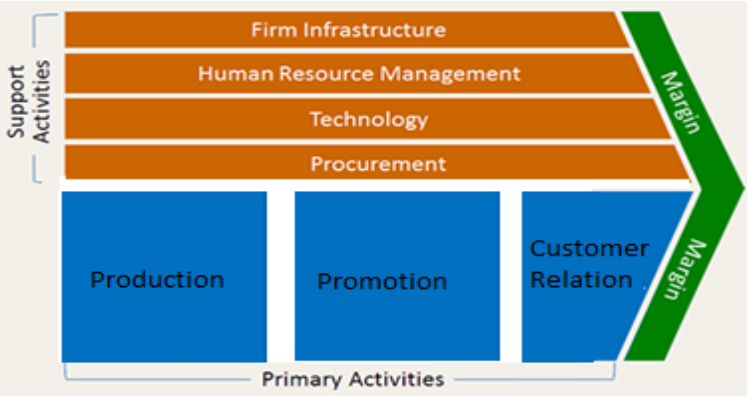



**Fig. 17 Value chain**
Source: (Porter, 1985)

There were about 42 criteria the experts chose as identified criteria for the enterprise. The criteria were then assigned weights based on their importance for the success of the business, and performance based on how the business is performing based on these criteria. Based on these performance from experts and internal staff the criteria were categorized as departments based on the type of the criteria for instance in this case study if the criteria is related to product quality or production then it was categorized as product department. If the criterion is related to, the advertisement and the medium of how the business is introduced to the customer then it was categorized as promotion. Any criterion related to communication among employees and customers is grouped as the customer relation department. Under each primary department by the same experts. These criteria were then grouped in to strength, weakness, opportunity and threat, and SWOT analysis was performed for each department. The following tables (Table 12 to 14) show the internal and external factors under the Product, Promotion, and Customer Relation departments, respectively.

The product provided by the enterprise is a floor tile; the enterprise provides all services of flooring to customers starting from consultation, design and implementation. The staff believes that the product they provide is quality and modern. The enterprise has a shortage of material supplier alternatives, which forces them to agree to conditions which are not favorable for them. The other problem is the perception of beauty for different customers, density mistakes and different conditions for pasting. The need for quality over price is now a days, loyalty of

customers, and since the enterprise provides product for different temperature fluctuation are opportunity for the enterprise. Supplier power is a threat so is loss of interest of customers for the value of their quality pasting.

**Table 12. SWOT analysis of Product**

| **Strength** | **Weakness** |
|---|---|
| • product quality (density) of reservations and representation<br>• Development of new products<br>• Density dependent on temperature fluctuations during application<br>• Offers comprehensive solutions - design, applications, customer service (standardization) | • The weakness in aesthetics (piercing the floor, splash)<br>• Dependence on application conditions for resins (temperature halls)<br>• News after missing Density<br>• Dependence on 3 suppliers with significant negotiating power in favor of suppliers. |
| **Opportunity** | **Threat** |
| • The pressure of customer quality flooring<br>• The willingness of large firms pay more for quality<br>• Returning Customer (loyalty through quality)<br>• Competition offers comparable quality Density<br>• Fluctuations in temperature during implementation | • Competition is achieved (in resins no longer a competitive advantage)<br>• Reliability of supplier quality<br>• Suppliers - significant bargaining power |

Source: (Haile et al, 2017b)

The enterprise has up to date marketing tools such as functioning website communication with customers via e-mail also has marketing team to bring new ideas. There is weak support for customer recommending and lack of professional circle promotion. The opportunities that the enterprise can utilize are that the willingness of customers to vouch for them, professional media and technology. There is no current promotion threat.

The last primary department of Atemit enterprise is customer relation; employees have good relation with customers, one to one customer relation, appealing traders and dealers. The weaknesses of the enterprise with respect to customer relation are low capacity of customer databases, lack of communication among teams and loyalty. There are untapped domestic market and new buildings which is a good opportunity to be exploited. The economic crisis and the

constant change in exchange rate of Euro reduces the ability of customers to pay for flooring, are among the current threats the enterprise is facing.

**Table 13. SWOT analysis of Promotion**

| | |
|---|---|
| **Strength**<br>• Use of reference - Reference Sheets - Case studies - Reference visits<br>• E-mailing (to ensure continuous communication and with potential. Code.)<br>• Functional website effectively reach potential. customer target groups<br>• Structure including marketing, teamwork (brings ideas) | **Weakness**<br>• There is no promotion in professional circles - or PR<br>• Weak support for recommending customers |
| **Opportunity**<br>• Customer References (willingness to acknowledge satisfaction)<br>• The opportunity to publish in professional media<br>• New technologies (eg. Network quality database ...) | **Threat**<br>• NO Current Threat |

Source: (Haile et al, 2017b)

**Table 14. SWOT analysis of Customer Relation**

| | |
|---|---|
| **Strength**<br>• People (employees) - Positive customer reviews<br>• Personal meetings and communication with the customer (1 representative in customer contact)<br>• Customer database segmentation, targeting (demanding a ban.)<br>• Traders also appeal to designers of new buildings<br>• Tested strategy and tactics in business, HR<br>• Dealer (developed business skills + understanding of customer needs)<br>• The system of education across the company + Directive | **Weakness**<br>• SURVIVAL customer database (insufficient capacity and functionality)<br>• Low capacity of working teams lack of communication, feel the pressure to perfect performance,<br>• Lack of gratitude - with loyalty |

| Opportunity | Threat |
|---|---|
| • Untapped domestic market<br>• New buildings | • Saving is important for some customers<br>• New buildings provide construction companies that are pushing prices<br>• Economic crisis (to reduce spending on the floor - rather invest in machines)<br>• The constant change of EUR exchange rate (to change prices) |

Source: (Haile et al, 2017b)

What was done in this case study was that to compare results from experts using SWOT analysis, SWOT analysis with hybrid Choquet fuzzy integral and TOPSIS, SWOT analysis with fuzzy TOPSIS and WSAM. The possible combination of strategic options for the company are discussed below:

**Strength and Opportunity (SO)**

Customer relation

- To take advantage of the opportunity to contact designers of new buildings to incorporate quality floor into their designs
- Unsatisfied market of the CR in relation to Employee Orientation per customer, Network of Trained Traders.

Product

- Independence from Denzit's temperature fluctuations in conjunction with Competitors does not offer comparable quality and application at different temperatures. Here we do not derive from the highest value in terms of opportunities, but from what is in relation to that strong side.

Promotion

Willingness to confirm and boast a new floor in reference to the Reference Sheets.

**Strength and Threat (ST)**

Customer relation

- Customer tries to save and economic crisis in the context of employee orientation on customer and personal meetings and customer relationship dealer (trained business skills + knowledge of customer needs) In order to save costs by convincing the customer that cheap is not necessarily the most effective.

Product

- The threat of addiction to poor quality. Suppliers and Competition is achieved (in reasons no longer a competitive advantage)
- Competitiveness innovations (resin is no longer a competitive advantage, Denzit touches)
- To compensate for the development of new products.

**Weakness and opportunity (WO)**

Customer relation

- Buy a new database and that the market is unsatisfied, it is recording that it will use larger database for the future. This will be an important investment if the company decide to expand the market geographically.

**Weakness and Threat (WT)**

Customer relation

- Since there is no customer loyalty and there is economic crisis there should be a new product with low price.

The result from this method is a methodical selection of effective combination strategy for the enterprise Atemit plc. The weights for the analysis was contributed by the internal staff and external experts. The following tables (Table 15 to17) shows the weight and performance of Strength of each department. The performance of the criteria was first collected from experts using linguistic variable not satisfactory, satisfactory and very satisfactory performance of the business with respect to each criteria. Then the data was presented using trapezoidal fuzzy membership function and defuzzified.

**Table 15. Weights of Product criteria**

| Criteria | Weight | Performance |
|---|---|---|
| product quality (density) of reservations, representation | 0.5 | 9.5 |
| Development of new products | 0.5 | 9.5 |
| Density dependent on temperature fluctuations during application | 0.6 | 5.5 |
| Offers comprehensive solutions – design, applications and customer service (standardization) | 0.5 | 9.5 |

Source: (Haile et al, 2017b)

**Table 16. Weights of Promotion criteria**

| Criteria | Weight | Performance |
|---|---|---|
| Use of reference - Reference Sheets - Case studies - Reference visits | 0.5 | 5.5 |
| E-mailing (to ensure continuous communication and with potential. Code. | 0.5 | 9.5 |
| Functional website | 0.4 | 2.5 |
| Structure including marketing, teamwork (brings ideas) | 0.5 | 9.5 |

Source: (Haile et al, 2017b)

**Table 17. Weights of Customer Relation criteria**

| Criteria | Weight | Performance |
|---|---|---|
| People (employees) - Positive customer reviews | 0.5 | 9.5 |
| Personal meetings and communication with the customer (1 representative in customer contact) | 0.5 | 9.5 |
| Customer database segmentation, targeting (demanding a ban.) | 0.5 | 5.5 |
| Traders also appeal to designers of new buildings | 0.7 | 2.5 |
| Tested strategy and tactics in business, HR | 0.5 | 9.5 |
| Dealer (developed business skills + understanding of customer needs) | 0.5 | 9.5 |
| The system of education across the company + Directive | 0.5 | 9.5 |

Source: (Haile et al, 2017b)

Method 1: In this case study, fuzzy TOPSIS method was used to aggregate the total evaluation of each category of the SWOT analysis, since TOPSIS is used to compare alternatives. The original file contained different weight and performance representation scale the table below shows the weights of criteria using a scale of 0 to 1 and performance using 1 to 10.The following

tables show the weights and performance point of each criterion in the strength part of the SWOT analysis.

Then the criteria was evaluated based on the values in the above tables (Table 15 to 17) using fuzzy TOPSIS as shown below in the tables (Table 18 to 20). $A^*$ in the following tables represent the ideal value expected from the criteria and $A^-$ represents the negative ideal value where in this case is 0 and 1 respectively. $D^-$ is the distance of the performance on the criteria to the negative ideal value where the $D^+$ is the distance from the positive ideal value. The weight and performance values are values of the criteria

**Table 18. Analysis of strength of Product**

| Weight | Performance |
|---|---|
| 0.714286 | 0.95 |
| 0.714286 | 0.95 |
| 0.857143 | 0.55 |
| 0.714286 | 0.95 |

| $A^*$ | $A^-$ |
|---|---|
| 1 | 0 |
| 1 | 0 |
| 1 | 0 |
| 1 | 0 |

| | |
|---|---|
| $D^+$ | 0.767683 |
| $D^-$ | 1.266342 |

Source: Author

As shown in the table above for this case the ideal and the negative ideal was represented using 1 and -1. The result was **0.622579**. The same analysis was done for the promotion department of the Atemit plc. The process of the fuzzy TOPSIS evaluation is shown in the table below.

**Table 19. Analysis of Strength of Promotion**

| Weight | Performance |
|---|---|
| 0,714286 | 0.55 |
| 0.714286 | 0.95 |
| 0.57 | 0.25 |
| 0.714286 | 0.95 |

| A* | $A^-$ |
|---|---|
| 1 | 0 |
| 1 | 0 |
| 1 | 0 |
| 1 | 0 |

| | |
|---|---|
| $D^+$ | 1.144798 |
| $D^-$ | 1.046691 |

Source: Author

The result of the evaluation for the promotion department is **0.477616**

**Table 20. Analysis of Strength of Customer Relation**

| Weight | Performance |
|---|---|
| 0.714286 | 0.95 |
| 0.714286 | 0.95 |
| 0.714286 | 0.55 |
| 1 | 0.25 |
| 0.714286 | 0.95 |
| 0.714286 | 0.95 |
| 0.714286 | 0.95 |

| $A^*$ | $A^-$ |
|---|---|
| 1 | 0 |
| 1 | 0 |
| 1 | 0 |
| 1 | 0 |
| 1 | 0 |
| 1 | 0 |
| 1 | 0 |

| | |
|---|---|
| $D^+$ | 1.2032 |
| $D^-$ | 1.5872 |

Source: Author

The calculated result for the customer relation department was **0.568803**. Each department's (Product P, Promotion Pm, and Customer relation C) weakness, opportunity and threat were evaluated the same way. The following table represents the evaluation of each department:

**Table 21. Evaluation of all departments using fuzzy TOPSIS**

| | | | |
|---|---|---|---|
| SP | 0.622579 | WP | 0.371833 |
| SPm | 0.477616 | WPm | 0.368728 |
| SC | 0.568803 | WC | 0.364822 |
| OP | 0.430229 | TP | 0.5 |
| Opm | 0.528055 | Tpm | 0 |
| OC | 0.340409 | TC | 0.409498 |

Source: (Haile et al, 2017b)

**Table 22. Threat analysis of Product using Choquet fuzzy integral**

| Criteria | Weight | Performance | $\lambda$ |
|---|---|---|---|
| Fluctuations in temperature during implementation Suppliers | 0.5 | 5.5 | -0.98 |
| Competition is achieved (in resins no longer a competitive advantage) | 0.6 | 5.5 | |
| significant bargaining power | 0.6 | 9.5 | |

Source: (Haile et al, 2017b)

The next method used to calculate the evaluation of each department was Choquet fuzzy integral. The first step in the evaluation process was to calculate lambda, then the aggregate

worth of each information was calculated. The data was arranged in an increasing order with respect to performance. Detailed information on calculating λ and Choquet fuzzy integral is discussed in the discussion section case study 1 to case study 3. The table above, Table 22. shows the Threat of Product department (TP). The value for the aggregation of treats the Product department is facing was calculated as 0.25. The result from Choquet fuzzy integral analysis is shown in the following table:

**Table 23. Evaluation of all departments using Choquet fuzzy integral**

| | | | |
|---|---|---|---|
| SP | 0.913583 | WP | 0.282056 |
| SPm | 0.84048 | WPm | 0.45 |
| SC | 0.938073 | WC | 0.282056 |
| OP | 0.736803 | TP | 0.25 |
| Opm | 0.74 | Tpm | 0 |
| OC | 0.43 | TC | 0.221268 |

Source: (Haile et al, 2017b)

The next step was for experts to assign weight for each department, based on the weights all possible strategies were evaluated using TOPSIS.

From the results obtained using weighted sum method, Choquet fuzzy integral and TOPSIS experts derived possible strategies. The following table shows the resulted evaluation of possible strategies from the results of Choquet fuzzy integral of each departments using TOPSIS.

**Table 24. Possible strategies using Choquet fuzzy integral and TOPSIS**

| SO | | WO | |
|---|---|---|---|
| SCOC | 0.325973 | WCOC | 0.176167 |
| SPOP | 0.325514 | WPOP | 0.175309 |
| SPmOPm | 0.264901 | WPmOPm | 0.182523 |
| ST | | WT | |
| SCTC | 0.303291 | WCTC | 0.146453 |
| SPTP | 0.297977 | WPTP | 0.136871 |
| SPmTPm | 0.210666 | WPmTPm | 0.113021 |

Source: (Haile et al, 2017b)

Based on the result from the above table the best strategy is SCOC; that is to use the strength of customer relation to utilize the opportunity in customer relation. As discussed above there are two options of SO customer relation strategy:

- To take advantage of the opportunity to contact designers of new buildings to incorporate quality floor into their designs
- Unsatisfied market of the CR in relation to Employee Orientation per customer, Network of Trained Traders.

The same conclusion to choose the above SCOC strategy was obtained from the analysis using fuzzy TOPSIS method. Although not all the strategic options rank the same way from the two analyses there is a strong correlation between the rankings of the two methods.

The **SCOC 0.48243** in the following table, Table 25. is the max-max strategy that shows a higher number among other max-max strategies that is to use the advantage of strength and opportunity of customer relation in the business to eliminate weakness. The next valuable choice of strategy is SPOP, 0.42855 that is the next max-max strategy choice for any reason if the first alternate strategy is inapplicable. In the analysis all strategic option were normalized to have the same measure.

**Table 25. Possible strategies using fuzzy TOPSIS with TOPSIS**

| | | | |
|---|---|---|---|
| SCOC | 0.482343 | WCOC | 0.219256 |
| SPOP | 0.479021 | WPOP | 0.225212 |
| SPmOPm | 0.42855 | WPmOPm | 0.216885 |
| SCTC | 0.434633 | WCTC | 0.167633 |
| SPTP | 0.392687 | WPTP | 0.098506 |
| SPmTPm | 0.342398 | WPmTPm | 0.096219 |

Source: (Haile et al, 2017b)

The resulting ranks from the different methods were analysed using Spearman's correlation coefficient. The resulting correlation was 0.97 that is very strong correlation, which implies a consistent result from the two methods. The following figure shows the correlation of results from two methods Fuzzy TOPSIS and a hybrid method Choquet fuzzy integral and TOPSIS. The

X axis represents the rank of strategies evaluated using fuzzy TOPSIS while the Y axis represents the rank of alternate strategies evaluated using Choquet fuzzy integral. The strategy symbol in the graph represents strategy rank in the two methods (1, 1) represents SCOC strategy that was the first choice of strategy in both Choquet fuzzy integral and fuzzy TOPSIS method with TOPSIS.

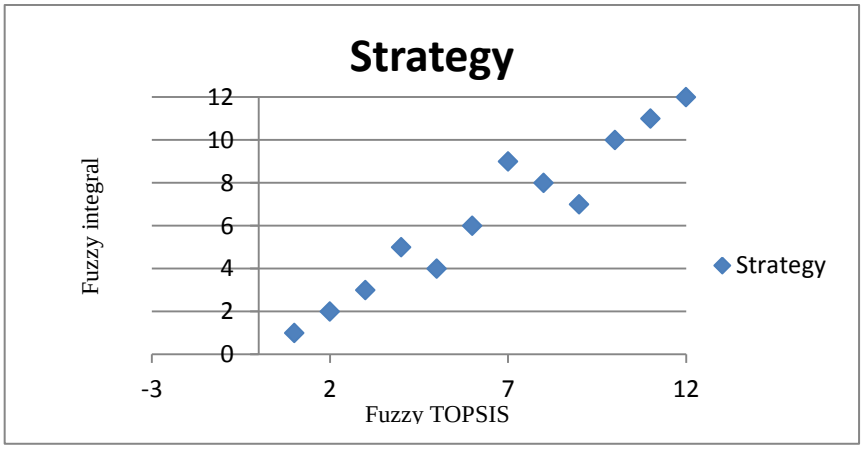



**Fig. 18 Correlation of fuzzy TOPSIS and Choquet fuzzy integral with TOPSIS**
Source: Author

## 4.5 Case study 5: Contemporary decision making in mid-sized city in the CR

There are a lot of attitudes to the city management. The way implemented in the central Europe tends to the more open and clear way of governance (Wolf & Steven, 2013). The first step of the process was the implementation of principles of the strategic planning and of the project management (Spee & Paula, 2011). After more than 15 years of experience some cities recapitulated the processes (Shrader et al, 1984) and decided to move forward by adopting the output-focused attitude (Šilhánková, 2011) and clear and fair decision-making process. The first step of the process was the implementation of principals of the strategic planning and of the project management. After more than 15 years of experience, some cities recapitulated the processes and decided to move forward with the decision-making process. The methodology introduced in this case was the practical example of the Czech city, Hradec Kralove, that is developing its internal processes more clear and transparent. The city is collecting projects and project ideas as the project-sheets. These data are periodically evaluated and ranked by different departments of the city according to their responsibilities. The final list is a floating document showing actual position of each project in the ranking hierarchy. The purpose of this case study

is to evaluate impact of different methods of ranking to the list to the position of the projects on the list. The hypothesis of the study is: **The position of the projects chosen for the practical realization or implementation is affected by the methodology used for the evaluation.** The city governance is a very complicated issue combining many different needs of different entities on many levels and in many fields. The local government is the one that is the closest to the public. In the central European environment inhabitants know their mayor and municipality employees usually in person. Therefore the responsibility for the outputs and outcomes of the management and city development is much higher than on other levels of the governance. This close interaction of the local stakeholders is a positive contribution to the local development but include some threats as well. The group of decision-makers faces new challenges; and the threat of the lock-in and not absorbing new ideas and impulse from the society (Rydin, 2010b), (Barry, 2001). To prevent this situation the main goals of the local society are expressed in the strategic development documents. These documents are created in cooperation of four main groups of actors in the city/region - local government plus public authorities, private companies, universities and the public (Pozoukidou, 2017) (Robert; et al, 2010). They set up the direction of the local development, define the goals and aims. The everyday work on the action level is up to the local government. As written above the local government has to balance many different needs and demands in the city. Not only the strategic goals but also the national and EU regulations, goals of their regional policies and of course there is a duty of ordinary city maintenance.

The projects implemented by the City of Hradec Králové should be evaluated in a comprehensive way, i.e. from all aspects of the sustainable development of the area. These include economic aspects (eg. employment, urban budget impact), social (eg. social, health, safety, etc.) as well as environmental aspects (including energy use). In the city of Hradec Králové, the evaluation of this type is currently lacking.

The methodology of the Strategic Sustainable Development Team of the City of Hradec Králové (hereinafter referred to as the "Strategic Team") contains composition and activity. The strategic team is always appointed by the Council of the City of Hradec Králové and its task is the activities described in this methodology. The organizational security structure is designed as the ideal combination of political leadership and professional guarantors responsible for

achieving goals and projects. Complex composition is considered to consist of the narrow leadership of the city and the self-governing unions affected by the implementation of the city projects.

The following figure shows the process flow of project selection at the local government of the city studied in this case study.

The Strategic Team is an expert guarantor of the strategic planning evaluation and, in particular, the evaluation of the projects to be funded from the city budget. Its main objective is to manage public funds, which is, on the one hand, most effective, but at the same time in line with the full development of individual thematic areas of sustainable development. By using a strategic team in the process of evaluating the individual project objectives of the city, an improvement in the quality of management in public administration in the city will be achieved, in particular in order to provide a comprehensive and objective evaluation of the submitted intentions for the political representatives of the city. The following figure shows the project selection process in the city.

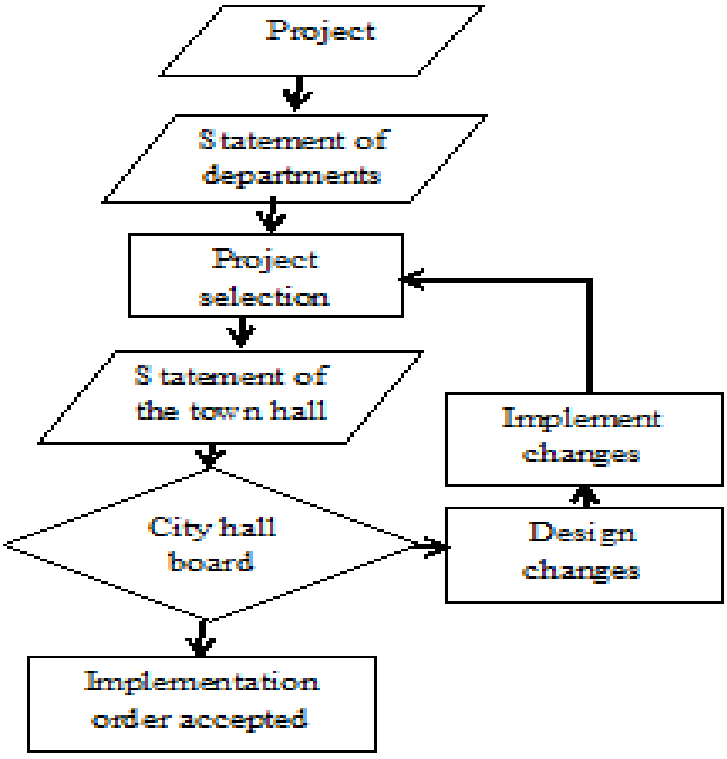



**Fig. 19 Project selection process**
Source: (Haile &Mastalka, 2017c)

The activities of the strategic team will be primarily the evaluation and prioritization of the city projects in the project stack, the assessment of their contribution to the development of the city, and the subsequent updating and evaluation of the City Action Plan based on the decision of the City Council. The Strategic Sustainable Development Team will expertly assess the individual projects proposed for inclusion in the Action Plan in terms of budget and budget outlook, their quality, contribution and consistency with the Strategic Plan for City Development (STATEGICKÝ Tým, 2017).

Not all of the city's budget expenditures make meaningful or necessary evaluations. For instance, removal of accidents, necessary repair, and repeated events where the similar amount was issued in the previous year. Other projects will be included in the evaluation process, for which all necessary information will be properly entered into the Project Stack at the SharePoint of the City of Hradec Králové. The Strategic Team recommends whether it considers the project to be relevant for project management. The projects are evaluated by the Strategic Team in terms of the need for projects according to the created criteria model. The criteria that are designed by the local government to be used are: urgency, availability of external sources, economy, readiness, compliance with city strategic development plan, and synergy with other projects. For this particular case experts enlarged the list with the compliance with other sectorial plans, compliance with political proclamation and "public demand". The description of the criteria is as follow:

Urgency – there are projects that are not a part of the strategic development documents but they would be fulfilled. Typically it would be the reaction to disasters, unexpected problems with the technical infrastructure or other unexpected problems (terrorist attack…).

Availability of external sources – the investment reality in the Central and Eastern Europe has been linked to the huge amount of subsidies for the last decade. Many local governments have invested only into the projects that were supported by the EU or national subsidies. However, this is not an ideal attitude; the subsidies have to be linked to the EU or national policy. Therefore there could be expressed the opinion that the local governments have helped to fulfil the goals on these levels. Anyway the availability of the external support is a very important issue during the decision-making project on the local level.

Economy – this point expresses the level of expected future mandatory expenditures of the municipality budget. This point would help to keep the long-time sustainable budgeting on the local level.

Readiness – especially "hard" investment projects in the CR are long-distance run. Very complicated law hand in hand with lot of stakeholders who are supposed and authorized to affect the process would extend the needed planning and permitting process to years.

Compliance with Strategic plan – the strategic plan would be the base for the development of each settlement and each project of the local government. However, the quality of the documents are very variable, the main idea of the strategic plan as the main planning tool (together with master plan and budget) remains.

Compliance with other sectorial plans – there are the issues on the local level that have to be worked out deeper (energy, social care, nature protection, climate change resilience/adaptation, security…). Therefore the sectorial plans are created. Despite there would be in compliance with the strategic plan, the authors would recommend to keep them as a special point of the evaluation.

Compliance with political proclamation – as mentioned above, the strategic plan would be the main and crucial document for the development of the municipality. The goals expressed in the strategic plans would be the goals of all the society, all stakeholders. The political representatives elected in the CR for four years usually declare their priorities in the proclamation of their political goals and aims.

"Public demand"– this criterion is designed to be used in the exact city this city is about. The municipality of this city has a long experience with strategic planning and evaluation of its impacts into the life of the city. The system of indicators has more than one hundred items and is evaluated periodically. Based on these indicators there could be expressed the level of "public demand". However the study would suggest to design the obligatory methodology for this criteria to avoid possible interpretation mistakes or manipulation.

Synergy with other projects – several projects are linked to each other. As a typical example would serve the reconversion of the public spaces that would be linked to the reconstruction of

the entire infrastructure under the surface. This is also the criteria that would be taken into account.

The practical part of the case study is based on the modelling of the ranking of the typical projects appearing in the everyday life of the local governance. The first project is the project of the infrastructure that is at the end of its lifetime period and urgently needs investments. The project is administratively prepared but not in compliance with the strategic development documents. The second project is a typical project that is not urgent but is involved in the strategic documents, ready to implement and the government is waiting just for the financial sources. The third project is the project that is not a part of any strategic document and is not needed operationally. The only reason for implementing this project is available resource (subsidy) and political will. Such an attitude of the governance is not appropriate but it can be seen in the practise and therefore the authors have involved it. The fourth project is a project that is not urgent but it is involved in all the long-term development documentation as well as willed by the public. The project number five is the urgent operational project that is ready to implement, there are available external sources and the project is neutral to the strategic development document. The values for projects with respect to these criteria is given according to the following remark.

- Criterion 1: Urgency

  1 - Very low (project not necessary, object or area not in poor technical condition)

  3 - Medium (project implementation required, object or area not in good technical condition)

  5 - Medium (project implementation is desirable, if not necessary, the facility is in poor technical condition)

- Criterion 2: External resources:

  Financing from external sources (expected / possible subsidies). It is evaluated according to the current open calls of the operational programs in the given year.

  0 - Without subsidy

  1 - Subsidy up to 30%

  3 - Subsidy up to 69%

5 - Subsidies of 70% or more

- Criterion 3: Economy:

Operational burden of city budget. This is the annual burden of the budget with regular expenses.

0 - Over 10 million - extreme load - the amount of operating and running costs generated by the project is high and there will be an extreme burden on the city budget for a period of one year

1 - Up to 10 million - heavy load - the project generates a large amount of operating costs for maintenance and operation over a period of one year and would result in a considerable burden on the city budget

3 - Up to 3 million - acceptable load - the project generates an acceptable level of maintenance and operation costs over a period of one year

5 - Up to 1 million - Minimum load - The project does not generate any major costs in addition to the normal maintenance and operating costs of the city over a one-year period.

- Criterion 4: readiness

Administrative readiness - project, feasibility study, grant application

The so-called "Hard projects":

0 - None

1 - Very low workmanship - there is only a study on a project

3- Intermediate work - the project documentation is already prepared, or the documentation for territorial management

5: All documentation - all necessary documentation is prepared for the project, including the building permit or the grant application

The so-called "Soft projects"

0 - intent

1 - Very low workmanship - there is a project proposal for the project

3 - Medium progress - preparatory phase - preparation of supplier selection, evaluation of supplier selection

5 - All documentation - implementation phase - selected contractor, project fully prepared, is already being implemented

- Criterion 5: Strategic Plan

Compatibility with the Strategic Urban Development Plan.

0 - Disagree - the content of the project does not meet the objectives set out in the Strategic Urban Development Plan

1 - Agrees with a minority - agrees with the SPRM in the key area

3 - Agrees for the most part - project focus agrees with SPRM in key area and measures

5 - Agrees - the content of the project agrees with the SPRM in the key area, measures and specific objectives

- Criterion 6: Social demand

Need from the public. Subjective criterion - its weight is increasing when it comes to the KMS priority, compliance with the program statement, continuity with long-term surveys and the results of the ECI Sustainable Development Indicators.

0 - None

1 - Very low

3 - Medium

5 - Very high

- Criterion 7: Synergy

Link to other planned projects of the city or other entities. (The invested investments - for example, when repairing the square, it is revealed that there is a need to repair the sewerage)

0 - No.

3 - Yes

Method 1: Weighted Sum Method: The change of project ranking with respect to the change in weight is demonstrated using WSAM and Analytic Hierarchy process methods. The following table shows the rank of projects where all criteria have the same weight. Prj represents project where wght is weight of criteria.

**Table 26. WSAM where weight of criteria is the same**

| Criteria | Wght | Prj 1 | Prj 2 | Prj 3 | Prj 4 | Prj 5 |
|---|---|---|---|---|---|---|
| Urgency | 0.11 | 0.22 | -0.1 | -0.1 | 0 | 0.22 |
| Availability of external sources | 0.11 | 0 | 0.2 | 0.22 | 0 | 0.22 |
| Economy | 0.11 | -0.1 | 0 | -0.1 | 0 | 0 |
| Readiness | 0.11 | 0.22 | 0.1 | 0.11 | 0.22 | 0.22 |
| Compliance with Strategic plan | 0.11 | -0.1 | 0.2 | 0 | 0.22 | 0 |
| Compliance with other sector plans | 0.11 | -0.1 | 0.1 | 0 | 0.22 | 0 |
| Compliance with political proclamation | 0.11 | 0.22 | 0.1 | 0.22 | 0.22 | 0 |
| "Public demand" | 0.11 | 0 | 0.1 | 0.11 | 0.22 | 0 |
| Synergy with other projects | 0.11 | 0 | 0.1 | 0 | 0 | 0 |
| WSAM | | 0.33 | 0.9 | 0.44 | 1.11 | 0.67 |
| Rank | | 5 | 2 | 4 | 1 | 3 |

Source: Author

**Table 27. Weighted sum method comparison with different weights of criteria**

| Criteria | wght | Prj 1 | Prj 2 | Prj 3 | Prj 4 | Prj 5 |
|---|---|---|---|---|---|---|
| Urgency | 0.2 | 0.4 | -0.2 | -0.2 | 0 | 0.4 |
| Availability of external sources | 0.1 | 0 | 0.2 | 0.2 | 0 | 0.2 |
| Economy | 0.2 | -0.2 | 0 | -0.2 | 0 | 0 |
| Readiness | 0.2 | 0.4 | 0.2 | 0.2 | 0.4 | 0.4 |
| Compliance with Strategic plan | 0.05 | -0.05 | 0.1 | 0 | 0.1 | 0 |
| Compliance with other sector plans | 0.05 | -0.05 | 0.05 | 0 | 0.1 | 0 |
| Compliance with political proclamation | 0.1 | 0.2 | 0.1 | 0.2 | 0.2 | 0 |
| "Public demand" | 0.05 | 0 | 0.05 | 0.05 | 0.1 | 0 |
| Synergy with other projects | 0.05 | 0 | 0.05 | 0 | 0 | 0 |
| WSAM | | 0.7 | 0.55 | 0.25 | 0.9 | 1 |
| Rank | | 3 | 4 | 5 | 2 | 1 |

Source: Author

The ranks in the table (Table 26.) were calculated using WSAM; that is to multiply the weight. Based on the results obtained in the table project four, prj 4, the project that is not urgent but it is involved in all the long-term development documentation is the first choice that will add more values to the city and satisfies more criteria. Project one,Prj1, infrastructure, is the least favourable project to implement. If the weight is changed the rank of project will also change accordingly. The table (Table 27) shows the change in rank as the weight changes. In the following table urgency, economics and readiness have the same higher importance than the rest of the criteria, availability of sources and compliance with political proclamation importance 0.1

Based on the new weight project five (prj 5), urgent operational project that is ready to be implemented is the first choice that will add more values to the city and satisfies more criteria. Project three, a project that is not a part of any strategic document and is not needed operationally, is the least favourable project to implement.

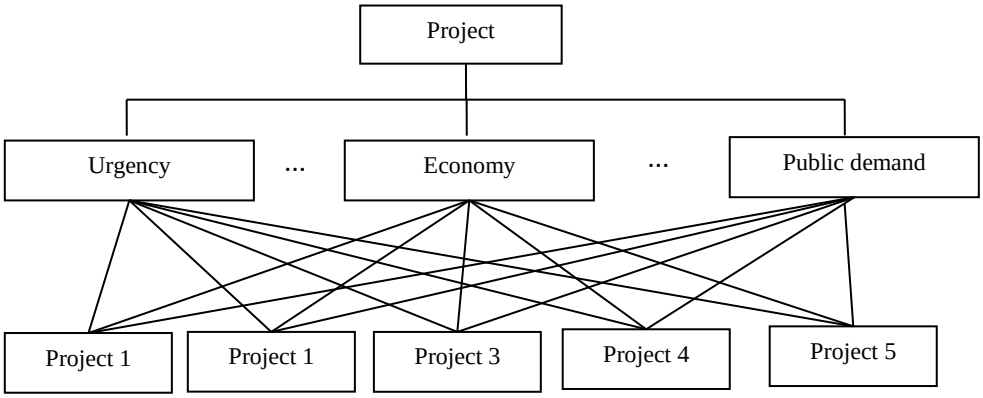



**Fig. 20 AHP for project selection**
Source: (Haile &Mastalka, 2017c)

Method 2: AHP was applied for the project selection process since the project selection problem can be represented hierarchically. The figure above shows the hierarchy for project selection discussed in this case study. Based on the points provided by experts a pairwise comparison matrix was prepared, the following table (Table 28.) shows the pairwise comparison of projects for the first criteria, Urgency. The total value of the projects was then calculated and ranked using wght 1. 0.11, for all the criteria.

**Table 28.Comparison of projects using AHP**

| | Prj 1 | Prj 2 | Prj 3 | Prj 4 | Prj 5 | GeoMean | Weight |
|---|---|---|---|---|---|---|---|
| **Prj 1** | 1 | 7 | 7 | 5 | 1 | 3.01 | 0.080034 |
| **Prj 2** | 1/7 | 1 | 1 | 1/3 | 1/7 | 0.37 | 0.009817 |
| **Prj 3** | 1/7 | 1 | 1 | 1/3 | 1/7 | 0.37 | 0.009817 |
| **Prj 4** | 1/5 | 3 | 3 | 1 | 1/7 | 0.76 | 0.020299 |
| **Prj 5** | 1 | 7 | 7 | 5 | 1 | 3.01 | 0.080034 |

Source: Author

Based on the results in the table project four, prj 4, the project that is not urgent but it is involved in all the long-term development documentation is the first choice that will add more values to the city and satisfies more criteria.

**Table 29. Results of AHP comparison**

| Criteria | wght | Prj 1 | Prj 2 | Prj 3 | Prj 4 | Prj 5 |
|---|---|---|---|---|---|---|
| Urgency | 0.11 | 0.04 | 0.01 | 0.01 | 0.01 | 0.04 |
| Availability of external sources | 0.11 | 0.01 | 0.03 | 0.03 | 0.01 | 0.03 |
| Economy | 0.11 | 0.01 | 0.03 | 0.01 | 0.03 | 0.03 |
| Readiness | 0.11 | 0.03 | 0.01 | 0.01 | 0.03 | 0.03 |
| Compliance with Strategic plan | 0.11 | 0 | 0.04 | 0.01 | 0.04 | 0.01 |
| Compliance with other sector plans | 0.11 | 0 | 0.03 | 0.01 | 0.06 | 0.01 |
| Compliance with political proclamation | 0.11 | 0.03 | 0.01 | 0.03 | 0.03 | 0.01 |
| "Public demand" | 0.11 | 0.01 | 0.02 | 0.02 | 0.05 | 0.01 |
| Synergy with other projects | 0.11 | 0.02 | 0.05 | 0.02 | 0.02 | 0.02 |
| Sum | 0.99 | 0.15 | 0.23 | 0.15 | 0.27 | 0.19 |
| Rank | | 4 | 2 | 5 | 1 | 3 |

Source: Author

Project three, Prj3, a project that is not a part of any strategic document and is not needed operationally, is the least favourable project to implement.

Method 3: The same methods were used to compare the same projects with different interval of project points. The following table shows the evaluation of projects where weight is 0.11 for all criteria and the point interval is -5 to 5. According to the table below the most effective project is project four while projects one and two are equally least desired.

**Table 30. Results of projects comparison with interval points [-5,5]**

| Criteria | Wght | Prj 1 | Prj 2 | Prj 3 | Prj 4 | Prj 5 |
|---|---|---|---|---|---|---|
| Urgency | 0.11 | 0.56 | 0.56 | 0 | 0.11 | 0.56 |
| Availability of external sources | 0.11 | 0.11 | 0.11 | 0.56 | 0.11 | 0.56 |
| Economy | 0.11 | -0.11 | -0.11 | 0 | 0.11 | 0.11 |
| Readiness | 0.11 | 0.56 | 0.56 | 0.33 | 0.56 | 0.56 |
| Compliance with Strategic plan | 0.11 | 0 | 0 | 0.11 | 0.56 | 0.11 |
| Compliance with other sectoral plans | 0.11 | 0 | 0 | 0.11 | 0.56 | 0.11 |
| Compliance with political proclamation | 0.11 | 0.56 | 0.56 | 0.56 | 0.56 | 0.11 |
| "Public demand" | 0.11 | 0.11 | 0.11 | 0.33 | 0.56 | 0.11 |
| Synergy with other projects | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 |
| WSAM | | 1.89 | 1.89 | 2.11 | 3.22 | 2.33 |
| Rank | | 4 | 4 | 3 | 1 | 2 |

Source: Author

The graph below (Fig. 21) shows the correlation between the ranks of projects obtained using WSAM and AHP where weight of all criteria is 0.11. The correlation legend in the graph represents the rank of projects resulted from the WSAM and AHP method evaluated using the same weight (1, 1) shows project 4 (prj 4) ranked first in analysis by both methods.

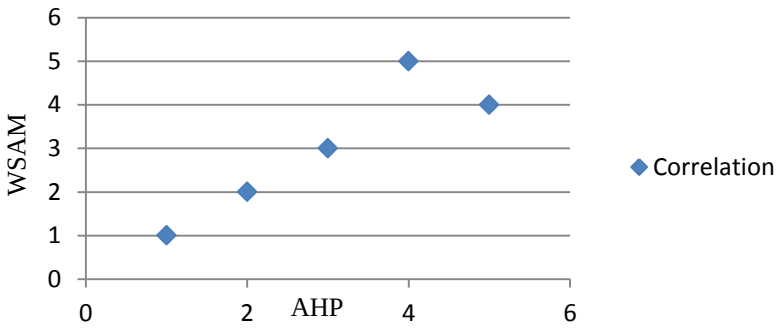



**Fig. 21 Spearman's correlation of results from WSAM and AHP**
Source: (Haile &Mastalka, 2017c)

The resulting ranks of projects obtained above by using WSAM and AHP methods with interval [-2,2] was then compared to see if there is a correlation, using Spearman's correlation (Eq. 3.21). Based on the graph and the result calculated using Spearman's correlation coefficient, 0.9. there is a strong similarity of results obtained using the two different methods.

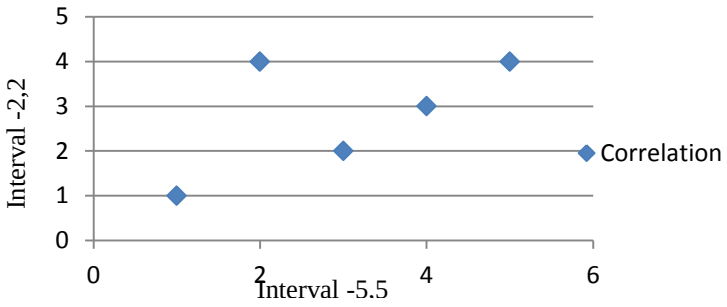



**Fig. 22 Spearman's correlation of results from -2,2 and -5,5**
Source: (Haile &Mastalka, 2017c)

Spearman's correlation coefficient was also used to compare the results obtained from the two intervals (-2,2 and -5,5). The results obtained from the interval -5 to 5 shows the mean of the results obtained from the two methods WSA and AHP with the interval -2 to 2.

The above graph in the above figure (Fig. 22) shows the Spearman's correlation coefficient among the results obtained from the interval -2,2 and -5,5. The calculated correlation coefficient also shows that there is 0.65 correlation among the two results.

In conclusion, the results of the modelling have shown that the strictly mathematic attitude of weighted decision process brought to the not-model-fitting reality of the governance could affect the results of the process. The implementation of the model-selected projects could prevent the political prioritization of any projects but on the other it is very sensitive to its tuning. The weights and used methodology are clear and could be expressed publically by the local government but it could also cause the lack of the responsibility of local politicians. Their decisions could be perceived as a result of the mathematical model and not as a product of their decisions that they are responsible for. As any other tool used for the city/regional development. The presented methodologies could be very helpful.

### 4.6 Case study 6: Case based reasoning

Candidate countries of EU are required to have administrative systems and public administration institutions capable of transposing, implementing and enforcing the acquis communautaire, EU legislation, according to the principle of "obligatory results" ("obligation de résultat") (Bundesministerium, 2007). Candidate countries have to meet the criteria required for EU Membership as adopted by the European Council in Copenhagen, Madrid and Luxembourg. In addition, candidate countries' progress will be measured against those criteria, i.e. in the

wording of the European Commission's Regular Reports, in terms of their "administrative and judicial capacity to apply the acquis", which signifies implicitly that their progress will be assessed against European administrative standards (Sigma, 2014). Over the years different frame works and tools have been developed by to help all cities of the EU member countries to meet the criteria. One of these tools is RFSC.

RFSC is a web tool (www.rfsc.eu) designed to help cities and urban territories promote and improve their integrated urban development actions (RFSC, 2011). Where "respect" means the RFSC values the diversity of European cities, respecting differences in local priorities and institutions. There is no one-size-fits-all solution for integrated urban development, no universal recipe for success. It's the shared vision that matters, the timeframes, targets and themes should be decided locally. RFSC enables cities to move at their own pace and choose the scope of their involvement. It offers a set of tools for evaluating and monitoring public policies, and an online space for cities to share their experiences. The RFSC rethinks the basis for sustainable development of cities by proposing a grid of 25 common questions formulated based on the following four dimensions: enhance the economic efficiency of territories, foster social cohesion in conurbations, improve the environmental quality of cities, and develop integrated governance practices. It means that RFSC analyses four areas simultaneously: economy, social, environment and governance. The RFSC is a vibrant community of cities that learn from each other, share experience and discuss common challenges. By joining the RFSC community, cities get access to different forms of exchange and support, including dedicated training sessions, peer learning and coaching from urban governance experts. Finally, for "cooperation", not competition, which is at the heart of the RFSC. Developed for cities and with cities, RFSC is a meeting place that aims to bring together various actors within one city, hundreds of cities and local authorities from across Europe and finally all those at the national and European level who believe that sustainable cities are the future (RFSC, 2012, 2016a). The RFSC is used in countries such as CR, France, Italy, Netherlands, Poland, Portugal, Spain, Sweden (RFSC, 2016b). The result of SWOT analysis evaluation of EU member countries' city could be used as an input for the RFSC method to identify the cities' focus.

Quality of Public Administration: A Toolbox for Practitioners was conceived as a helpful and practical guide for civil and judicial administrations to the challenges of good

governance in a constantly changing environment. It examines the key elements of good governance and highlights positive real-world responses in Member States to dilemmas in administration, signposting the way that others may also wish to follow. The Toolbox concentrates solely on the administration of public policy and services, including both civil and judicial systems. It is about governance as a process. It does not cover the specifics of individual policies or services - for example regarding education, taxation, health, customs, competition, training, etc. (EU Commission, 2015). The figure below (Fig. 23) shows the toolbox.

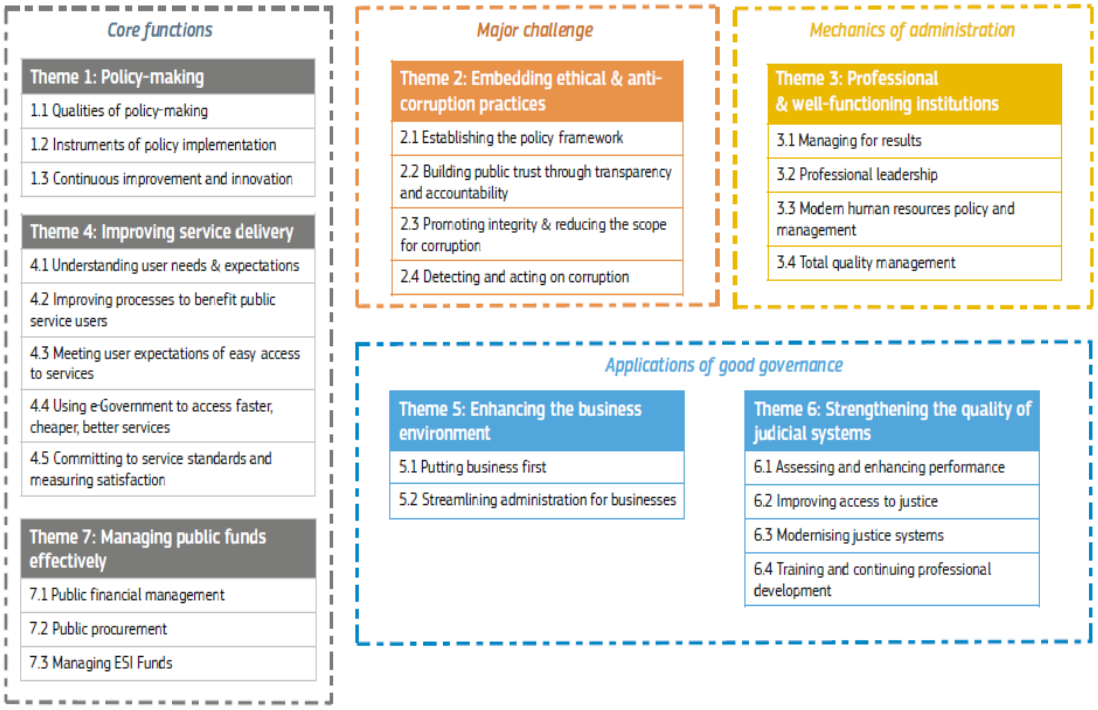



**Fig. 23 Toolbox overview by theme and topic**
Source: (EU Commission, 2015)

Many projects are also funded by the EU, under different programs, to improve public administration policies and other governance issues. One of these programs is regional policy. This program has funded different projects on the issues like sustainable development, technology, and quality of life for the elderly people. In this case stucy two projects under the regional program, focused on the issue of improving quality of life for

the elderly people are discussed briefly. Most of these projects are designed in a way to be implementable by all EU member countries.

What is proposed in this dissertation work is a reasoning system that could be used by EU member countries to solve specific city problems or make decision based on the experiences of others. By solving problems in the same or similar way, quality of public administration of cities could get closer to achieving unanimity. What makes the proposed method different from the RFSC discussed in the above section is the way data is stored and retrieved. City council or experts provide the system with desired criteria and the system returns top solutions based on those criteria. The system focuses on cities since cities play a key role in the social and economic development of all European territories and provides home for the majority of population (EU Commission, 2011). A hypothetical case study was also performed to clarify the application of the method for project selection in solving a specific issue.

There have been different projects on improving the standard of living for the elderly people, in the EU. Some of those projects are implemented in collaboration between cities for example Q-Ageing and design led-innovation for active aging.

European Regional Development-funded Q-Ageing united partners from Germany, Hungary, Italy, Poland and Slovenia. Together they demonstrated the significant contribution older people can make to society through a final set of pilot projects tested in each country.

A key feature of Q-Ageing is its toolbox, which is a culmination of the work carried out under the project. It paves the way for the development of senior-friendly public spaces and improvement of mobility through senior recreation parks, open air space, as well as urban transportation facilities. The toolbox is intended for use by all EU-Member States. A Transnational Ageing Resource Centre was also established under Q-Ageing and serves as an online community space for the elderly. 30 temporary jobs were created as a result of the project (EU Commission, 2014).

Main attributes of the project include problem statement, budget, duration, and solution, the following table (Table 31.) shows these attributes and their values.

**Table. 31. Attributes of Q-Ageing**

| Attributes | Values |
|---|---|
| Problem statement | Making aging better for elderly people |
| Budget | 2 218 871 Euro |
| EU investment | 1 768 345 Euro |
| Duration | 12/2008-03/2012 |

Source: (EU Commission, 2014)

The findings under Q-Ageing support the idea that demographic ageing could be better tackled by ensuring elderly people stay longer in the labor market and remain healthy, active, and autonomous well into retirement. Q-Ageing partners have demonstrated the significance of actual and potential contribution that older people can make to the society through a final set of 18 pilot projects tested in various central European countries and regions. These include the online 'SkypeCare' for the elderly in Hungary and a day care center in Slovenia (EU Commission, 2014).

Design led-innovation for active aging is a project conducted by eight cities, RÉG. Bruxelles-Cap./Brussels Hfdst, GEW, Belgium, Antwerpen , Belgium, Yugozapaden, Bulgaria, Helsinki-Uusimaa, Finland, Etelä-Suomi, Finland, Berlin, Germany, Norge, Norway, Mazowieckie, Poland, Cataluña, Spain and Stockholm, Sweden. Each of these eight cities focused on a specific aspect of elderly care services, called 'scenarios'. The project aimed at an integrated approach, including stakeholders and users (EU Commission, 2016). The aim of the project was:

- Rethink and redefine senior care by using innovative processes and design methods
- Find feasible and sustainable solutions that keep senior citizens physically and socially active and that provide them with the care they need
- Improve the effectiveness of local policies by learning from best practices elsewhere and assessing their transferability

- Use design to build the innovation capacity of cities, to enhance their service development, and to improve their policy making
- Adopt a 360-degree approach by searching for systemic solutions in different areas and by involving all kinds of stakeholders
- Make it easier for public authorities to find strategic and service design competencies to support their policy making
- Increase awareness of the complex issues that arise from demographic ageing and the many challenges that senior care poses
- Jointly develop action plans, design briefs, best practice descriptions, field visits, thematic workshops, and guidelines for policy makers and public organizations (EU commission, 2016).

The following table (Table 32.) shows the attributes chosen from Design led-innovation for active aging project

**Table 32. Attributes of Design led-innovation for active aging**

| **Attributes** | **Values** |
|---|---|
| Problem statement | Making aging better for elderly people |
| Budget | 2 022 700 Euro |
| EU investment | 1 366 133 Euro |
| Duration | 01/2012-06/2014 |

Source: (EU Commission, 2016)

For demonstration purpose, a hypothetical case where one of the weaknesses of a city is low quality of life for elderly people is considered. The city desires to implement a project for improving life standard for elderly people. For the sake of simple demonstration the two projects, discussed above are the only cases in the case library that were performed on improving life standard for elderly people. Also, let the three attributes: budget, duration and EU investment be the only important variables. EU investment is assumed as an important variable believing the EU will grant the same amount of money for the same project implementation. The two cases discussed here are

only used to show the possibility of implementing the proposed method and the information used here is general.

The first step is to find a project whose objective is similar with the hypothetical problem, using text parser and key words like elderly people and aging. Once the two cases are found, the next step is to compare them based on the attributes of the hypothetical case. The city needs a project with lower budget. EU investment is very important for the city since the city needs to spend as minimum amount of budget as possible. Time duration is not a big issue for the city. The following table (Table 33.) shows cases, their attributes, and the weight of the attributes.

**Table 33. Case attributes and their values**

| Attributes | Case 1 | Case 2 | Weight |
|---|---|---|---|
| Budget | 2 218 871 Euro | 2 022 700 Euro | 0.5 |
| EU investment | 1 768 345 Euro | 1 366 133 Euro | 0.7 |
| Duration | 12/2008-03/2012 | 01/2012-06/2014 | 0.2 |

Source: (EU Commission, 2014, 2016)

First, the measurement of the attributes will be changed to similar unit. In this case sequencing method was used. Since there are only two cases and two sequences the interval from 1 to 2 is used. The table below (Table 34.) shows the value of case attributes on the scale of 1 to 2.

**Table 34. Case values on the scale of 1 to 2**

| Attributes | Case 1 | Case 2 | Weight |
|---|---|---|---|
| Budget | 1 | 2 | 0.5 |
| EU investment | 2 | 1 | 0.7 |
| Duration | 2 | 1 | 0.2 |

Source: (Haile & Krupka, 2017a)

The first step is to Calculate lambda based on the equation (Eq. 3.17).

$$\lambda+1=\prod_{i=1}^{3}\left(1+\lambda g_{\lambda}(x_i)\right)=(1+0.5\lambda)*(1+0.7\lambda)*(1+0.2\lambda),\ \lambda>-1$$

After calculating the roots of the polynomial resulted from the above equation, the following results were obtained: $\lambda$=0, $\lambda$=-0.744 and $\lambda$=-7.69. $\lambda$ =-0.744 was chosen since

it is the value that satisfies fuzzy measure criteria. Then the combined aggregate for the attributes was computed: $g_\lambda(12)=g_\lambda(1)+g_\lambda(2)+\lambda g_\lambda(1)g_\lambda(2)$, where, $g_\lambda(1)$ is the weight for the first attribute (budget), $g_\lambda(2)$ is weight for EU investment and $g_\lambda(3)$ is weight for duration of project. By substituting the values $g_\lambda(12)=$ 0.9396, $g_\lambda(13)=$ 0.6256, $g_\lambda(23)=$ 0.79584 and $g_\lambda(123)=1$ was calculated

The next step is to calculate the aggregate evaluation of each case to determine the better choice, based on equation (Eq. 3.17)

**Table 35. Fuzzy aggregate evaluation of attributes**

| **Case 1 $E^{def}$** | **Case 2 $E^{def}$** |
|---|---|
| 1.78 | 1.5 |

Source: (Haile & Krupka, 2017a)

Based on the result from the above table (Table 35.) case 1 is the better choice for the hypothetical city but since the results of both cases is close the best solution will be for the city to consider both cases and design a new solution based on the two cases. The budget for the project will be significantly less since by using this method some steps of project development cycles will be avoided.

### 4.7 Case Based Reasoning Prototype

Strategy implementation is the where all the plans and ploys of strategic planning come to be used. The execution of the strategic plan may vary from the original intension, and the environment expected in the strategy formulation phase may change. The implementation is the process where the organization tries to solve unexpected problems with actions that will complement the SP. Therefore, it is important to closely control and evaluate every action taken in the strategy implementation phase. Projects and programs that organizations pursue in order to achieve the desired goal of SP or to solve unexpected problems are the main actions in the strategy implementation phase. Projects have direct effect on the successful implementation of SP, which is why in this dissertation work project selection methods and models are discussed. One way this dissertation work provides is case based reasoning. Implementing CBR takes resources that are not available at this step, resources like server, human resource, and access to all projects in the EU. What was done in this dissertation work was to implement prototype CBR using Eclipse, COLIBRI Studio and XML. Eclipse is most widely used JAVA Integrated

Development Environment (IDE). COLIBRI Studio is composed of several plugins for the Eclipse IDE that provides the tools required to implement CBR systems (GAIA, 2008).

The Prototype was developed in two ways one was to use COLIBRI Studio and to change a few retrieval methods and the second is to use Eclipse and XML to implement CBR system for project index. The results from the two methods are also explained in this section. Some methods and screenshots of the prototype are shown below to explain the implementation process.

There were about 30 projects index lists from the EU Open Portal and from the case study 4.6 discussed above, in excel file, for the prototype. All projects in the case base have criteria like Some of the cases are described below (EU Open Portal, 2017).

- Electronic scanning MIMO Radar for railway level crossing obstruction detection alerting: The overall project objective is to develop an innovative low cost, low maintenance, high performance, high reliability electronic scanning radar sensor system (ES24) for level crossing obstacle detection, capable of detecting objects ranging from large vehicles to bicycles & people, including people lying down. Key features are, only a single sensor is needed to identify the wide range of object sizes, the sensor has no rotating parts & operates in all weathers.ES24 will enable track operators to monitor whether the track is clear or an object has been detected, significantly improving safety for both train passengers & crossing users.More than 2,000 significant accidents occur each year on EU member states' railways
- Paleozoic Seafloor Spreading: It is now recognised that large oceanic detachment faults are fundamentally important along slow-spreading rate portions of the mid-ocean ridge system. Objectives are to: (i) systematically back-strip successive tectonic events that have affected the ophiolite, in order to recover primary seafloor relationships; (ii) determine whether relative tectonic rotation has occurred across the detachment fault, a defining feature of modern examples; and (iii) quantify the role of large- and small-scale faulting in accommodating displacement within the detachment system. The project will provide: (i) extensive training in field-based tectonic applications of palaeomagnetism, directly complementing the Fellow's existing expertise and experience in laboratory techniques, thereby allowing her to conduct future investigations in complex tectonic environments; and (ii) engagement with the

international oceanic scientific community, opening future opportunities to move into oceanic geodynamic research.

The first step in developing a CBR prototype for reusing projects in solving problem was to create and XML index for projects from the excel sheet.

```
<?xml version="1.0" encoding="UTF-8" standalone="true"?>

<data-set xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">

<record>
        <CId>673348</CId>
        <Cdesc>Electronic scanning MIMO Radar for railway level crossing obstruction detection
        alerting.....
        </Cdesc>
        <Duration>182</Duration>
        <Budget>71429</Budget>
        <EUCont>50000</EUCont>
        <Country>UK</Country>
</record>
<record>
        <CId>660362</CId>
        <Cdesc>Paleozoic Seafloor Spreading</Cdesc>
        <Duration>730</Duration>
        <Budget>183454.8l</Budget>
        <EUCont>183454</EUCont>
        <Country>UK</Country>
</record>
<record>
        <CId>702222</CId>
        <Cdesc>Quality aging</Cdesc>
        <Duration>1167</Duration>
        <Budget>2218871</Budget>
        <EUCont>1768345</EUCont>
        <Country>DE</Country>
</record>
<record>
        <CId>750204</CId>
        <Cdesc>Active aging</Cdesc>
        <Duration>913</Duration>
        <Budget>2022700</Budget>
        <EUCont>1366133 </EUCont>
        <Country>BE</Country>
</record>
</data-set>
```

Then a project was created in COLIBRI Studio. Important criteria were then selected and designed in the prototype the selected criteria were the ones shown in the above XML code.

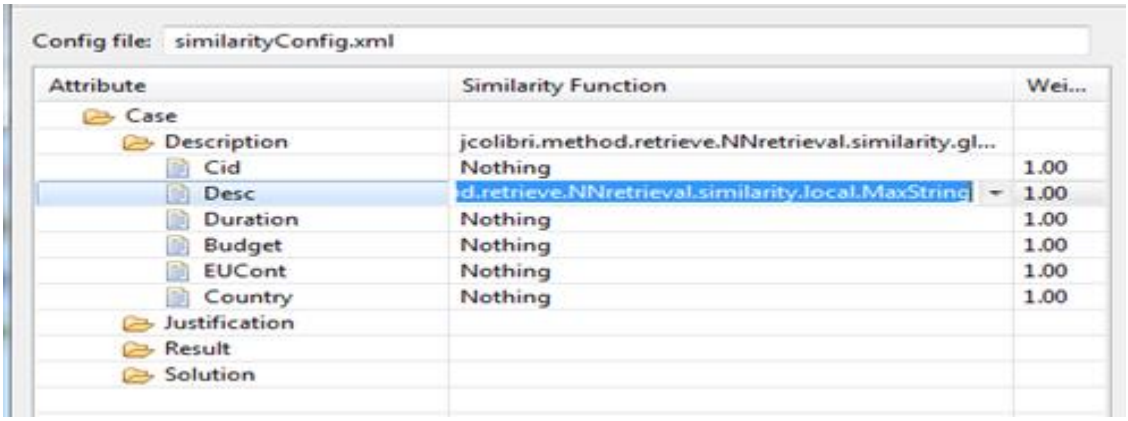



**Fig. 24 Similarity configuration wizard**
Source: (GIA, 2008)

Then the data from the XML file was imported to the project using the COLIBRI Studio wizard and then the attributes were matched with the columns. Once the project is created the platform will generate methods like set, get and similarity configuration.

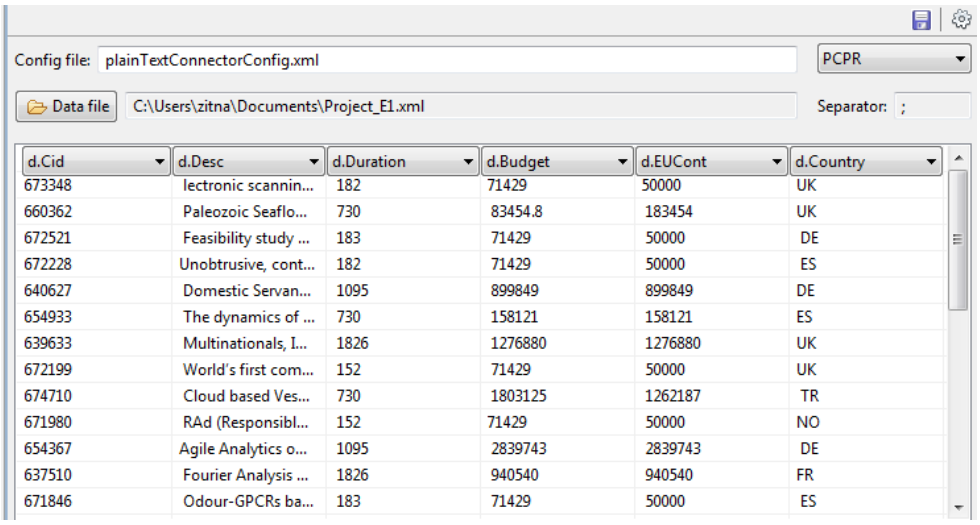
```
public java.lang.Integer getCid()
        {
                return Cid;
        }
    public void setCid(java.lang.Integer Cid)
        {
                this.Cid = Cid;
        }
    private java.lang.String Desc;
    public java.lang.String getDesc()
        {
                return Desc;
        }
    public void setDesc(java.lang.String Desc)
        {
                this.Desc = Desc;
        }
    private java.lang.Integer Duration;
    public java.lang.Integer getDuration()
        {
                return Duration;
        }
    public void setDuration(java.lang.Integer Duration)
        {
                this.Duration = Duration;
        }
    private java.lang.Double Budget;
    public java.lang.Double getBudget()
        {
                return Budget;
```

```
        }
    public void setBudget(java.lang.Double Budget)
        {
            this.Budget = Budget;
        }
    private java.lang.Double EUCont;
    public java.lang.Double getEUCont()
        {
            return EUCont;
        }
    public void setEUCont(java.lang.Double EUCont)
        {
            this.EUCont = EUCont;
        }

    private java.lang.String Country;

    public java.lang.String getCountry()
        {
            return Country;
        }
    public void setCountry(java.lang.String Country)
        {
            this.Country = Country;
        }
```

Then a query takes a key word to search in the descreption tag (CDesc)

```
                    NodeList myList= record.getChildNodes();
                        for(int j=0; j<myList.getLength();j++) {
                    getTextContent(myList.item(3). getTextContent().
contains(keyword1) || getTextContent(myList.item(j). getTextContent().
contains(keyword2) || getTextContent(myList.item(j). getTextContent().
contains(keyword3)){
                                    Node n=myList.item(j);
                                    if(n.getNodeType()==Node.ELEMENT_NODE) {
                                        Element name=(Element)n;
        }
    }
}
```

COLIBRI Studio provides wizard to set weight of criteria to refine results and uses project selection method to refine the results.




| d.Cid | d.Desc | d.Duration | d.Budget | d.EUCont | d.Country |
|---|---|---|---|---|---|
| 673348 | lectronic scannin... | 182 | 71429 | 50000 | UK |
| 660362 | Paleozoic Seaflo... | 730 | 83454.8 | 183454 | UK |
| 672521 | Feasibility study ... | 183 | 71429 | 50000 | DE |
| 672228 | Unobtrusive, cont... | 182 | 71429 | 50000 | ES |
| 640627 | Domestic Servan... | 1095 | 899849 | 899849 | DE |
| 654933 | The dynamics of ... | 730 | 158121 | 158121 | ES |
| 639633 | Multinationals, I... | 1826 | 1276880 | 1276880 | UK |
| 672199 | World's first com... | 152 | 71429 | 50000 | UK |
| 674710 | Cloud based Ves... | 730 | 1803125 | 1262187 | TR |
| 671980 | RAd (Responsibl... | 152 | 71429 | 50000 | NO |
| 654367 | Agile Analytics o... | 1095 | 2839743 | 2839743 | DE |
| 637510 | Fourier Analysis ... | 1826 | 940540 | 940540 | FR |
| 671846 | Odour-GPCRs ba... | 183 | 71429 | 50000 | ES |

**Fig. 25 Importing cases from XML file**
Source: (GIA, 2008)

The other prototype developed in this research was new CBR prototype using console input output system. The prototype takes up to three keywords and search for them in the description in the index:

```
System.out.println("enter key word 1");
    keyword1= bufRead.readLine();
  System.out.println("enter key word 3");
    keyword2= bufRead.readLine();
  System.out.println("enter key word 3");
    keyword3= bufRead.readLine();
```

then the projects that match at least one keyword will be searched from the file

**ALL** projects **FROM** project index XML

**IF** the case description contains "***KEYWORD 1***" OR "***KEYWORD 2***" OR "***KEYWORD 3***"

The results from this statement will be then stored in a temporary list (temp) the next step is to get the weight of other criteria to choose the best solution.

The first step is to rank each case based on atteribute and their weights. That is to change all attributes to the same measure for instance rank where in this case a hiegher number represents

better. In this dissertation work the method was to use Choquet fuzzy integral where in the query the appplication takes weights. Finds root and of a polynomial that is the result from calculating lambda using polynomial multiplication. The method uses the labda that is between 0 and -1.

Inserting new cas to the case base coild be done as shown below

```
Element newCase = doc.createElement("record");

                Element cId = doc.createElement("CId");
                cId.setTextContent("664629");
                Element cdes = doc.createElement("Cdesc");
                cdes.setTextContent("Multidisciplinary Institute for Ageing");
                Element duration = doc.createElement("Duration");
                duration.setTextContent("365");
                Element budget = doc.createElement("Budget");
                budget.setTextContent("499232");
                Element euC = doc.createElement("EUCont");
                euC.setTextContent("499232");
                Element country = doc.createElement("Country");
                country.setTextContent("UK");
                newCase.appendChild(cId);
                newCase.appendChild(cdes);
                newCase.appendChild(duration);
                newCase.appendChild(budget);
                newCase.appendChild(euC);
                newCase.appendChild(country);
                caseTag.appendChild(newCase);
```

The problem faced in the prototype were

- In finding key word if the spelling in either the index or the input is in US english and the other is in UK english the case won't be discovered for example in the case base there were three projects about AGING but the program return only two because the third was written as AGEING
- Finding a polynomial root for lambda for more than three criteria causes an overflow for the system used for prototyping

The results from the two prototypes from COLIBRI studio and from the console program was the same. For the tests run on the prototype. The following is the output from the prototype developed with XML and Eclipse using the same weights as discussed in section 4.6. even if the

project “Multidisciplinary Institute for Ageing” was inseted to the XML index because of the spelling difference the project was not included in the first phase of selection.

```
 CId:  702222
Cdesc:  Quality aging
Duration:  1167
Budget:  2218871
EUCont:  1768345
Country:  DE
CId:  750204
Cdesc:  Active aging
Duration:  913
Budget:  2022700
EUCont:  1366133
Country:  BE
```

# 5. Conclusion

Main benefits of the models in from this dissertation are:

- **This model could be used in writing a report for stakeholders by explaining the success of local government in percentile, which is more understandable and precise.**
- **Fuzzification and defuzzification methods in the model allow linguistic variables in data collection and vagueness.**
- **The model could also be used in choosing effective strategy by strategic teams at the local or federal level of governance, since strategy is the main factor in running a successful organization, public or otherwise.**
- **The model can also be used in selecting projects that complement the strategic plan document in the public sector discussed in case study 5 in section 4.**
- **If the proposed method is implemented by EU agencies cities will be able to share experience and decrease a considerable amount of cost for researches.**

Strategy evaluation for nonprofit organization and government bodies is not the same as profit organizations, where their success could be measured financially. There are different known strategy evaluation methods such as gap analysis, bench marking, PEST and SWOT analysis; these methods were researched to find a simple and effective method for the evaluation process. SWOT analysis was chosen since it was a convenient way to evaluate an organization with respect to its environment.

The main objective of the research was to create a model for evaluating strategy in a way the results could easily be understood by stakeholders and responsible parties. Moreover, to compare strategy options using fuzzy aggregation, MCDM and SWOT analysis. Finally create a prototype CBR model to improve organization's weakness using experiences of other similar organizations.

MCDM such as AHP, ANP and TOPSIS methods and fuzzy aggregation methods like Sugeno lambda fuzzy measure and Choquet fuzzy integral methods were researched to make analytical evaluation of the SWOT analysis. After consideration and research, fuzzy aggregation methods

were chosen over the MCDM methods for the evaluation whereas MCDM are used for strategy options comparison and selection. The main tasks of the dissertation work are:

- To implement quantitative evaluation on SP of the public sector
- To test the proposed method for different organizations as to proof the feasibility of the method
- To use these quantitative methods to choose effective strategy
- To evaluate the proposed method using experts from relevant fields of study
- To introduce smart decision making in the public sector, to improve the success of SP
- To research if common threats in SP of EU cities exist
- To propose a method to share experience among EU cities to overcome threats and learn from one another in order to implement the EU goal in public administration

The model was applied for two cities and two private organizations. The results of the method for the private organizations were compared with results from other methods and experts.

Project selection and other strategic decisions in most cities are made by a strategic team composed of the city major, representatives of regional ministry, internal and external experts. Of course, the final decisions of cities always depend on the strategic team and the city council the kind of information discussed in the case studies 2, 3, 5 and 6 could be used as tool in making their decision. The result of SWOT analysis of a city using the model in this dissertation could also be used as an input for the RFSC by helping researchers get a clear analytical analysis of a city's performance on economy, social, environment and governance issues. The proposed method in this dissertation work was used for private and public organizations to proof the feasibility and consistency of results from the model. Furthermore the results from the model were compared with results from other methods using Spearman's correlation.

As discussed in the above sections, identifying the state of an organization is only the first step in improving its success; a research was conducted to prove the importance of CBR for the EU member countries specifically their cities and prototype of CBR system was developed using XML and COLIBRI Studio and another prototype using XML and Eclipse. The prototype was

tested on a sample of 30 projects. The outcomes of the study could be divided in to two parts. The first part was the development of new approach and model for quantitative evaluation of cities/ local government. The second part is the proposal and prototyping of CBR where the advantages of the system was explained and demonstrated.

# 6. Reference


AMIN, S.H., RAZMI, J., ZHANG, G. (2011). Supplier Selection and Order Allocation based on SWOT Analysis and Fuzzy Linear Programming, *Expert Systems with Appl.*, 38, 334-342.

ABBASS, F.A. (2003). *Strategic Management Formulation, Implementation and Control in a Dynamic Environment*, The Haworth Press Inc.

AMODT, A.A., PLAZA, E. (1994). Case-Based Reasoning: Foundational Issues, Methodological Variations, and System Approaches, *AI Communications*, 7, IOS Press.

BARRY, B.W. (1997). *Strategic Planning Workbook for Nonprofit Organizations*, St. Paul, MN: Amherst H. Wilder Foundation.

BARRY A. (2001). *Political Machines: Governing a Technological Society*, London: Athlone.; Marolla, Cesar. Climate health risks in megacities.

BAYAZIT, O. (2006). Use of Analytic Network Process in Vendor Selection Decisions, *Benchmarking: An INTERNATIONAL Journal*, 13(5), 566-579.

BRYSON, J.M. (2004). Strategic *Planing for Public and Nonprofit Organaizations*, 3rd ed., San Francisco: Jossey-Bass.

BRYSON, J.M., Alston, F.K. (2005). *Creating and Implementing Your Strategic Plan: a workbook for public and nonprofit organizations*, 2nd ed. San Francisco: Jossey-Bass.

BRYSON, J.M. (2011). *Strategic Planning for Public and Nonprofit Organizations: a guide to strengthening and sustaining organizational achievement*, 4th ed. San Francisco, John Wiley & Sons.

BUNDESMINISTERIUM. (2007). *Leipzig Charter on Sustainable European Cities*, available at: http://www.bmub.bund.de/fileadmin/Daten_BMU/Download_PDF/Nationale_Stadtentwicklung/leipzig_charta_en_bf.pdf, [Accessed Jun 2016].

CHENG, J.Y., JAHAU, L.CH. (2014). Accelerating Preliminary eco-Innovation Design for Products that Integrates Case-Based Reasoning and TRIZ Method, *Journal of cleaner production*, 998-1006.

CHANG, Ch.W., Wu, CH.R., LIN, H.L. (2008). Integrating Fuzzy Theory and Hierarchy Concepts to Evaluate Software Quality, *Springer Science and Business Media LL,C*, 263-276.

CHANG, H.H., HUANG, W.Ch., (2006). Application of a Quantification SWOT Analytical Method, *Mathematics and Computer Modelling*, 43, 158-169.

CHOQUET, G. (1953). *Theory of Capacities, Annales de l'Institut Fourier*, 5, 131-295.

CLIFF, N. (1996). *Ordinal methods for behavioral data analysis. Mahwah*, NJ: Lawrence Erlbaum Associates.

EADIE, D.C. (1983). Putting a Powerful Tool to Practical Use: The Application of Strategic Planning in the Public Sector, *Public Administration Review*, 43(5), Available at:

http://www.jstor.org/stable/975852?origin=crossref>, [Accessed Feb. 2016], 447-452.

EU Commission. (2011). *Cities of Tomorrow Challenges, Visions, Ways Forward*, European Union regional policy, Available at:

http://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/citiesoftomorrow_final.pdf., [Accessed 18 Feb. 2016].

EU Commission. (2014*). Q-Ageing*, , Available at:

http://ec.europa.eu/regional_policy/en/projects/poland/q-ageing-creating-better-lives-for-the-over-60s [ Accessed on Nov. 2016].

EU Commission. (2015). *Quality of Public Administration - A Toolbox for Practitioners*, Available at:

http://teismai.lt/data/public/uploads/2016/03/eu_publicadmin_toolbox_full_en.pdf, [ Accessed on Nov. 2016].

EU Commission. (2016). *Making Ageing Better: service design can innovate senior care*, Available at:

http://ec.europa.eu/regional_policy/en/projects/belgium/making-ageing-better-service-design-can-innovate-senior-care [Accessed on Feb. 2016].

EU Open Portal. (2017). *CORDIS-EU Research Projects under Horizon 2020 (2014-2020)*, available at:

http://cordis.europa.eu/projects/ [Accessed Jun 2017].

DIEDERIK, J. D. (2007). Analysis of Benefits, Opportunities, Costs and Risks(BOCR) with AHP-ANP: a critical validation, *Mathematical and computer modeling*, 46, 892-905.

GIA. (2008). *ColibriStudio*, Madrid, Spain. Available at:

http://gaia.fdi.ucm.es/research/colibri/colibristudio/documentation, [Accessed Sep. 2016].

GANG, K., DAJI, E., Yi, P., YONG, S. (2013). Data Processing for the AHP/ANP, *Springer Heidelberg*, New York Dordrecht London.

GRABISCH M. (1996). *The Application of Fuzzy Integrals in Multicriteria Decision Making, Thomson-CSF*, Central Research Laboratory Domaine de Corbeville, 91404 Orsay cedex, France, 445-456.

GRABISCH, M., MUROFUSHI, T., SUGENO, M. (2000). Fuzzy Measures and Integrals Theory and Applications (edited volume), *Studies in Fuzziness*, Physica Verlag.

HAILE, M. (2014). Application of Analytic Network Process for the Assessment and Evaluation of Software Product, *15th International conference of PhD. Students, young scientists and pedagogues*, Nitra, 427-432.

HAILE, M., KRUPKA, J. (2016a). Modelling of SWOT Analysis using Fuzzy Integral, ISSC 2016 International Conference on Soft Science, *The European Proceeding of Social and Behavioural Sciences EpSBS*: 75-82.

HAILE, M., KRUPKA, J., MASTALKA M. (2016b). Evaluation of Strategic Planning Process Using Analysis of Fuzzy Integral, *11th International Scientific Conference on Distance Learning in Applied Informatics*, 503-512.

HAILE, M., KRUPKA, J. (2016c). Fuzzy Evaluation of SWOT, *International journal of supply chain managment*, 5(3), 172-179.

HAILE, M., KRUPKA, J. (2016d). Application of Case Based Reasoning in Public Administration, In *International Scientific Conference in Public Administration 2016*, University of Pardubice, Pardubice, CR.

HAILE, M., KRUPKA, J. (2017a). Public Administration Project Selection Using Case-Based Reasoning, *Scientific papers of the University of Pardubice Series D*, Pardubice, CR, Accepted for publication.

HAILE, M., KRUPKA, J. KANTOROVA K. (2017b). Comparison of SWOT Analysis Evaluations – Case Study, *Scientific papers of the University of Pardubice Series D*, Pardubice, CR, (in review process).

HAILE, M., MASTALKA, M. (2017c). Contemporary decision-making of mid-size city in Czech Republic using MCDM, *European Journal of Government and Economics*, (in review process).

HOUBEN, G., LENIE, K., VANHOOF, K. (1999). A knowledge-based SWOT-Analysis System as an Instrument for Strategic Planning in Small and Medium Sized Enterprises, *Decision Support System*, 26, 125-135.

HUMPHREY, A. (2005). SWOT Analysis for Management Consulting, SRI Alumni Newsletter. *Retrieved from SRI International*.

HUMPHREY, A. (n.d.). Research: The Science of Team Action Management [online] The Father of TAM, TAM UK Retrieved, Available on:

http://www.tamplc.com/research.htm, [Accessed Jun 2012].

ISABELS, K.R., UTHRA, G. (2012). An Application of Linguistic Variables in Assignment Problem with Fuzzy Costs, *International Journal Of Computational Engineering Research*, 2(4), 1065-1069.

KASABOV, N.K. (1996). Fundamentals of Neural networks, Fuzzy Systems, and Knowledge Engineering, *Massachusetts Institute of Technology*, the MIT press.

KENNETH C.B. (1998). A Study Of Strategic Planning In Federal Organizations, *Dissertation submitted to the Faculty of the Virginia Polytechnic Institute and State University in partial fulfillment of the requirements for the degree of Doctor of Philosophy*.

KETCHEN, D., SHORT, J. (2011), *Mastering Strategic Management.: Evaluation and Execution*, [Accessed Jun. 2015]Available at :

http://2012books.lardbucket.org/pdfs/strategic-management-evaluation-and-execution.pdf.

MORDEN T. (2007). *Principles of Strategic Management (Innovative Business Textbooks)*, Ashgate Publishing Limited; 3rd Revised edition,.

PANOS M.P. (2000). *Multi-Criteria Decision Making Methods: a Comparative Study*, Kluwer Academic Publishers, The Netherlands.

PARDUBICE. (2016). SWOT analysis of Pardubice. Available at: http://www.pardubice.eu/o-pardubicich/strategicky-plan/2007-2014/swot-analyzy/, [Accessed May 2016].

PERLÍN, R., BIČÍK, I. (2006). Strategický Plán Mikroregionu: Metodická Příručka pro Zájemce o Strategické Plánování ve Venkovských Mikroregionech a obcích, *Strategic plan of the micro-region: methodological handbook pro strategic planners in countryside micro-regions and villages*, Praha.

PORTER. M.E. (1985). *The Competitive Advantage: Creating and Sustaining Superior Performance*, NY: Free Press.

POZOUKIDOU, G., GAVANAS, N., VERANI, E. (2017). *Sustainable management and strategic planning*. Basingstoke, Taylor & Francis Ltd, Available at:

https://www.witpress.com/elibrary/sdp/12/5/1522), [Accessed Sep. 2017].

ROBERT A., ANU J., PASI K., TATU P. (2010). *Exploring Quadruple Helix*, University of Tampere Institute for Social Research Work Research Centre.

RUSCIO J. (2008). Constructing Confidence Intervals for Spearman ' s Rank Correlation with Ordinal Data: A Simulation Study Comparing Analytic and Bootstrap Methods, *Journal of Modern Applied Statistical Methods*, 7 (2), 416-434.

RYDIN Y. (2010). Planning and the technological society: Discussing the London plan, *International Journal of Urban and Regional Research*, 34(2), 243-259.

RFSC, *Referenční Rámec pro Udržitelná Evropská Města [Reference Framework for Sustainable Cities]*, Ministerstvo pro místní rozvoj ČR [Ministry of Regional Development CZ] Available at:

http://www.mmr.cz/cs/Podpora-regionu-a-cestovni-ruch/Regionalni-politika/Referencni-ramec-pro-udrzitelna-evropska-mesta-(RF, [Accessed Feb. 2016].

RFSC. (2012). Develop your stategy/project, Reference *framework for european sustainable cities*. Available at:

http://app.rfsc.eu/tools/develop-your-sustainable-strategy-1, [Accessed 29 Jun 2014],.

RFSC. (2016a). *Reference Framework for European Sustainable Cities. A toolkit for the integrated approach,* Available at:

http://www.rfsc-community.eu/, [Accessed 24 Feb 2016].

RFSC. (2016b). *Reference Framework for European Sustainable Cities. A toolkit for the integrated approach,* Available at:

http://www.rfsc-community.eu/news/, [Accessed 25 Feb 2016].

SAATY, T.L. (1996). *Decision Making with Dependence and Feedback: the Analytic Network Process*, RWS publications. Pittsburgh.

SAATY, T.L. (1999). *Fundamentals of the Analytic Network Process*, In: ISAHP 1999. Kobe. Japan.

SAATY, T.L. (2001a). Decision Making with the Analytic Network Process and its "super decisions' software: the national missile defense (NMD) example", *ISAHP 2001 proceedings,* Bern, Switzerland.

SAATY, T.L. (2001b). Deriving the AHP 1-9 Scale from First Principles, *ISAHP 2001 proceedings*, Bern, Switzerland.

SAATY, T.L. (2005). *Theory and Application of the Analytic Network Process: decision making with benefits, opportunities, costs and risks*, RWS Publications. Pittsburgh.

SAATY, T.L. (2008). The Analytic Network Process, *Iran J Oper Res*, 1-27.

SACKETT, K., JONES, J., ERDLEY, W.S. (2005). Incorporating Healthcare Informatics into the Strategic Planning Process in Nursing Education, *Nurs Leadersh Forum. 2005 Spring,* 9(3), 98-104.

SCOLOZZI, R., SCHIRPKE, U., MORRI, E., D'AMATO, D., SANTOLINI, R. (2014). Ecosystem services-based SWOT analysis of protected area for conservation strategies, *Journal of Environmental Management,* 146, 543-551.

SEVKLI, M., OZTEKIN, A., UYSAL, O., TORLAK, G., TURKYILMAZ, A., DELEN, D. (2012). Development of a fuzzy ANP based SWOT analysis for the airline industry in Turkey, *Expert Systems with Appl,*. 39, 14-24.

SIGMA. (2014). *The Principles of Public Administration*, 2 Rue André Pascal 75775 Paris Cedex 16 France, Available at:

http://www.sigmaweb.org/publications/Principles-Public-Administration-Nov2014.pdf, [accessed on May 2016].

SHRADER, C.B., LEW, T., DAN, R.D. (1984). Strategic planning and organizational performance: A critical appraisal, *Journal of Management*, 10(2), 149-171.

SINGH, M., MADASU, V.K., SRIVASTAVA, S., HAMANDLU, M. (2013). Choquet Integral Based Verification of Handwritten Signatures, *Journal of intelligent and fuzzy system*, 24 (1), 145-161.

SPEE, A.P., PAULA J. (2011). Strategic planning as communicative process, *Organization Studies*, 32(9), 1217-1245.

STRATEGY. (2008). Strategický Plán [Strategic Plan]. *Strategie pro Prahu. Praha: Magistrát města Praha, 2008.* [online]. Available at: http://www.monet.cz/strategplan/obsah.asp, [Accessed 13 Jan 2016].

STATEGICKÝ Tým. (2017). Projektového Řízení Města Hradec Králové, *Magistrát města Hradec Králové*.

SUGENO, M. (1974). *Theory of Fuzzy Integrals and its Applications*, Tokyo Institute of Technology, Japan.

ŠILHÁNKOVÁ, V. (2011). *Indicators of Sustainable Development for Municipalities*. Hradec Králové: Civitas per populi.

TORRA, V., NARUKAWA, Y. (2004). On the Interpretation of some Fuzzy Integrals, Modelling decisions for artificial intelligence, *Springer Berlin Heidelberg*, 3131, 316-326.

TRAMARICO, C. et al. (2015). Analytic Hierarchy Process and Supply Chain Management: a bliometric study, Information Technology and Quantitative Management, *Procedia Computer Science*, 55, 441-450.

VERKEYN, A., BOTTELDOOREN, D., BAETS, B. (2011). Generic Learning of fuzzy Integrals Accumulating Human-Reported Environmental Stress, *Applied Soft Computing* 11, 305-314.

WEI, Ch.Ch., LIOU, T.S., LEE, K.L. (2008). An ERP Performance Measurement Framework using a Fuzzy Integral Approach, *Journal of manufacturing technology management*, 19, 607-626.

WOLF, C., STEVEN W.F. (2013). Strategic Planning Research: Toward a Theory-Driven Agenda, *Journal of Management*, 43(6), 1754-1788.

YANG, H. (2012). Measuring Software Product Quality with ISO Standards Based on Fuzzy Logic Technique, *Springer- Verlag Berlin Heidelberg*, 137, 59-67.

YU-CHENG T. (2011). Application of the Fuzzy Analytic Hierarchy Process to the Lead-free Equipment Selection Decision International, *Journal of Business and Systems Research*, 5(1).

YUKSEL, I., Dagdeviren, M. (2007). Using the Analytic Network Process (ANP) in a SWOT analysis – A case study for a textile firm, *Information Sciences*, 177, 3364-3382.

# 7. Appendix

**Questionnaire used in case Study 2 section 4.2**

| **Strength** | **Importance** | **The current performance of these characteristics** | | |
|---|---|---|---|---|
| | | **Not satisfactory** | **satisfactory** | **Very satisfactory** |
| Sufficient capacity of elementary secondary educational facilities | | | | |
| Well-functioning public transport system | | | | |
| Implementation of comprehensive flood protection systems | | | | |
| Gradual renewal and development of energy networks | | | | |
| Size and strength of the city economy | | | | |
| **Weakness** | **Importance** | **How weak is the city currently performing on these characteristics** | | |
| | | **Not badly** | **badly** | **Very badly** |
| Poor coordination with private sector | | | | |
| Weak crime fighting and drug protection | | | | |
| Hypertrophied and complicated system of public administration | | | | |
| Ineffective utilization of housing fund | | | | |
| Insufficient effectiveness and, consequently, lower capacity of the central wastewater treatment plant | | | | |
| **Opportunity** | **Importance** | **How are these opportunities currently effecting the success of the city** | | |
| | | **Not effective** | **Effective** | **Very effective** |
| Support from EU | | | | |
| Position heart of Europe | | | | |
| Well-developed and diverse telecommunications networks | | | | |

| | | | | |
|---|---|---|---|---|
| suitable for multimedia communication | | | | |
| Greater range of tourist destinations within and outside Prague's Heritage Conservation Area of the city | | | | |
| Balanced social structure | | | | |
| **Threats** | **Importance** | **How are these Threats currently influencing the success of the city** | | |
| | | **Not influential** | **Influential** | **Very influential** |
| Loss of citizens interest for public affair | | | | |
| Competition of other cities | | | | |
| Loss of Prague's international standing as a unique heritage site | | | | |
| Lack of financial resources for the development of modern educational programs and comprehensive social services | | | | |
| Growing xenophobia and expression of racism and extremism | | | | |

## List of projects used for prototype testing

| Cid | Cdesc | Duration | Budget | EUCont | Country |
|---|---|---|---|---|---|
| 673348 | Electronic scanning MIMO Rada | 182 | 71429 | 50000 | UK |
| 660362 | Paleozoic Seafloor Spreading | 730 | 183454.8 | 183454 | UK |
| 672521 | Feasibility study of a supereffic | 183 | 71429 | 50000 | DE |
| 672228 | Unobtrusive, continuous and q | 182 | 71429 | 50000 | ES |
| 640627 | Domestic Servants in Colonial S | 1095 | 899849 | 899849 | DE |
| 654933 | The dynamics of the mammalia | 730 | 158121 | 158121 | ES |
| 639633 | Multinationals, Institutions and | 1826 | 1276880 | 1276880 | UK |
| 672199 | World's first complete motion- | 152 | 71429 | 50000 | UK |
| 674710 | Cloud based Vessel Allocation | 730 | 1803125 | 1262187 | TR |
| 671980 | RAd (Responsible Advertising) | 152 | 71429 | 50000 | NO |
| 654367 | Agile Analytics on Big Data Cub | 1095 | 2839743 | 2839743 | DE |
| 637510 | Fourier Analysis For/And Partia | 1826 | 940540 | 940540 | FR |
| 671846 | Odour-GPCRs based technology | 183 | 71429 | 50000 | ES |
| 662561 | FOOD SAFETY CONTROLS FOR A | 182 | 71429 | 50000 | ES |
| 673651 | EU market research for an inno | 183 | 71429 | 50000 | UK |
| 664629 | Multidisciplinary Institute for A | 365 | 499232 | 499232 | PT |
| 666427 | A demonstration plant of enha | 822 | 2021077 | 1414754 | FI |
| 674364 | Zero Emission Robot-Boat for C | 182 | 71429 | 50000 | BG |
| 661373 | At first glance: How saccades di | 730 | 165598 | 165598 | NL |
| 651407 | A new integrated sustainable p | 181 | 71429 | 50000 | UK |
| 636573 | Congestion Reduction in Europ | 1095 | 3981461 | 3870146 | UK |
| 673917 | MLSYSTEM - heatable, integrat | 183 | 71429 | 50000 | PL |
| 652171 | Poultry manure valorization | 181 | 71429 | 50000 | NL |
| 650515 | Low-temperature anaerobic di | 180 | 71429 | 50000 | IE |
| 659193 | The impact of recent retrotrans | 730 | 177598 | 177598 | NL |
| 659749 | INTerdisciplinary ACTion for ac | 365 | 97727 | 97727 | UK |
| 644742 | Low-cost / energy Efficient Ole | 1095 | 3986262 | 3986262 | FR |
| 674292 | Smart Large Scale Radio Techno | 152 | 71429 | 50000 | DE |
| 644631 | High-performance, Flexible, AU | 1095 | 3658942 | 3658942 | FI |
| 702222 | Quality aging | 1167 | 2218871 | 1768345 | DE |
| 750204 | Active aging | 913 | 2022700 | 1366133 | BE |