FUZZY MULTI ATTRIBUTE VALUATION OF SOFTWARE PROJECTS VIA FUZZY REAL OPTIONS IN BANKING INDUSTRY USING BALANCED SCORECARD

(BANKACILIK SEKTÖRÜNDEKİ YAZILIM PROJELERİNİN BALANCED SCORE-CARD YÖNTEMİ YARDIMIYLA GERÇEK OPSİYONLAR KULLANILARAK BULANIK ÇOK ÖLÇÜTLÜ DEĞERLENDİRİLMESİ)

by

Özlem AFACAN, B.S.

Thesis

Submitted in Partial Fulfillment

of the Requirements

for the Degree of

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in

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in the

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ÖZLEM AFACAN
September 2012

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LIST OF SYMBOLS

BCS:	Balance Scorecard
BT:	Bilgi Teknolojileri
CA:	Competition Advantage
CCS:	Compliance with the Current System
DE:	Decreasing Expenses
FROV:	Fuzzy Real Options Values
HR:	Human Resources
HRM:	Human Resources Management
INC:	Increasing Number of Customers
IKFM:	Increasing Known of Firm in Market
IS:	Information System
IT:	Information Technology
MADM:	Multi-attribute Decision Making
MP:	Market Potential
NPV:	Net Present Value
OTI:	Operation time Income
PM:	Project Manager
PQES:	Providing Quick and Easy service
RO:	Real Options
PT:	Project Team
TA:	Technological Additive
TOPSIS:	Technique for Ordering Preference by Similarity of Ideal Solution
UK:	United Kingdom
US:	United States

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ABSTRACT

Banking sector is getting bigger and bigger day by day and it becomes more competitive. Trade rivalry drives the companies to extreme measures. However in daily life many projects are generated in enterprises. New software and technology projects are very important in being powerful and to have great position in banking sector. Choosing the right project may preserve the companies from extreme measures decision. Information Technology department has the biggest role to choose the correct project. A strategic approach to project selection yields better results for organizations by minimizing risk and maximizing the potential upside. There are a lot of methods about selecting project under multi criteria. Also new techniques are being developed day by day by academicians. In this study one of greatest banks in Turkey requests to develop and implement one of the three new software projects by real options integrated multi criteria decision making method. New offered technique is used to decide decision criteria and make selection among these projects. We use balanced scorecard method for determining the criteria according to the top management's vision and then we apply these criteria to fuzzy TOPSIS with fuzzy real options method. These three projects are: "Our Bank" which is new special internet banking system for only special customers, second project is called "New Faced Internet Banking" everybody who is customer of bank or not can use this site and the last project is called "Information Technology Qualified User Creating and Canceling Software" which aims to make information technology user creation and deletion process easy and reportable. We applied the offered model to select the most applicable, useful and profitable.

RÉSUMÉ

Le secteur bancaire grandit plus en plus jour par jour et il devient plus concurrentiel. Rivalité commerciale conduit les entreprises à des mesures extrêmes. Cependant, dans la vie quotidienne de nombreux projets sont générés dans les entreprises. Un nouveau logiciel et des projets technologiques sont très importants pour être puissant et d'avoir idéalement situé dans le secteur bancaire. Choisir le bon projet peut préserver les entreprises de la décision de mesures extrêmes. Département de technologie de l'information a le rôle le plus important de choisir le bon projet. Une approche stratégique de la sélection des projets donne de meilleurs résultats pour les organisations en minimisant les risques et en maximisant le potentiel de hausse. Il ya beaucoup de méthodes sur la sélection des projets selon des critères multiples. Également de nouvelles techniques sont mises au point au jour le jour par les académiciens. Dans cette étude des plus grandes banques en Turquie demandent à élaborer et à mettre en œuvre l'un des trois projets de nouveaux logiciels par les options réelles intégrées à plusieurs critères de décision méthode de fabrication. Nouvelle technique offerte est utilisé pour décider des critères de décision et de faire une sélection parmi ces projets. Nous utilisons la méthode Balanced Scorecard pour déterminer les critères selon la vision de la haute direction, puis on applique ces critères à TOPSIS flou avec la méthode des options réelles floue. Ces trois projets sont les suivants: «Notre banque» qui est nouveau régime spécial pour les services bancaires par Internet seulement les clients particuliers, deuxième projet est appelé «New Banking Faced Internet» et tout le monde qui est client de la banque ou non peut utiliser ce site, et le dernier projet s'appelle "utilisateur technologies de l'information qualifiée création et annulation Logiciel" qui vise à faire de la création d'utilisateurs technologies de l'information et le processus de suppression facile à déclaration obligatoire. Nous avons appliqué le modèle offert pour sélectionner la plus pertinente, utile et rentable.

ÖZET

Günümüzde bankacılık sektörü günden güne büyümekte ve daha rekabetçi bir hal almaktadır. Rekabetçi iş yaşantısı firmaları uç seviyelerde önlemler almaya sürüklemektedir. Günlük yaşantıda kuruluşlarda birçok proje üretilse de yeni yazılım ve teknoloji projeleri bankacılık sektöründe güçlü ve iyi bir pozisyonda olmak için büyük önem taşımaktadır. Doğru proje seçimi firmaları uç önlem almaktan korumaktadır. Bilgi Teknolojileri birimi doğru projelerin seçilmesi, geliştirilmesi ve uygulanması açısından büyük önem taşımaktadır. Proje seçimine stratejik bakış riski azaltma kazanımların arttırma yönündedir. Çok kriterli proje seçimi yeni popüler bir konu olmuş sadece bu konuda çalışan birçok firma kurulmuştur. Bu konu akademisyenler için yeni bir araştırma konusunu olmuş ve birçok yöntem geliştirmişlerdir. Bazı firmalar proje seçim yöntemlerinde akademisyenlerle birlikte çalışmaktadır. Gün geçtikçe de akademisyenler tarafından yeni yöntemler geliştirilmektedir. Geliştirilen yöntemler içinde öne çıkan ve avantaj sağlayanlar firmalar tarafından kullanılmaktadır. Türkiye'nin en büyük bankalarından biri üç büyük yeni yazılım ve teknoloji projesi arasından seçim yapmak istemektedir. Proje seçiminde yeni bir yöntem denenerek doğru proje seçim kriterlerinin belirlenmesi istenmektedir. Bu nedenle gerçek opsiyonlar entegreli çok kriterli karar verme yöntemiyle üç proje arasında seçim yaparak geliştirme ve uygulama yapılması sağlanacaktır. Seçim kriterlerinin stratejilerini doğru yansıtması firma için önemlidir. Bu çalışmada karar kriterlerinin belirlenerek üç proje arasında seçim yapabilmek için yeni bir teknik önerilmiştir. Üst yönetimin vizyonuna göre BSC yönteminin dört bakış açısı bir anket yardımıyla ele alınarak kriterler belirlenmiştir. Belirlenen kriterlerin değerlendirilmesi ve projelerin seçimi için bulanık gerçek opsiyonları ile bulanık TOPSIS yöntemleri uygulanmıştır. Seçim yapılacak üç projeden ikisi günümüzde de yaygın bir şekilde kullanılan ve birçok kişinin neredeyse günlük tüm işlerini yapabildiği ortam internet ortamıyla ilgilidir. İnternet kullanımı birçok işin daha hızlı ve zamanında yapılmasına olanak sağladığı için tüm sektörlerde bir avantaj kapısı haline gelmektedir. Bu iki internet projesine ek olarak IT'nin kendi iç gündelik işlerini kolaylaştıracak ihtiyaç

duyulan bir projedir. Değerlendirilen üç projeden ilki "Bizim banka" özel müşteriler için tasarlanması planlanan yeni bir internet bankacılığı sistemidir. Şubesiz bankacılık sloganıyla çıkış yapması planlanmaktadır. İkinci olarak banka müşterisi olan ya da olmayan herkesin kullanabileceği "Yeni yüzlü internet bankacılığı" internet bankacılığı projesidir. Mevcut internet bankacılığının yeniden yapılandırılması ve teknolojisinin yenilenmesiyle daha geniş bir kitleye hitap etmesi beklenmektedir. Son olarak bilgi teknolojileri çalışanlarının kullanıcı yaratma ve silme taleplerini kolaylaştırıp raporlanmasını sağlayacak "İzinli kullanıcı yaratımı ve iptali bilişim yazılımı" projesidir. Bu üç proje arasında uygulanabilir, kullanışlı ve karlı olanın seçilmesi için geliştirilen model uygulanmıştır.

1 INTRODUCTION

Banking sector is becoming more competitive day by day. Trade rivalry drives the companies to extreme measures and extreme projects. However in daily life many projects are generated in enterprises. Choosing the right project may preserve the companies from extreme measures decision. Figure 1.1 shows project selection flow (Tan et al., 2010).

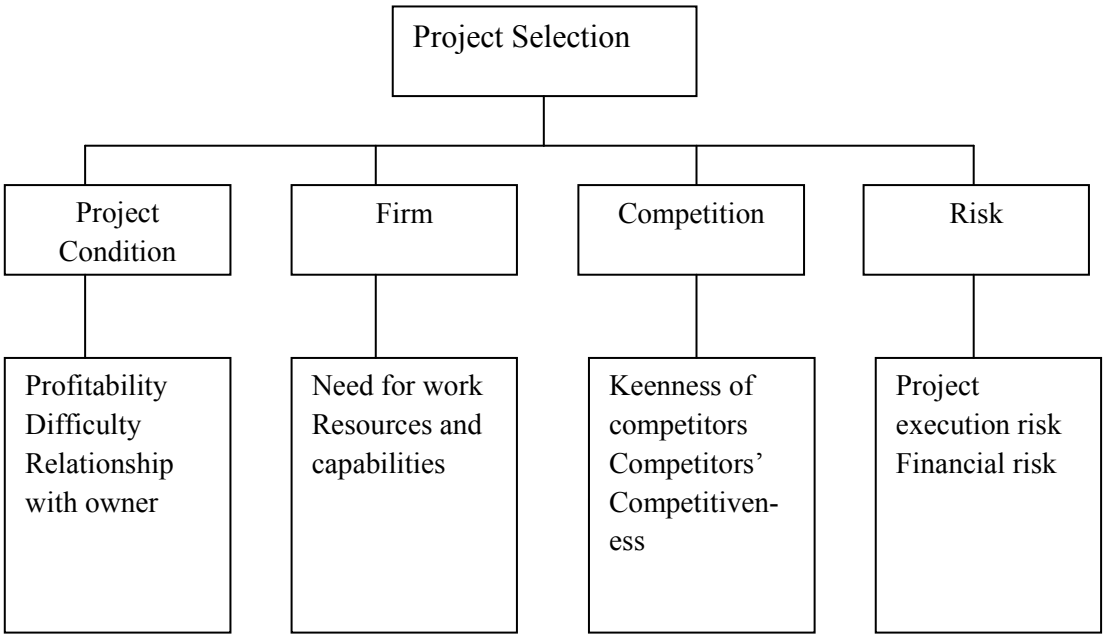

Figure 1.1 Project selection flow

A strategic approach to project selection yields better results for organizations by minimizing risk and maximizing the potential upside. With finite resources and infinite project possibilities, project selection could be the most important step in the project life-cycle. New projects are a response to threats or opportunities, and choosing the best possible response, from a complex web of possibilities, are often beyond the capacity of the human brain (Seeber, 2011).

The balance scorecard allows companies to evaluate whether they are meeting their objectives, based on both financial and non-financial measures using tangible and intangible assets (Schniederjans et al., 2004). A strategic planning study such as BSC is very useful from vision to action (Cebeci, 2009).

BSC makes quite clear where IT should be making its investments to assure that IT aligns with the business (Downey, 2011).

In this study the company's work area is based on software and technology development for banking industry. They work as a part of a bank but also develop projects for international banks if they offer. This technology firm has over six hundred employee also has al lot of departments. The main departments are project office, infrastructure, software, test and the operation. IT department has the biggest role to choose the correct project because new software and technology projects are very important in being powerful and to have great position in banking sector.

Multi-criteria decision making mentions to select the best opinion from all of the probable options in the existence of multiple, conflicting criteria (Ballı & Korukoğlu, 2009).

Multi-criteria approaches developed over the last 40 years as an answer to the growing complexity of decision problems. They allow one to address problems with exhibiting conflicting, incomparable, or incommensurable multiple criteria, different scales, or uncertain information. Even today, in the time of common business computerizing there is no universal approach applicable in solving all kinds of decision problems. Apart from multi criterion feature, the problem of alternative evaluation is also its multi leveling (some of the parameters may be obtained as a result of subordinate parameters aggregation) (Lapunka, 2012).

TOPSIS is one of the well known outranking methods for multiple-criteria decision-making and can be easily used for ranking alternatives (Ballı & Korukoğlu, 2009).

In fuzzy TOPSIS model the subjective and objective criteria are simultaneously considered in the real life (Ding, 2011). The selection of appropriate projects for bidding is a multiple attribute group decision-making exercise. In a real decision process, there are many uncertainties and ambiguities, and time limitations mean that decision makers cannot always make precise judgments. The numerical example demonstrates that the fuzzy TOPSIS approach can be used to simulate the decision process in project selection, and the results provide contractors with valuable insight into the project selection problem (Tan et al., 2010). Using the fuzzy set theory, decision makers have more descriptive power to describe uncertain and flexible project information (Tolga, 2008).

Real options approach, as a strategic decision making tool, borrows ideas from financial options because it explicitly accounts for future flexibility value. Real options analysis is based on the assumption that there is an underlying source of uncertainty, such as the price of a commodity or the outcome of a research project. Over time, the outcome of the underlying uncertainty is revealed, and decision makers can adjust their strategy accordingly (Liao & Ho, 2010).

Also the real options methodology helps to use real options to structure investments in different ways that increase the value of projects (Petravicius, 2009). Strong evidence is found that practitioners indeed follow the logic of real options in managing the risk of their IT investments, though largely based on intuition (Benaroch et al., 2006).

Fuzzy real option valuation can be used in fuzzy TOPSIS for project selection problems. Fuzzy Real Option Valuation (FROV) was found to be more appropriate to measure the strategic value than the traditional financial method (net present value, NPV, etc.). When the NPV is ambiguous in deciding whether to go or not to go, for instance, just below zero NPV and high volatility of expected benefit, FROV can offer the additive value of the project reflecting volatility of benefit due to the volatility (Lee et al., 2010).

In this work, real case study requests to develop and implement one of the three new software projects by real options integrated multi-criteria decision making method at one of greatest banks in Turkey. As every IT firms have their own project acceptation

and selection process also this firm has its own project acceptation selection and implementation flow as below.
First of all one offer must be accepted as a project. Business requests so many change from IT also they are not unfair because every day customers request new things from business and technology improvements become very quickly. To be powerful in the competitive banking sector you must take action quickly. For that reason every request is exactly researched. Revise pros and cons with business. If one request is accepted as a project then process begins.

First step is assignment of a project manager (PM) to the project. Second PM communicates with team leaders to determine if they will have role in project team (PT) or not. If answer is ok then PM requests resource who will work in PT from this team. After PT is determined PM arranges meeting with PT to determine the needs and make project plan and set projects deadline to be production. After all of these steps project tasks begin. If everything goes good no detention will be lived and project will finish on time.

Projects selection is important for every IT department they must work very close with business. For this project selection flow new offered technique is used to decide decision criteria and make selection among these projects. Hence financial data has strong importance in banking; the authorities of the company do not let the data out the corporation. In addition while the experts' ideas used in balanced scorecard and TOPSIS methods are vague in nature so those are whys fuzzy logic is preferred in this study. We use balanced scorecard method for determining the criteria according to the top management's vision and then we apply these criteria to fuzzy TOPSIS with fuzzy real options method.

In today's technology world using internet is very normal; people do every kind of their jobs from internet. For that reason all sectors in market detect this big gaining area.

So many web based projects are developed by IT departments. But new projects with different properties become popular and reap a profit. From this point of view two of evaluated projects are web base internet projects.

First project is “Our Bank” project which aims to gain new or old customers whose ages are between twenty and forty. It is new special internet banking system for only special customers including almost every operation which can be done without going to bank branch.

Second project is called “New Faced Internet Banking” everybody who is customer of bank or not can use this site. Old one is changing with new one which is using new technology and getting user friendly.

IT department has its own needs to do daily works quickly and give quick response to customers. Two of important scopes of IT are auditing and managing qualified IT users. One of evaluated projects is for IT requirements and about auditing, managing qualified users. Project is called “Information Technology Qualified User Creating and Canceling Software” which aims to make information technology user creation and deletion process easy and reportable. It will be useful to give exact reports to audit department from one and main point.

The rest of the study is arranged as follows: The second section includes literature survey and section three is about the balanced scorecard method for software project selection. In Section 4, selection criteria represented. The preceding section contains fuzzy TOPSIS model. The fuzzy real option value explained in Section 6. Steps of offered model represented in Section 7. The last part of study is conclusion section.

2 LITRATURE SURVEY

IT project decisions, and the ways they are made, inevitably shape our destiny. Get them right and boost business success. Get them wrong and we preside over investment disasters. The reality is that not only are IT selection decisions tough, but so are all management decisions. Paul Nutt, professor of management sciences at Ohio State University's Fisher College of Business, reports in his recent book, Why Decisions Fail: Avoiding the Blunders and Traps That Lead to Debacles that more than 50 percent of all management business decisions fail, sometimes in big and inglorious ways[1].

Maroukian (2010) investigated about IT company that support the Greek banking sector needs analysis phase of projects investigated the effect of environmental factors. Importance of defining services provision in an 'IT-enabled business' context has been discussed whereby the development and deployment of IT software products support corporate strategic envisioning, business vitality and viability through the achievement of specific business goals. After the investigation and the study success of the project, project management, partner management, time management, resource management, communication, and risk management is investigated and associated with environmental factors are found.

In their recent work Deng et al. (2008) are examined decision support system with multi-criteria analysis method, information system project evaluation, selection and mentioned IS projects are multi-criteria analysis problems also created multi-criteria decision support system. The proposed decision support system framework has a number of advantages for solving the IS project evaluation and selection problems include the flexibility to respond quickly to the decision maker's questions, the ability to help the decision maker better understand the decision problem and the implications of their decision behaviors, and the capability to accommodate various requirements of the decision problem and the decision maker.

[1] http://www.cio.com/article/31909/How_to_Select_the_Right_IT_Projects

Van-Niekerk & Steyn (2011) are studied about determination of the criteria for selecting projects. Nuclear oil development project are examined. Traditional project evaluation and success criteria of the project are to finish on time or within budget may remain. However, traditional methods of assessment based on high-tech projects, the thesis should not be revealed. In short, the structure of the project and the project success criteria determined according to the environmental conditions in their respective fields and facilities. For example, after 10 years of high-tech projects, not according to the traditional criteria, been able to provide the continuity should be judged accordingly. Delphi method was used.

Tiwana & Keil (2009) made investigation on the effects on the performance of the system development for projects to be developed internally or outsource. Project control mechanisms are different from internal or outsourced projects. Outsource projects related to internal projects. In their study, 57 outsourced, 79 internal projects and 136 companies were examined with partial least squares is used. A distinction between attempted control and realized control to explain this disconnect, and show how anticipated transaction hazards motivate the former but meeting specific informational and social prerequisites facilitate the latter are introduced.

Palcic an Lalic[2] are examined many articles about the right selection and application of the project and used data in some articles. They tried to find the best criterion for the selection of the Project. A wrong decision, consequences could be bad. For determining the criteria a lot of methods mentioned but AHP method is used. A simple application is written in Excell to determine the criteria.

Well–structured IT of Irish financial institution is subjected to (Benaroch et al., 2006) study. Main objective of their study was real option is not connected IT risk management To match risk 50 IT Project are selected and examined for investment Risk factors found as a priority. Option-based risk management (OBRiM) framework is used.

[2] http://ijsimm.com/Full_Papers/Fulltext2009/text8-1_16-26.pdf

In recent study of Heimerl et al. (2009) main objective was IT projects simultaneously designated project schedule problem. Aim is to reduce the cost of labor. The problem is modeled in the mixed-integer linear program. Different problem parameters, project completion time, quality is the source and the workload like are used. Comparing the MIP-solution with the ones derived by simple heuristics currently used in an IT-service company we observe that costs can be decreased substantial.

Table 2.1 Literature survey summary table

Authors	Scope & Purpose of the Study
Benaroch, Lichtenstein, Robinson (2006)	Main objective of their study was real option is not connected IT risk management to match risk. 50 IT projects are selected and examined for investment risk factors. Option-based risk management (OBRiM) framework is used.
Deng and Wibowo (2008)	Examined decision support system with multi-criteria analysis method for information system project evaluation and selection. Multi-criteria decision support system is created.
Heimerl & Kolisch (2009)	IT projects simultaneously designated project schedule problem. Main objective is to reduce the cost of labor. The problem is modeled in the mixed-integer linear program.
Palcic & Lalic (2009)	Examined many articles about the right selection and application of the project and used data in some articles. They tried to find the best criterion for the selection of the project. AHP method is used.
Tiwana & Keil (2009)	Made investigation on the effects on the performance of the system development for projects to be developed internally or outsource. Partial least squares is used.
Maroukian (2010)	Investigated about IT company that support the Greek banking sector needs. Examined the effect of environmental factors.
Van-Niekerk & Steyn (2011)	Studied about determination of the criteria for selecting projects. Nuclear oil development project are examined. They used Delphi method.

3 BALANCED SCORECARD

3.1 What is balanced scorecard?

The balanced scorecard method is a technique companies use to translate their strategies into objectives and measures (Kaplan & Norton, 1996). Scorecard allows companies to evaluate whether they are meeting their objectives, based on both financial and non-financial measures using tangible and intangible assets. The balanced scorecard aim measures organizational performance according to four balanced perspective: financial perspective, customer perspective, internal business perspective and learning and growth perspective. Each of the four scorecards are interconnected and related to the company's strategic plan which is represented in Figure 3.1 (Kaplan & Norton, 1996).

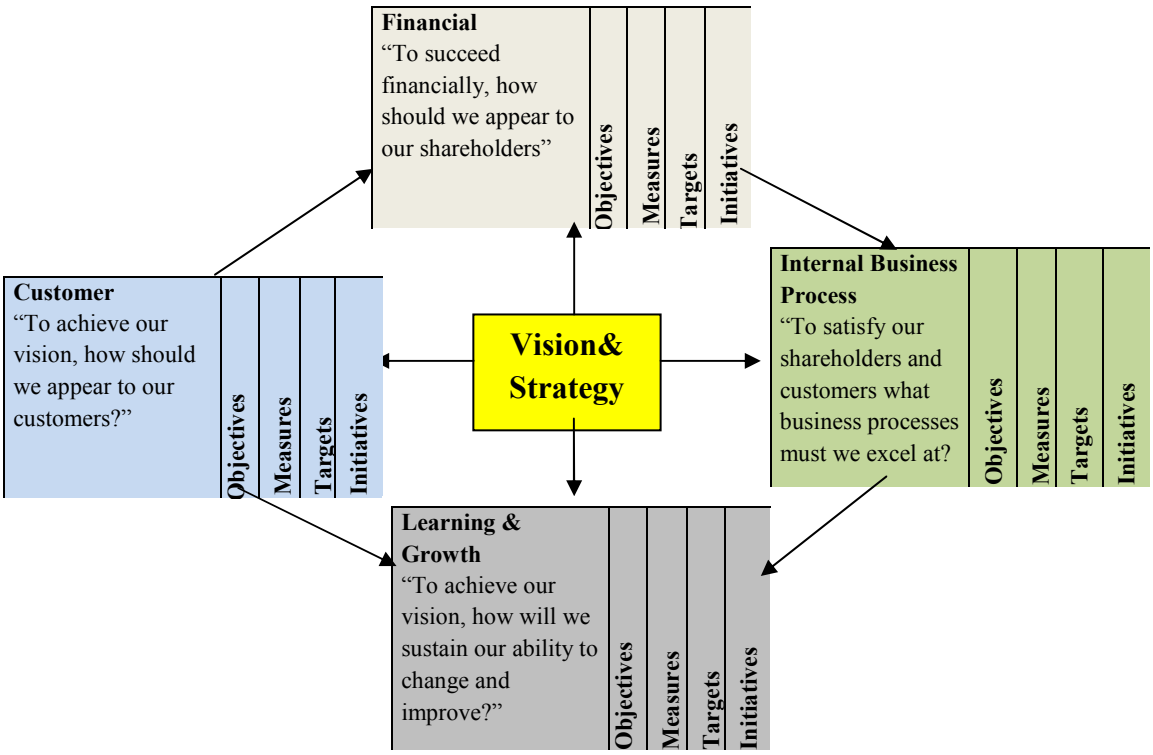

Figure 3.1 The structure of balanced scorecard

Financial Perspective: financial objectives serve as the focus for the objectives and measures of the other three perspectives. Every measure should be part of a cause-and-effect relationship culminating in long-term sustainable financial performance. This perspective tries to answer the two questions: "How the enterprise seems to business owners?" and "How do enterprise will be financially successful". Objectives of financial performance become focus point of their other perspectives3.

Customer Perspective: financial success is closely linked to customer satisfaction. Satisfied customers mean repeat business, referrals and new business and thereby contribute to the financial results of the company. In BSC, once the market segmentation is performed, objectives and measures for target groups should be defined. There are two sets of measures used in customer perspective: customer core management group used by most companies (customer satisfaction, customer retention, market share etc) and performance drivers of customer outcomes which answer the questions such as "What should a company offer to customers to improve customer satisfaction and retention in order to increase market share?"[3] .

Internal Operations Perspective: The internal process perspective is concerned with the internal processes within a company that create and deliver the goods and services of the company. It is also concerned with the processes that are to deliver the value proposition defined in the customer perspective. It focuses on the activities and key processes required in order for the company to excel at providing the value expected by the customers, so that the measures in the customer perspective will be supported. Measures in this perspective could also be implemented to support the measures in the financial perspectives, where e.g. smaller lead-times or better quality may result in greater profits. Measures in the internal perspective could be: lead-time, innovation rates, service measures, quality measures, efficiency measures, costs reductions etc[4].

Learning and Growth Perspective: the ability, flexibility and motivation of staff support all of the financial results, customer satisfaction and operational activities

[3] http://www.bscdesigner.com/balanced-scorecard-the-four-perspectives-customer-perspective.html
[4] http://www.businessmate.org/Article.php?ArtikelId=14

measured in the other three quadrants of balanced scorecard. The balanced scorecard shows how the overall strategic objectives are translated into the performance drivers that the company has identified as critical success factors.

3.2 Benefits of Using BSC

Traditional performance measurement, focusing on external accounting data, is obsolete and something more is needed to provide the information age enterprises with efficient planning tools. Among the long row of benefits of applying Balanced Scorecard, these are the most significant:

- Strategic initiatives that follow "best practices" methodologies cascade through the entire organization
- Increased Creativity and Unexpected Ideas.
- The Balanced Scorecard helps align key performance measures with strategy at all levels of an organization.
- The Balanced Scorecard provides management with a comprehensive picture of business operations.
- The methodology facilitates communication and understanding of business goals and strategies at all levels of an organization.
- Maximized Cooperation - Team members are focused on helping one another succeed.
- Usable Results - Transforms strategy into action and desired behaviors.
- The Balanced Scorecard concept provides strategic feedback and learning.
- A cross organizational team - More open channels of communications - Enthusiastic People.
- Initiatives are continually measured and evaluated against industry standards.
- The Balanced Scorecard helps reduce the vast amount of information the company IT systems process into essentials.
- Unique Competitive Advantage[5].

[5] http://thebalancedscorecard.com/benefits_bsc.html

3.3 Where and How Can BSC Be Applied?

The balanced scorecard is a robust organization-wide strategic planning, management and communications system.

These are strategy-based systems that align the work people do with organization vision and strategy, communicate strategic intent throughout the organization and to external stakeholders, and provide a basis for better aligning strategic objectives with resources. In strategy-based scorecard systems, strategic and operational performance measures (outcomes, outputs, process and inputs) are only one of several important components, and the measures are used to better inform decision making at all levels in the organization. In strategy-based systems, accomplishments and results are the main focus, based on good strategy executed well. A planning and management scorecard system uses strategic and operational performance information to measure and evaluate how well the organization is performing with financial and customer results, operational efficiency, and organization capacity building (Rohm, 2008).

More than half of major companies in the US, Europe and Asia are using Balanced Scorecard approaches. The official figures vary slightly but the Gartner Group suggests that over 50% of large US firms have adopted the BSC. A recent global study by Bain & Co finds that the Balanced Scorecard is one of the top-ten most widely used management tools around the world. The widest use of the BSC approach has traditionally been in the US, the UK and Northern Europe, but there is very strong growth in Balanced Scorecard adoption in South America, the Middle East and Asia[6].

While the Balanced Scorecard was initially designed for commercial companies, the framework has found wide-spread use in the public and not-for-profit sector. However, it is important to make a few changes to the strategy map template in order to make it suitable to government, public sector and not-for-profit organizations:

- Move the Financial Perspective from top spot on the strategy map template. The overall objective of most public sector, government and not-for-profit

[6] http://www.ap-institute.com/Balanced%20Scorecard.html

organizations is not to make money, maximize profits or deliver shareholder return. While finance is important, it is usually not the overall reason why the organization exists.

- Instead, the main objective of public sector, government and not-for-profit organizations is to deliver services to their key stakeholders, which can be the public, central government bodies or certain communities. This perspective usually sits at the top of the template to highlight the key stakeholder deliverables and outcomes[6].

Many federal departments, state governments and city councils in the US and elsewhere have adopted the BSC for strategic management. Exhibit 3 provides a list of users of BSC in the United States. Table 3.1 shows users of BSC in United States (Ramanna, 2008).

Table 3.1 Users of BSC in United States

Federal	States	Cities	Counties
Defense	Virginia	San Diego	Monroe
Energy	Iowa	Portland	Fairfax
Commerce	Maryland	Charlotte	Mecklenburg
Transportation	Texas	Seattle	Santa Clara
Coast	Guard	Minnesota	Austin
IRS	Oregon	Olathe	
Veterans	Affairs	Washington	

All business professionals would admit that Human Resource Department is an important part of any business structure. You may have the best technologies, output capacities and equipment but you may be not getting proper profits because you personnel are poorly managed. When HR management works at its best you will immediately see positive results. However, the work of HR department also needs to be evaluated. HR managers should always get better and improve performance[7].

[7] http://www.hr-scorecard-metrics.com/balanced-scorecard-in-human-resource-management.htm

Balanced Scorecard should be used to link Human Resource Management activities with the organization's strategy and evaluate the extent to which its functions add value to business strategies and goals. Measure of HRM practices primarily relate to productivity, people, and process. Productivity measures involve determining output per employee (such as revenue per employee). Measuring people includes assessing employees' behavior, attitudes, skills, and/or knowledge. While process measures focus on assessing employees' satisfaction with how the organization compensate, reward, and develop them so that they continue to add value to organizational competitiveness as a whole[8]. Figure 3.2 shows BSC for HR[7].

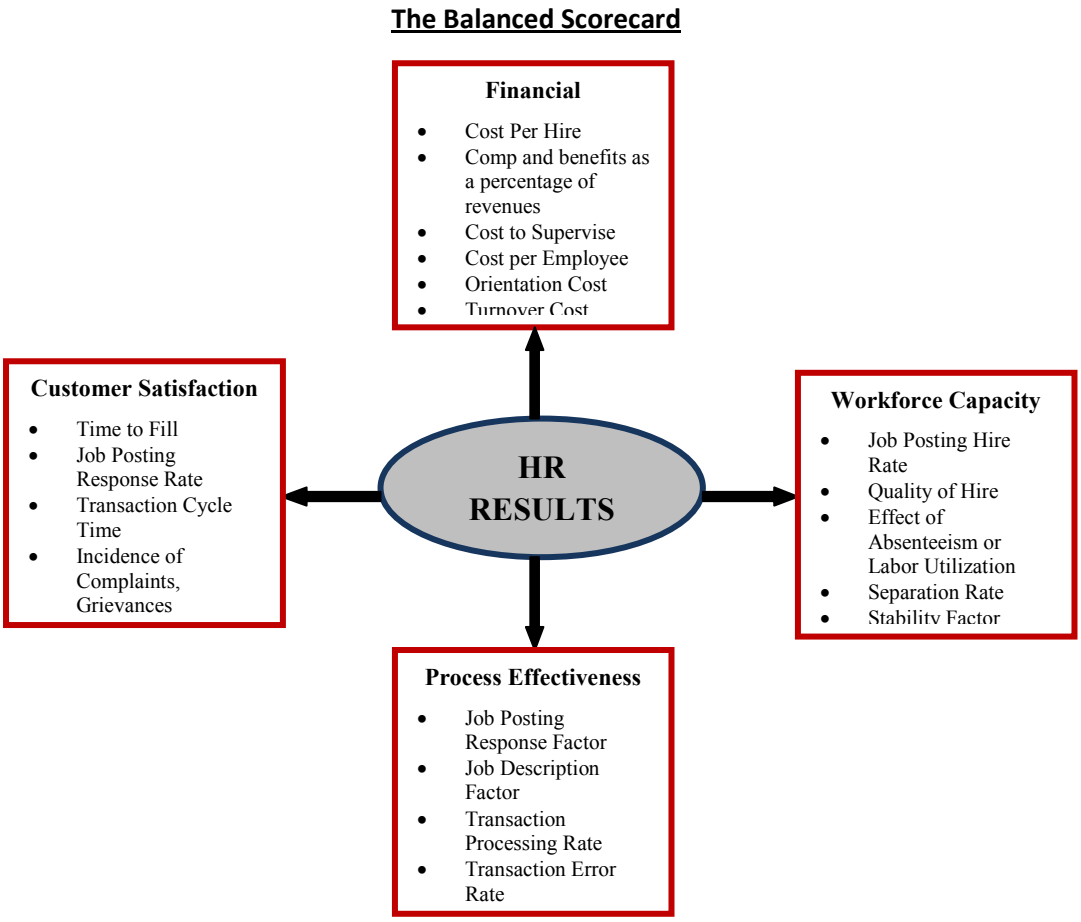

Figure3.2 Balanced scorecard for HR

[8] http://www.hrmbusiness.com/2009/02/using-balanced-scorecard-in-hr.html

Like any other organization, by adopting the Balanced Scorecard Methodology, the bank will be able to translate its business strategy into a clear action plan. Through the scorecard, the bank can clearly define its strategic areas like value, quality, and customer satisfaction. It will enable the bank's decision makers to measure and understand how individual business units impact these strategic areas and also determine how much it needs to invest in people, systems, and procedures to improve that performance[9].

Use of Balanced Scorecard in banks and financial organizations helps all employees at all levels better understand strategic vision of the company. Statistics show that only 5% of employees have a good understanding of the company strategy, and only 25% of managerial staff participates in strategic planning. It is especially important for financial organizations to link their budgets to the adopted strategy. A strategy for a financial organization is something bigger than attracting as many customers as possible or opening of thousands of new accounts. Balanced Scorecard visualizes the strategy thus making it comprehensive in easy to understand. Through its implementation management of a financial organization will be able to reveal weak and strong points, loss making and profitable areas, efficiency of existing programs and campaigns, effectiveness of learning efforts etc. Figure 3.3 shows BSC for a bank[10].

[9] http://www.oxbridgewriters.com/essays/banking/adopting-balanced-scorecard-in-bank.php

[10] http://www.bscdesigner.com/use-of-balanced-scorecard-in-banks-and-financial-organizations.htm

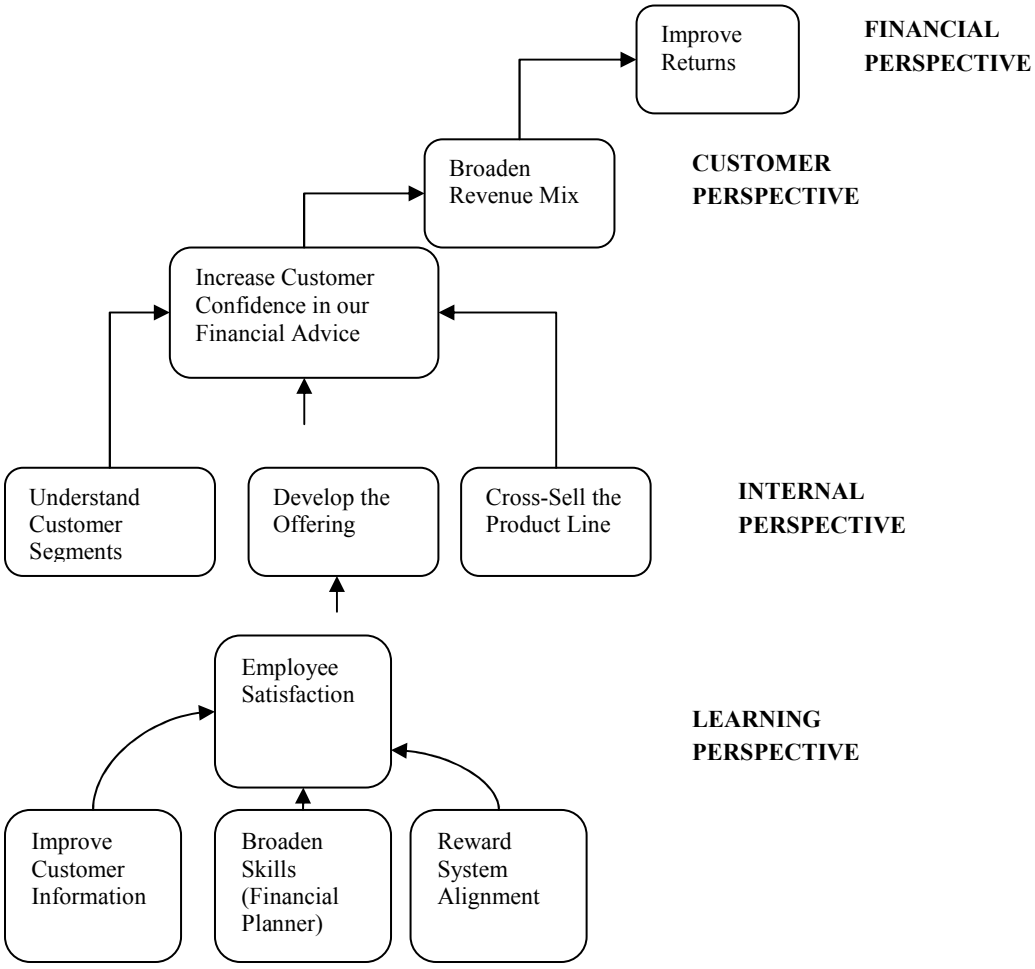

Figure 3.3 BSC works for four perspectives for bank

Performance monitoring is only of secondary importance, even though emergency hospitals with more than five years' experience with the BSC tend to use it for that purpose. The BSC is almost never used in the hospitals' reward systems (Aidermark et al., 2010). Many healthcare organizations have developed operational or clinical key performance index (KPI) dashboards. A strategic BSC captures drives as well as outcomes. Healthcare organizations with strategically derived BSC can improve on results, not just report on them. A strategic BSC can greatly enhance the strategic planning process for healthcare[11]. Figure 3.4 show an example of a Mental Health System in U.S.[12]

[11] http://www.qa.au.edu/page2/research/BSCHealthCare.pdf

[12] http://www.omh.ny.gov/omhweb/Statewideplan/2006/interim_report/update/html/chapter_1.html

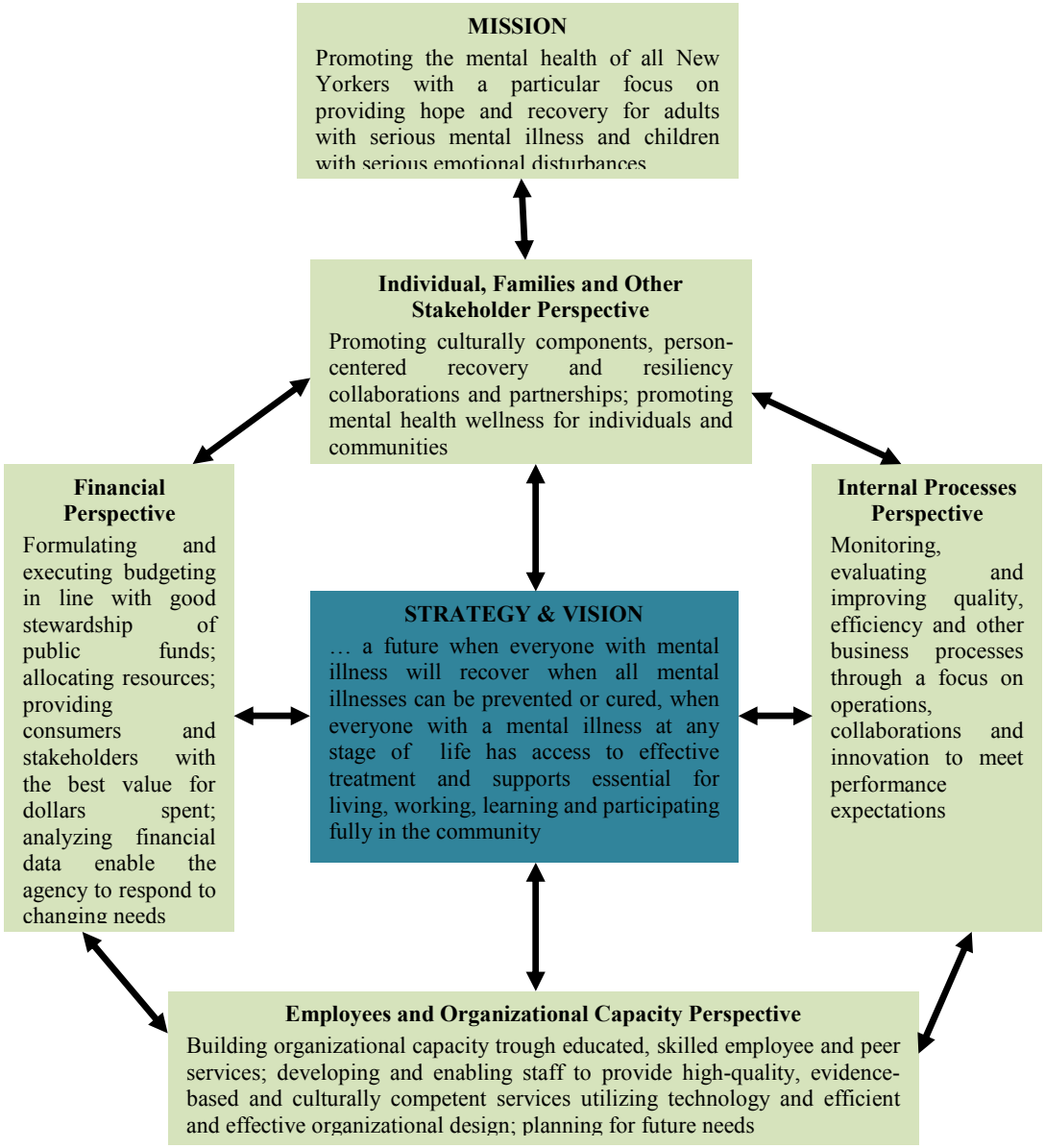

Figure 3.4 Basic Design of the BSC for approach public Mental Health System in U.S.

BSC is using as performance management system in every kind of service especially in HR, healthcare and the banking as you can see above. But the main questions of BSC answer are below.

- How can customers be satisfied?
- How can we operate more efficiently?
- How we develop the abilities we need to; execute our strategies?

How can we satisfy our stakeholder?

4 CRITERIA

BSC is used to decide to selection criteria of projects. A survey is applied to management board. Questions were about four perspectives of BSC. Details of survey can be found in Appendix A and Table A.1. Managers can communicate with all part of firm and also with customer and the management of bank. They know all of aspects so it was easy to answer the questions in the survey with four perspectives of BSC. Answers of the survey were strategic part of firm mission and they became decision criteria of the projects selection. Ten criteria are found for making selection for three projects.

Criteria are as follows: decreasing expenses, increasing number of customers, increasing known of firm in market, technological additive and operation time income, compliance with the current system, competition advantage, marketing potential, providing quick and easy service, fuzzy real option values. Table 4.1 shows criteria that are used for project selection.

Table 4.1 Criteria used for selection of new software projects

Decreasing expenses	when the project finishes number of employee decrease so expenses for an employee will gain or electric that is used for a banking process will decrease
Increasing number of customers	when the project new customers will be gained
Increasing known of firm in market	when the project finish whit this project everybody will have more knowledge about firm
Technological additive:	new technology will use and project team will learn more and new information about the new technology and knowledge will increase
Operation time income	time that is used to consume while doing operation in bank will decrease with new project
Compliance with the current system	new project must be adaptable and work with the current system without any problem any extra development
Competition advantage	being more competitive in market in other competitors who are using new technology
Marketing potential	can new project sell to other banks
Providing quick and easy service	new project must provide quick and easy service to customers
Fuzzy Real Option Values	

5 FUZZY TOPSIS

5.1 Fuzzy Set Theory

Fuzzy set theory was proposed by Zadeh in 1965. Different from the crisp set and crisp value in traditional mathematics, Zadeh proposed the fuzzy set and the membership degree to represent the quantification of meaning and used them to deal with the uncertainty and fuzziness in real circumstances. Zadeh believed subjective opinion, speculation, or perception had certain degrees of fuzziness and many traditional accurate quantitative methods and probability calculations were no longer capable of solving human logic and other complicated problems. Therefore, the traditional quantitative methods had to be replaced by the analytical methods in fuzzy mathematics to solve this type of problem (Kuo et al., 2012).

The fuzzy set theory is designed to deal with the extraction of the primary possible outcome from a multiplicity of information that is expressed in vague and imprecise terms. Fuzzy set theory treats vague data as probability distributions in terms of set memberships. Once determined and defined, sets of memberships in probability distributions can be effectively used in logical reasoning (Ding, 2011).

5.2 Fuzzy TOPSIS Model

The fuzzy TOPSIS is the fuzzy extension of TOPSIS to efficiently handle the fuzziness of the data involved in the decision making. It is easy to understand and it can effectively handle both qualitative and quantitative data in the multi-attribute decision making problems. It bases upon the concept that the chosen alternative should have the shortest distance from the Positive Ideal Solution , i.e., the solution that maximizes the benefit criteria and minimizes the cost criteria; and the farthest from the Negative Ideal Solution, i.e., the solution that maximizes the cost criteria and minimizes the benefit criteria (Salehi & Tavakkoli-Moghaddam, 2008).

Today many enterprises use decision making tools to help with their decisions. In rural scenarios, where many important decisions must be taken, these tools may be easily implemented and used by governments and/or farmers. A fuzzy model has great potential as a valuable tool in evaluating such decisions owing to the uncertainty and difficulty in finding quantitative information in some aspects involving this sector. In the illustrative example presented, the problem is affected by many factors which may offer only imprecise and uncertain data. The examples demonstrate the power of this method to identify preferred options from a given combination of quantitative and qualitative information (Armero et al., 2011). Because of ease of processing and creating intuitive triangular fuzzy numbers are used.

5.3 Triangular Fuzzy TOPSIS

Let the fuzzy numbers $\tilde{A} = (a_1, a_2, a_3)$ and $\tilde{B} = (b_1, b_2, b_3)$ be triangular, then the basic operations are given in Eq. (5.1-5.3) (Ballı & Korukoğlu, 2009).

$$\tilde{A} \otimes \tilde{B} = (a_1 \times b_1, a_2 \times b_2, a_3 \times b_3) \tag{5.1}$$

$$\tilde{A} \oplus \tilde{B} = (a_1 + b_1, a_2 + b_2, a_3 + b_3) \tag{5.2}$$

$$(\tilde{A})^{-1} \approx (1/a_3,\ 1/a_2,\ 1/a_1) \tag{5.3}$$

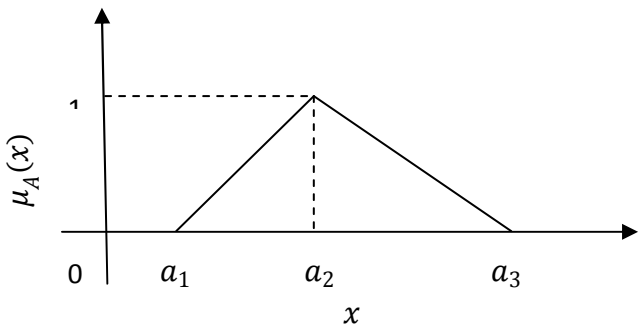

Figure 5.1 Triangular fuzzy number memberships

$$\mu(x/\tilde{A}) = \begin{cases} 0, & x < a_1, \\ (x - a_1)/(a_2 - a_1), & a_1 \le x \le a_2, \\ (a_3 - x)/(a_3 - a_2), & a_2 \le x \le a_3, \\ 0, & x > a_3 \end{cases} \tag{5.4}$$

5.4 Fuzzy TOPSIS used in this study

After Hwang and Yoon developed TOPSIS method, many methods based on TOPSIS were investigated by other researchers. Chen and Hwang transformed Hwang and Yoon's method to the fuzzy case. In the problem, valuation process requires fuzzy TOPSIS. Hierarchical fuzzy TOPSIS was developed by (Büyüközkan et al., 2007); also in this study this model will be used. First, the fuzzy TOPSIS method developed by Chen and Hwang is familiarized because the model is based on that method with minor differences (Tolga, 2008):

First, a decision matrix, *D*, of $m \times n$ dimension is defined as in Eq. (5.5).

$$D = \begin{array}{c} \\ A_1 \\ \vdots \\ A_i \\ \vdots \\ A_m \end{array} \begin{array}{c} \begin{array}{cccccc} X_1 & \dots & X_j & \dots & X_n \end{array} \\ \begin{bmatrix} x_{11} & \dots & x_{1j} & \dots & x_{1n} \\ \vdots & & \vdots & & \vdots \\ x_{i1} & \dots & x_{ij} & \dots & x_{in} \\ \vdots & & \vdots & & \vdots \\ x_{m1} & \dots & x_{mj} & \dots & x_{mn} \end{bmatrix} \end{array} \tag{5.5}$$

Where x_{ij} , $\forall i$, j may be crisp or fuzzy. If x_{ij} is fuzzy, it is represented by a trapezoidal number as $x_{ij} = (a_{ij}, b_{ij}, c_{ij}, d_{ij})$ the fuzzy weights can be described by Eq. (5.6).

$$\tilde{w}_j = (\alpha_j, \beta_j, \chi_j, \delta_j) \tag{5.6}$$

5.4.1 Algorithm

The problem is solved using the following steps.

Step 1. Normalize the decision matrix. The decision matrix must first be normalized so that the elements are unit-free. To avoid the complicated normalization formula used in classical TOPSIS, linear scale transformation is used as follows:

$$r_{ij} = \begin{cases} x_{ij} \big/ x_j^*, \forall j, x_j \text{ is a benefit attribute} \\ x_j^- \big/ x_{ij}, \forall j, x_j \text{ is a cost attribute} \end{cases} \tag{5.7}$$

In the formula above x_j^* and x_j^- represent the largest and the lowest scores respectively. By applying Eq. (5.7), we can rewrite the decision matrix in Eq. (5.5) as in Eq. (5.8).

$$D' = \begin{array}{c} \\ A_1 \\ \vdots \\ A_i \\ \vdots \\ A_m \end{array} \begin{array}{c} \begin{array}{cccccc} X_1 & \cdots & X_j & \cdots & X_n \end{array} \\ \begin{bmatrix} r_{11} & \cdots & r_{1j} & \cdots & r_{1n} \\ \vdots & & \vdots & & \vdots \\ r_{i1} & \cdots & r_{ij} & \cdots & r_{in} \\ \vdots & & \vdots & & \vdots \\ r_{m1} & \cdots & r_{mj} & \cdots & r_{mn} \end{bmatrix} \end{array} \tag{5.8}$$

When x_{ij} is crisp, its corresponding r_{ij} must be crisp; when x_{ij} is fuzzy, its corresponding r_{ij} must be fuzzy. Eq. (5.5) is then replaced by the following fuzzy operations: Let $\tilde{x}_{ij} = (a_{ij}, b_{ij}, c_{ij}, d_{ij})$, $\tilde{x}_j^- = (a_j^-, b_j^-, c_j^-, d_j^-)$ and $\tilde{x}_j^* = (a_j^*, b_j^*, c_j^*, d_j^*)$, we have:

$$\tilde{r}_{ij} = \begin{cases} \tilde{x}_{ij}(\div)\tilde{x}_j^* = \left(\dfrac{a_{ij}}{d_j^*}, \dfrac{b_{ij}}{c_j^*}, \dfrac{c_{ij}}{b_j^*}, \dfrac{d_{ij}}{a_j^*} \right) \\ \tilde{x}_j^-(\div)\tilde{x}_{ij} = \left(\dfrac{a_i^-}{d_{ij}}, \dfrac{b_i^-}{c_{ij}}, \dfrac{c_i^-}{b_{ij}}, \dfrac{d_i^-}{a_{ij}} \right) \end{cases} \tag{5.9}$$

Step 2. Obtain the weighted normalized decision matrix. This matrix is obtained using

$$v_{ij} = r_{ij} w_j \quad \forall_j, j \tag{5.10}$$

When both r_{ij} and w_{ij} are crisp, v_{ij} is crisp; while when either r_{ij} or w_{ij} (or both) are fuzzy, Eq. (5.6) may be replaced by the following fuzzy operations:

$$\tilde{v}_{ij} = \tilde{r}_{ij}(\times)\tilde{w}_j = \left(\frac{a_{ij}}{d_j^*}\alpha_j, \frac{b_{ij}}{c_j^*}\beta_j, \frac{c_{ij}}{b_j^*}\chi_j, \frac{d_{ij}}{a_j^*}\delta_j \right) \tag{5.11}$$

$$\tilde{v}_{ij} = \tilde{r}_{ij}(\times)\tilde{w}_j = \left(\frac{a_i^-}{d_{ij}}\alpha_j, \frac{b_i^-}{c_{ij}}\beta_j, \frac{c_i^-}{b_{ij}}\chi_j, \frac{d_i^-}{a_{ij}}\delta_j \right) \tag{5.12}$$

Eq. (5.11) is used when the *j*th attribute is a benefit attribute. Eq. (5.12) is used when the *j*th attribute is a cost attribute. The result of Eq. (5.11) and (5.12) can be summarized as in Eq. (5.13).

$$v = \begin{array}{c} \\ A_1 \\ \vdots \\ A_i \\ \vdots \\ A_m \end{array} \begin{array}{c} \begin{array}{cccccc} X_1 & \cdots & X_j & \cdots & X_n \end{array} \\ \begin{bmatrix} v_{11} & \cdots & v_{1j} & \cdots & v_{1n} \\ \vdots & & \vdots & & \vdots \\ v_{i1} & \cdots & v_{ij} & \cdots & v_{in} \\ \vdots & & \vdots & & \vdots \\ v_{m1} & \cdots & v_{mj} & \cdots & v_{mn} \end{bmatrix} \end{array} \tag{5.13}$$

Step 3. Obtain the positive ideal solution (PIS), A^*, and the negative ideal solution (NIS). PIS and NIS are defined as:

$$A^* = \left[v_1^*, \ldots, v_n^* \right], \tag{5.14}$$

$$A^- = \left[v_1^-, \ldots, v_n^- \right], \tag{5.15}$$

where $v_j^* = \max_i v_{ij}$ and $v_j^- = \min_i v_{ij}$. For crisp data, v_j^* and v_j^- are obtained straightforwardly. In case of fuzzy data, $\tilde{v}_j^*$ and $\tilde{v}_j^-$ may be obtained through some

ranking procedures. Chen and Hwang use Lee and Li ranking method for comparison of fuzzy numbers. The $\tilde{v}_j^*$ and $\tilde{v}_j^-$ are the fuzzy numbers with the largest generalized mean and the smallest generalized mean, respectively. The generalized mean for fuzzy number $\tilde{v}_{ij}, \forall j$ is defined as:

$$M(\tilde{v}_{ij}) = \frac{-a_{ij}^2 - b_{ij}^2 + c_{ij}^2 + d_{ij}^2 - a_{ij}b_{ij} + c_{ij}d_{ij}}{\left[3\left(-a_{ij} - b_{ij} + c_{ij} + d_{ij}\right)\right]} \tag{5.16}$$

For each column *j*, we find a $\tilde{v}_{ij}$ whose greatest mean is $\tilde{v}_j^*$ and lowest mean is $\tilde{v}_j^-$.

Step 4. Obtain the Separation Measures S_i^* and S_i^-. In the classical case, separation measures are defined as:

$$S_i^* = \sum_{j=1}^{n} D_{ij}^*, \quad i = 1, ..., m \tag{5.17}$$

$$S_i^- = \sum_{j=1}^{n} D_{ij}^-, \quad i = 1, ..., m \tag{5.18}$$

For crisp data, the difference measures D_{ij}^* and D_{ij}^- are given as:

$$D_{ij}^* = \left| v_{ij} - v_j^* \right| \tag{5.19}$$

$$D_{ij}^- = \left| v_{ij} - v_j^- \right| \tag{5.20}$$

The computation is straight forward. For fuzzy data, the difference between two fuzzy numbers $\mu_{v_{ij}}(x)$ and $\mu_{v_j^*}(x)$ is explained as given in Eq. (5.17).

$$D_{ij}^* = \sum_{j=1}^{n} d\left(\tilde{v}_{ij}, \tilde{v}_j^*\right), \forall i, j \tag{5.21}$$

Similarly, the difference between $\mu_{v_{ij}}(x)$ and $\mu_{v_j^-}(x)$ is defined as:

$$D_{ij}^- = \sum_{j=1}^{n} d\left(\tilde{v}_{ij}, \tilde{v}_j^-\right), \forall i, j \tag{5.22}$$

The other fuzzy number $\tilde{B}$ is denoted as: $\tilde{B} = (e, f, g, h)$ in Li's method is given in Eq. (5.23):

$$d(\tilde{A},\tilde{B}) = \sqrt{\frac{\left[(a-e)^2 + 2(b-f)^2 + 2(c-g)^2 + (d-h)^2\right]}{6}} \tag{5.23}$$

Note that both D_{ij}^{*}, D_{ij}^{-} are crisp numbers.

Step 5. Compute the relative closeness to ideals. This index is used to combine S_i^{*} and S_i^{-} indices calculated in Step 4. Since S_i^{*} and S_i^{-} are crisp numbers, they can be combined:

$$C_i = S_i^{-} / \left(S_i^{*} + S_i^{-}\right) \tag{5.24}$$

The alternatives are ranked in descending order of the C_i index.

5.4.2 Fuzzy Hierarchical TOPSIS

The following hierarchical fuzzy TOPSIS model was developed by Kahraman (Büyüközkan et al., 2007). An application of model (i.e. combined with fuzzy real option valuation model) will be given at the 7th section.

Assume that *n* main attributes, *m* sub-attributes, *k* alternatives, and *s* respondents. Each main attribute has r_i sub-attributes where the total number of sub-attributes *m* is equal to $\sum_{i=1}^{n} r_i$.

The first matrix ($\tilde{I}_{MA}$), given by Eq. (5.25), is constructed from the weights of the main attributes with respect to the goal.

$$\tilde{I}_{MA} = \begin{array}{c} \\ MA_1 \\ MA_2 \\ \vdots \\ MA_p \\ \vdots \\ MA_n \end{array} \begin{array}{c} \text{Goal} \\ \left[\begin{array}{c} \tilde{w}_1 \\ \tilde{w}_2 \\ \\ \tilde{w}_p \\ \\ \tilde{w}_n \end{array}\right] \end{array} \tag{5.25}$$

Where $\tilde{w}_p$ the arithmetic mean of the weights is assigned by the respondents and is calculated by Eq. (5.26):

$$\tilde{w}_p = \frac{\sum_{i=1}^{s} \tilde{q}_{pi}}{s}, \quad p = 1,2,...,n \tag{5.26}$$

where $\tilde{q}_{pi}$ denotes the fuzzy evaluation score of pth main attribute with respect to goal assessed by the ith respondent. The second matrix ($\tilde{I}_{SA}$) represents the weights of the sub-attributes with respect to the main attributes. The weights vector obtained from $\tilde{I}_{MA}$ are written above this $\tilde{I}_{SA}$ as illustrated in Eq. (5.27).

$$\tilde{I}_{SA} = \begin{array}{c} \\ MA_1 \\ SA_{11} \\ SA_{12} \\ \vdots \\ SA_{1r_1} \\ SA_{21} \\ SA_{22} \\ \vdots \\ SA_{2r_2} \\ \vdots \\ SA_{pl} \\ \vdots \\ SA_{n1} \\ SA_{n2} \\ \vdots \\ SA_{nr_n} \end{array} \begin{array}{c} \begin{array}{cccccc} \tilde{w}_1 & \tilde{w}_2 & \cdots & \tilde{w}_p & \cdots & \tilde{w}_n \\ MA_1 & MA_2 & \cdots & MA_p & \cdots & MA_n \end{array} \\ \begin{bmatrix} \tilde{w}_{11} & 0 & \cdots & 0 & \cdots & 0 \\ \tilde{w}_{12} & 0 & \cdots & 0 & \cdots & 0 \\ \vdots & \vdots & & \vdots & & \vdots \\ \tilde{w}_{1r_1} & 0 & \cdots & 0 & \cdots & 0 \\ 0 & \tilde{w}_{21} & \cdots & 0 & \cdots & 0 \\ 0 & \tilde{w}_{22} & \cdots & 0 & \cdots & 0 \\ \vdots & \vdots & & \vdots & & \vdots \\ 0 & \tilde{w}_{2r_2} & \cdots & 0 & \cdots & 0 \\ \vdots & 0 & & & & \vdots \\ 0 & 0 & \cdots & \tilde{w}_{pl} & \cdots & 0 \\ \vdots & \vdots & & & & 0 \\ 0 & 0 & \cdots & 0 & \cdots & \tilde{w}_{n1} \\ 0 & 0 & \cdots & 0 & \cdots & \tilde{w}_{n2} \\ \vdots & \vdots & & \vdots & & \vdots \\ 0 & 0 & \cdots & 0 & \cdots & \tilde{w}_{nr_n} \end{bmatrix} \end{array} \tag{5.27}$$

where $\tilde{w}_{pl}$ is the arithmetic mean of the weights assigned by the respondents and it is calculated by Eq. (5.28).

$$\tilde{w}_{pl} = \frac{\sum_{i=1}^{s} \tilde{q}_{pli}}{s} \tag{5.28}$$

where $\tilde{q}_{pli}$ is the weight of *l*th sub-attribute with respect to *p*th main attribute assessed by the *i*th respondent.

The third matrix ($\tilde{I}_A$) is formed by the scores of the alternatives with respect to the sub-attributes. The weights vector obtained from $\tilde{I}_{SA}$ are written above this $\tilde{I}_A$ as in Eq. (5.29).

$$\tilde{I}_A = \begin{array}{c} \\ \\ A_1 \\ A_2 \\ \vdots \\ A_q \\ \vdots \\ A_k \end{array} \begin{array}{c} \begin{array}{cccccccc} \tilde{W}_{11} & \tilde{W}_{12} & \dots & \tilde{W}_{1r_1} & \dots & \tilde{W}_{pl} & \dots & \tilde{W}_{nr_n} \\ SA_{11} & SA_{12} & \dots & SA_{1r_1} & \dots & SA_{pl} & \dots & SA_{nr_n} \end{array} \\ \begin{bmatrix} \tilde{c}_{111} & \tilde{c}_{112} & \dots & \tilde{c}_{11r_1} & \dots & \tilde{c}_{1pl} & \dots & \tilde{c}_{1nr_n} \\ \tilde{c}_{211} & \tilde{c}_{212} & \dots & \tilde{c}_{21r_1} & \dots & \tilde{c}_{2pl} & \dots & \tilde{c}_{2nr_n} \\ \vdots & \vdots & & \vdots & & \vdots & & \vdots \\ \tilde{c}_{q11} & \tilde{c}_{q12} & \dots & \tilde{c}_{q1r_1} & \dots & \tilde{c}_{qpl} & \dots & \tilde{c}_{qnr_n} \\ \vdots & \vdots & & \vdots & & \vdots & & \vdots \\ \tilde{c}_{k11} & \tilde{c}_{k12} & \dots & \tilde{c}_{k1r_1} & \dots & \tilde{c}_{kpl} & \dots & \tilde{c}_{knr_n} \end{bmatrix} \end{array} \tag{5.29}$$

$$\text{where, } \tilde{W}_{pl} = \sum_{j=1}^{n} \tilde{w}_p \tilde{w}_{pj} \tag{5.30}$$

Since $w_{pj} = 0$ for $j \neq l$, we can use Eq. (5.31) instead of Eq. (5.30)

$$\tilde{W}_{pl} = \tilde{w}_p \tilde{w}_{pl} \tag{5.31}$$

In $\tilde{I}_A$, $\tilde{c}_{qpl}$ is the arithmetic mean of the scores assigned by the respondents and it is calculated by Eq. (5.32).

$$\tilde{c}_{qpl} = \frac{\sum_{i=1}^{s} \tilde{q}_{qpli}}{s} \tag{5.32}$$

where $\tilde{q}_{qpli}$ is the fuzzy evaluation score of *q*th alternative with respect to *l*th sub-attribute under *p*th main attribute assessed by *i*th respondent.

After obtaining $\tilde{c}_{qpl}$ s, the hierarchical structure is ready to be included to the fuzzy TOPSIS algorithm described at the beginning of this section.

6 FUZZY REAL OPTIONS VALUE

The real options approach studies on the evaluation of R&D projects increase in huge numbers in recent years. Because capital investment of an R&D project is similar to purchasing of an option on a future investment, many researchers have worked on this subject. There are usually several phases in an R&D project, and at the end of each phase the decision maker should decide to exercise the option or not (i.e. option to stop or defer the project). Technically, if success is reached, option on continuing the project is exercised and more investment is made. But if the Project fails there is no need to invest more money to that project, and consequently the downside risk limit is reached to the capital investment cost of the R&D Project (Tolga, 2008).

In real options, the options involve real assets. To have a real option means to have the possibility for a certain period to either choose for or against making an investment decision. Real options can be valued using the analogue option theories that have been developed for financial options, but do not mean that they are the same. Real options are concerned about strategic decisions of a company, where degrees of freedom are limited to the capabilities of the company. In these strategic decisions different stakeholders play a role, especially if the resources needed for an investment are significant and thereby the continuity of the company is at stake. In addition, it is quite different from traditional discounted cash flow investment approaches. The traditional methods are very hard to make a decision when there is uncertainty about the exact outcome of the investment. And since these methods ignore the value of flexibility and discount heavily for external uncertainty involved, many interesting and innovative activities and projects are cancelled because of the uncertainties[13].

Detailed valuation in project management or business analysis real options process is needed. After analysis of frameworks the main steps are summarized to:

[13] http://centerforpbbefr.rutgers.edu/2007/086-A%20fuzzy%20approach.doc

Qualitative management screening. It is the first step where managers have to decide which projects, assets, or strategies are perspective for further analysis, in accordance with overall business strategy.

Discounted Cash Flow and net present value analysis. For each project that is important to management, a discounted cash flow model is created. This serves as the base case analysis, where a net present value and other traditional valuation methods are calculated.

Real options problem framing. The problem within the context of a real option is the next critical step. Based on the overall problem identification certain strategic optionalities as the option to expand, abandon or others would have become visible for each project.

Estimating Volatility of future cash flows. Discounted cash flow produces only a single-point estimate result; there is little confidence in its accuracy given that future events that affect forecast cash flows are highly uncertain. There is need to describe volatility in real option analysis to better estimate the future cash flows (Petravicius, 2009).

Uncovering real options can be tough. Unlike financial options, real options are not precisely defined or neatly packaged. But they do exist in almost every business decision, and they tend to take a limited number of forms. By understanding these forms, managers can become better able to spot the options in their own decisions. The following are hypothetical examples of the most common types of real options:[14]

Timing Option: Sales of low-fat ice cream are surging. Operating at full capacity, the Healthy Cow Creamery is considering whether to expand its plant. Launching the expansion would require a big up-front investment, and the company's managers can't be sure that the sales boom will persist. They have the option of delaying the investment until they learn more about the strength of demand. It may be that the risk

[14] http://www.real-options.com/overview_intro.htm

avoided by waiting to invest has a greater value than the sales that might be forfeited by postponing construction.

Growth Options: Friend-to-Friend, a company that sells cosmetics through a network of independent salespeople, is trying to decide whether to enter the vast Chinese market. The initial investment to build a manufacturing and sales organization would be large, but it may lead to the opportunity to sell a whole range of products through an established sales network. The investment would thus create growth options that have value above and beyond the returns generated by the initial operations.

Staging Option: The top management team at International Widget is reviewing a proposal from the senior vice president of operations to install a new manufacturing system. The proposal calls for a full, multimillion-dollar rollout at all factories over the next two years. But the business benefits of the project remain uncertain. The company has the option to invest in the new system in stages rather than all at once. The conclusion of each stage ill in turn provide further options for continuing, for delaying, or for abandoning the effort. All these options add value to the proposed project.

Exit Options: Molecular Sciences has a patent for a promising new chemical product, but it's worried about the size of the market opportunity, and it's unsure whether the manufacturing process will meet government regulations regarding toxic chemicals. If the company does begin an effort to commercialize the product, though, it will have the option to abandon the project if demand doesn't materialize or if the environmental liability appears too large. The exit option increases the value of the project because it reduces the size of the investment at risk.

Flexibility options: Cell, Incorporated needs to decide how to best manufacture its latest cellular telephone. Demand for the new product is uncertain, although forecasts indicate that sales will be spread across two continents. A traditional manufacturing analysis indicates that a single plant would be much cheaper to build and operate than two plants on two continents. But the analysis fails to take into account the flexibility of option that would be created by building two plants the option to shift production from continent to continent in response to shifts in demand, exchange rates, or production

costs. If the value of the option outweighs the cost saved by building just one plant, then Cell should invest in two plants and carry the excess capacity.

Operating options: Bright Light Software has long contracted with other companies to produce and package its CD-ROMs Its sales have grown rapidly in recent years, however, and now the company is trying to decide whether it makes sense to build its own plant. If it goes ahead, it would gain a number of operating options. It would, for example, have the option to shut down the operations during times of weak demand and the option to run additional shifts during times of high demand. The value of these options adds to the value of the plant.

Learning Options: Hollywood Partners is planning to release three movies in the midst of the Christmas season. Before the films actually open, the studio's executives can't tell which one will be the biggest hit, so they can't be sure how to best allocate their marketing and advertising dollars. But they have an important learning option. They can release each movie on a limited number of screens in selected cities and then refine their marketing plans based on what they learn. They can, for example, roll out the most popular movie nationwide and give it a large advertising budget while putting the other films into more limited release.

This study is an example of growth option that investment would create growth options that have value above and beyond the returns generated by the initial operations.

Fuzzy systems theory is suitable for presentment of expert ability. Fuzzy real options are purposed to contend with risks that are hard to predict with an open mind. The fuzzy also think of uncertainty and require less data so it is preferred to provide pleasurable outcomes.

$$E\left(\tilde{A}\right)=\frac{a_2+a_3}{2}+\frac{a_1+a_4-a_2-a_3}{6} \tag{6.1}$$

$$\sigma^2\left(\tilde{A}\right)=\frac{\left(a_3-a_2\right)^2}{4}+\frac{\left(a_3-a_2\right)\left(a_2+a_4-a_1-a_3\right)}{6}\frac{\left(a_2+a_4-a_1-a_3\right)^2}{24} \tag{6.2}$$

With these formulae given above, which are used in Tolga et al. (2009), fuzzy real option value (FROV) can be calculated as below:

$$FROV = \tilde{S}_0 e^{-T} N(d_1) - \tilde{X} e^{-rT} N(d_2) \tag{6.3}$$

$$d_1 = \frac{\ln(E(\tilde{S}_0)/E(\tilde{X})) + (r + \sigma^2/2)T}{\sigma\sqrt{T}} \tag{6.4}$$

here $d_2 = d_1 - \sigma\sqrt{T}$, and where $\tilde{S}_0$ denotes the possible values of the present value (PV) of expected cash flows (CF), in a similar manner $\tilde{X}$ quantifies the possible values of investment cost, $E\left(\tilde{S}_0\right)$ is the possibilistic mean value of the PV of expected CF, z $E\left(\tilde{X}\right)$ stands for the possibilistic mean value of expected costs, $\sigma\left(\tilde{S}_0\right)$ denotes the possibilistic variance of the PV of the expected CF.

6.1 Real Option Usage in IT Project Selection

The reality of most IT departments is that capital is limited, or rationed, so that positive net present value (NPV) projects are not always funded. In the present work we examine enterprise technology projects that have a positive traditional NPV. Incorporating real option value enables management to more objectively compare and rank projects in a capital rationed information technology portfolio management process, and decide upon the optimal deployment strategy for the project. The present work examines different phase-wise deployment strategies for large enterprise technology projects and incorporates real options into the decision making framework (Jeffery et al., 2003).

An NPV calculation, where you invest now or never, values the project at 50%x$5 - 50%x$6 = -$0.50. If you sink $1 and wait and see, the real option value of the project is 50%x$5 - 50%x$0 - $1 = $1.50 as you don't have to invest if the state of the world is bad. So flexibility can be profitable! (Walters & Giles, 2000)?

This flexibility has several strategic forms:

- Using real options values the ability to invest now and make follow-up investments later if the original project is a success (a growth option). These kinds of options characterize pharmaceutical R&D rather well, for example.

- Real options can also value the ability to abandon the project if it is unsuccessful (an exit option). A North Sea oil company has had much well-publicized success valuing its 5-year oil and gas exploration licenses in this way.

- And real options can value the ability to wait and learn, resolving uncertainty, before investing (a timing option). Eurotunnel has a statutory option on a second tunnel under the English Channel, to be opened not earlier than 2020 (its lease on the first tunnel expires in 2052). The current fixed link came in one year late and 11 billion over budget. What price the ability to resolve uncertainty this time?

When using real options to frame the IT platform investment problem, the cost of the initial positioning investment can be seen as the "price" paid to obtain the set of options enabled by the positioning investment. (A deferral option is a special case where the positioning investment cost is zero.) Each follow-on project enabled by the positioning investment is modeled as a separate option. Positioning investments can take two basic forms: provisional adoption initiatives (prototypes or pilot projects) that allow a detailed evaluation of the technology and need not provide lasting benefit in themselves, and larger "baseline" implementations of the full platform. Either way, the total option value of the positioning investment is equal to the sum of the option values of follow-on projects plus the NPV (possibly negative) of the positioning investment (Fichman, 2004).

Three conditions are prerequisite to using real options concepts to structure the evaluation and management of technology investments, and all three conditions hold strongly for IT projects (Hilhorst, 2009).

- Uncertainty regarding net payoffs: as we have described earlier, net payoffs in IT projects are typically uncertain.

- Irreversibility in project costs. Irreversibility is defined as the impossibility to reverse or correct a decision with no cost. Regarding the condition of irreversibility, the adoption of an IT project is essentially an investment in a new organizational capability, and such investments are largely irreversible due to the tight coupling of technology and organization .While a portion of expenditures for hardware and software can be reversed in some cases, other direct costs associated with organizational learning and adaptation cannot be reversed. These costs include expenditures for training, hiring experienced workers and consultants, engaging in learning by doing, developing new policies and procedures, and absorbing losses in productivity during the transition from old to new.
- Managerial flexibility regarding how projects are structured. As described earlier, managers have considerable flexibility in how they approach IT projects. This flexibility can take the form of flexibility in the configuration of a project, for example through staging or incremental development.

Figure 6.1 shows real options research strategies[15]

[15] http://www.emeraldinsight.com/fig/8924_10_1016_S0742-3322_07_24005-7.png

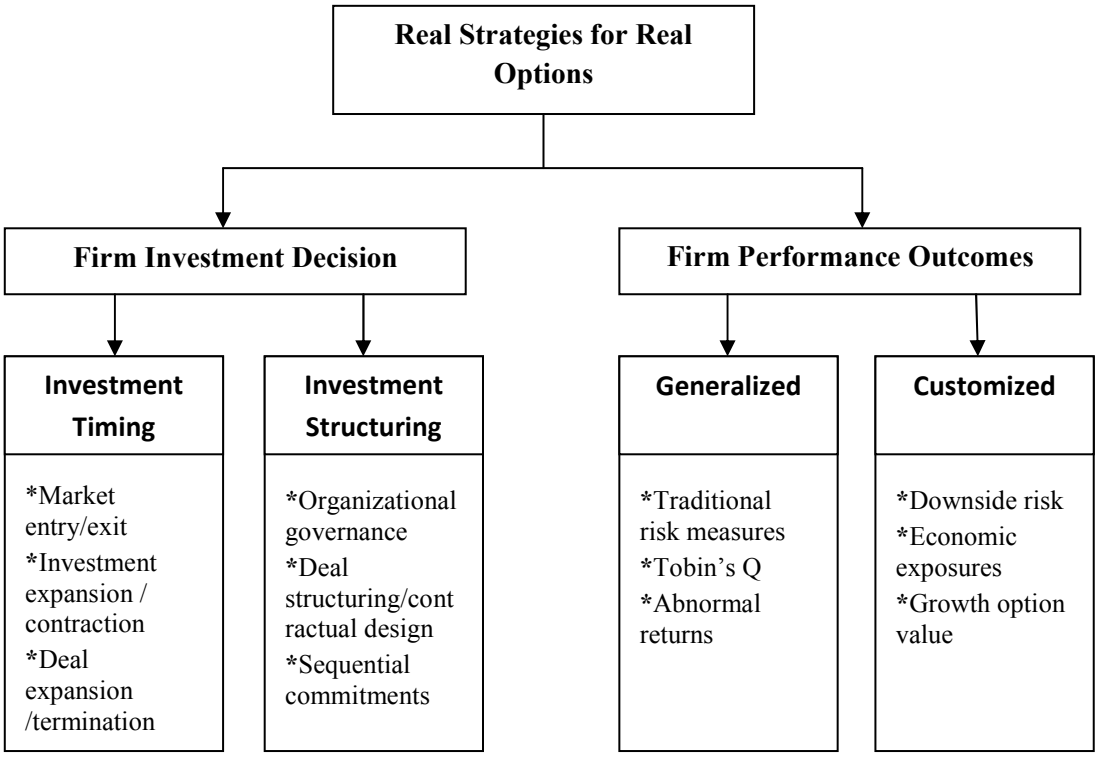

Figure 6.1 Research strategies for real options

As we mentioned before risk managements is important for all investment projects. Fuzzy real option minimizes the risk under uncertainty and decide more realistic. FROV will be used in offered model with Fuzzy TOPSIS. There will be more detail in next sections.

7 CASE STUDY

7.1 PROBLEM DEFINITION

One of greatest banks in Turkey requests to develop and implement one of the three new software projects by real options integrated multi criteria decision making method. Especially two of them are big projects and it is expected to gain great outcomes after projects finish. In the other hand the third project is important because after project finish it is expected to make one big part of the daily jobs of IT employee easy. Till this study no professional methods tried to make chose between projects and make investment to this project. They believe something was wrong with traditional methods. One of the other scope is new method will provide new and easy decision making flow. Firm wanted to review and exactly define its mission. BSC which is one of the new methods is used to convert its mission to strategy. This strategy would help to selection of projects. It is always risky to implement the strategy and as we mentioned before there is always risk for that kind of technology project. To minimize the risk FROV was chosen. It is integrated to fuzzy TOPSIS method.

First project is “Our Bank” project which aims to gain new or old customers whose ages are between twenty and forty. It is new special internet banking system for only special customers including almost every operation which can be done without going to bank branch.

Second project is called “New Faced Internet Banking” everybody who is customer of bank or not can use this site. Old one is changing with new one which is using new technology and getting user friendly.

The last project is called “Information Technology Qualified User Creating and Canceling Software” which aims to make information technology user creation and

deletion process easy and reportable. It will be useful to give exact reports to audit department from one and main point.

7.2 MODEL FORMULATION

Step 1: Produce criteria by balanced score card; use it creating initial TOPSIS matrix.

Step 2: Construct $\tilde{I}_{MA}$ matrix according to the data received from respondents.

Step 3: Construct $\tilde{I}_{SA}$ matrix and if there are sub-sub-attributes, then also construct $\tilde{I}_{SSA}$ matrix according to the data received from the respondents.

Step 4: For fuzzy real options value, calculate $E\left(\tilde{S}_0\right), E\left(\tilde{X}\right)$ and $\sigma\left(\tilde{S}_0\right)$ values for each alternative separately via Eq. (6.1) and (6.2).

Step 5: Calculate d_1 *and* d_2 values respectively by Eq. (6.4).

Step 6: Find $FROV$ for each alternative by Eq. (6.3) which is used by (Tolga, 2008).

Step 7: Construct $\tilde{I}_A$ matrix according to the data received from respondents and values calculated at Step5.

Step 8: Include $\tilde{I}_A$ matrix to fuzzy TOPSIS algorithm described in study of Tolga (2008). Then apply the algorithm of fuzzy TOPSIS.

Step 9: Rank the alternatives in descending order according to the C_i index found from fuzzy TOPSIS and implement the best alternative.

Figure 7.1 basically shows the flow chart of the model.

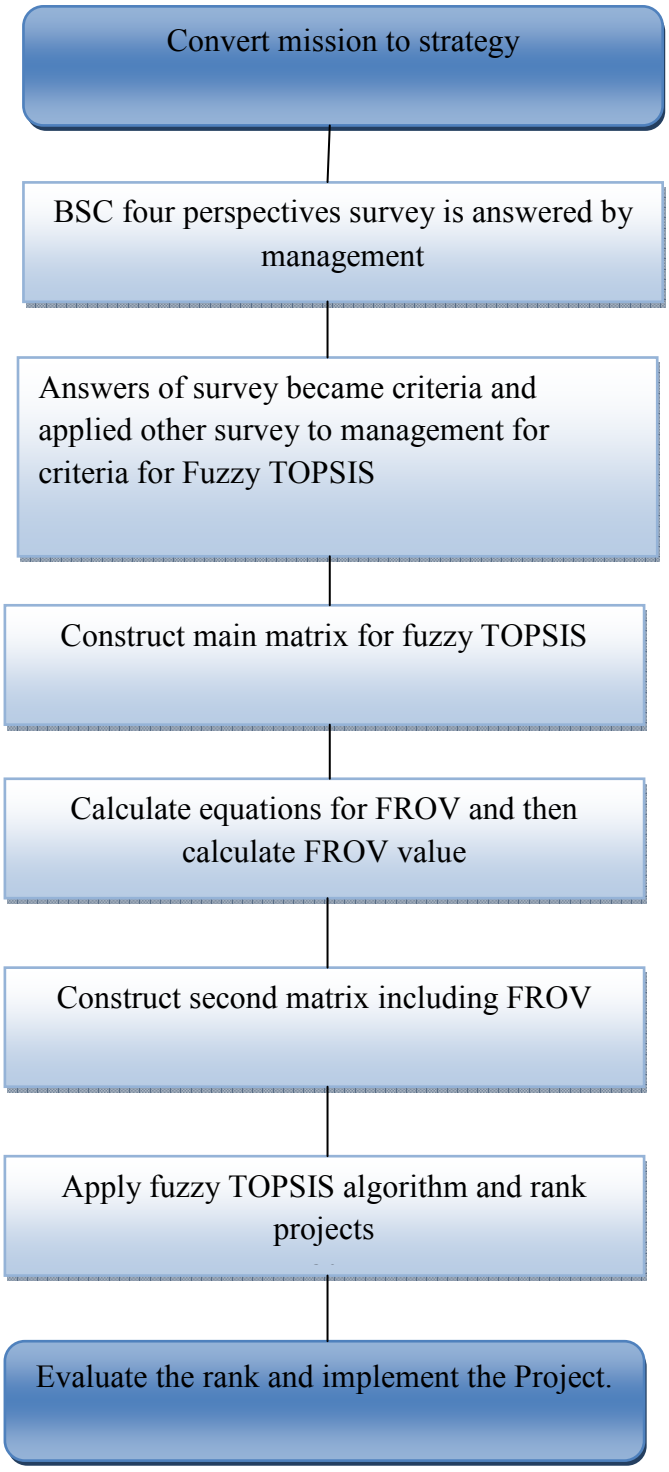

Figure7.1 Model flow chart

7.3 Defining Criteria with BSC Survey

As mentioned on previous sections BSC has four perspectives. The survey is prepared according to these four perspectives. As the first step of model BSC survey is applied to three top managers of firm. They also communicate all departments and management of bank also with customers. Questions that they answered are below the results of survey for each person is in Table A.1.

Financial Perspective:

Q1. Before or after the implementing the projects what kind of behaviour is expecting?

Q2. Which property of projects provides financial income?

Q8. What is expected from projects to have placed in global?

Customer Perspective:

Q3. How then are expected to affect the company's stance on the market after the end of the projects?

Q7. What is expected from project to have forward-looking market share?

Q9. What kind of benefits for customers are expecting after finishing the projects?

Internal Business Perspective:

Q5.What is expected from projects to improve the existing environment?

Q6.What eases and accelerates implementing the projects?

Learning and Growth Perspective:

Q4.What kind of benefits for employees are expected from projects ?

Managers answered these questions and after the criteria defined according to this survey they give degree of importance to these criteria for fuzzy TOPSIS which will be used in of model.

7.4 FROV Parameters

7.4.1 Common Variables

Banks have huge data warehouse systems. Every kind of data is important for them because any time anybody from management team or audit etc. can want some reports to understand everything is going well or calculations are consistent or have problems in somewhere. Data warehouse system is a kind of treasure for that kind of reports or questions. They run so many queries in this treasure and then provide meaningful data for business. Data showed in Table 7.1 is provided from data warehouse team. The values that are showed in the table are not the real values they are fuzzy numbers because firm did not want to give real transaction numbers and costs. These data will be used for calculations of FROV.

Table 7.1 Monthly transactions data done by branches

The average monthly number of transactions from all branches (AMT)	119.798.903,00TL
Monthly transaction costs for all branches (MTC)	17.979.685,55TL
Monthly number of customers who have transactions (MNC)	45.348.311,00TL
Customers' average monthly number of transactions(CAMT)	26,41TL
Average transaction cost (ATC)	0,15TL
Customers' average monthly transaction cost(CAMC)	3,90TL

In the evaluated projects different teams will be affected. Every team has different average of team member cost. Table 7.2 shows teams that are affected and their average hourly team member cost. The values that are showed in the table are not the real values they are fuzzy numbers because firm did not want to give the real values of its pricing data.

Table 7.2 Affected team member hourly cost

TEAM	Average Hourly Cost of a Team Member(AHC)
Infrastructure(INF)	31,25 TL
Software(SW)	31,25 TL
Operations Management(OM)	15,625 TL
Audit (AUD)	37,5 TL
Access Management(AMNG)	15,625 TL

The equations 6.1, 6.2, 6.3, 6.4 are used the make calculation for FROV. The details of parameters for this study are as below.

$\tilde{X}$ is the sum of hardware, license cost and the cost of the work done by the PT during the project. The components and values of them for $\tilde{X}$ of each project will be given in Table B.1.

$\tilde{S}_0$ is the sum of income(I) and the cost(C) of the project also they are calculated from the values in the tables 7.1, 7.2 and are showed in Table B.1 .

I is the sum of incomes, C is the cost of hardware and support cost for three years. Components of I are changed according to the project. Details of calculation and the components of I will be given in next sections for each project. C is standard calculation for each project.

T is time for every projects evaluation it is 3 for every project.

r is risk free rate which is taken from the web site of Central Bank of Turkey and it is.

AMT, MTC, MNC, CAMT, ATC, CAMC are used from the Table 7.1. INF, SW, OM, AUD, AMNG are used from Table 7.2.

7.4.2 Parameters Calculation for Projects

Project1

$\tilde{X}$ is cost of the work done by the PT during the project. Because it will use no extra hardware and license it will be integrated to current environment.

$\tilde{S}_0$ is calculated as the sum of I and C and detail are below:
I is calculated if customer number who uses internet and whose age are twenty and forty is increased by %0.5 it is calculated as below:

$$I = MNC \times 0.05 \times CAMT \times ATC \quad (7.1.1)$$

C is calculated as the cost of hardware and support cost for three years.

Project2

$\tilde{X}$ is the sum of hardware, license cost and the cost of the work done by the PT during the project. This project has great cost of hardware and support. But also it is expected more income from this project.

$\tilde{S}_0$ is calculated as the sum of I and C and detail are below:

I is calculated as if %90 all off transactions done from branches done from internet by customers average %90 of AMT will be gain for the bank. It is calculated as below:

$$I = AMT \times 0.9 \quad (7.1.2)$$

C is calculated as the cost of hardware and support cost for three years.

Project3

Table 7.3 Team based daily spent hours

TEAM Spent Hour	Average Spent Hour for a Team(ASH)
INF	0,4
OM	0,4
AUD	0,8
AMNG	0,8

$\tilde{X}$ is the cost of the work done by the PT during the project. This project has no extra hardware or license cost because it will be integrated to current environment.

$\tilde{S}_0$ is calculated as the sum of I and C and detail are below:

In this project four teams are affected. If this project is implemented three of the affected teams will is have income because they will transfer the part of their work to another group who does the same transactions. So while three teams have man/hour gain last team will have extra work. Based on these I is calculated as. Also the details for components of the equation and the values of them will be given in Table B.1.
ASH is taken from Table 7.2 for each affected group. AHC is taken from Table 7.3 for each affected group. GT teams are INF, OM, AUD who transfer their work and gain man/hour and LT team is AMNG who get extra work. MWD is mentioned as monthly working days.

$$I = GT - LT \tag{7.1.3}$$

- $GT = \sum_{1}^{3} ASH \times AHC \times MWD \times T \times 12$
- $LT = ASH \times AHC \times MWD \times T \times 12$

C is calculated as the cost of hardware and support cost for three years.

7.4.3 Other Calculations for FROV

Table 7.4 shows the calculated values of 6.1 for all projects which are used for FROV calculation. We have four fuzzy numbers fuzzy set both $\tilde{X}$ and $\tilde{S}_0$ we found the fuzzy numbers as the %20-30 percentage greater or less than the values of $\tilde{X}, \tilde{S}_0$. You can found the details of these fuzzy sets of $\tilde{X}$ and $\tilde{S}_0$ in Table B.2 and Table B.3.

Table 7.4 Equation 5.1 calculated values for all projects

PROJECTS	$E(\tilde{X})$	$E(\tilde{S}_0)$
Project1	435.000	325.000.000
Project2	1.041.666,667	561.666.666,7
Project3	17.500	25.000

By the equation 6.4 d_1, d_2 are calculated for this calculation to use in this equations. We can calculate the volatility (σ) of the rate of the change of the project return as

$$\sqrt{\mathrm{Var}(\tilde{A})} / E(\tilde{A}) \qquad (7.2)$$

We can see the calculation of d_1, d_2 for project1

$E(\tilde{X})$ is 435.000 as we can see in Table 7.4.

$E(\tilde{S}_0)$ is 325.000.000 as we can see in Table 7.4.

r is interest rate which is calculated from web side of Central Bank of Turkey as 0,1213.

σ is calculated from eq. 7.2 as 0,12.

σ^2 is calculated as 0,02.

T is also three years.

After defining all of the variables we just applied the eq. 6.4 and fond d_1 = 33,01 and d_2 =32,08.

Table 7.5 Income, FROV, d_1 and d_2

Projects	d_1	d_2	I	FROV
Project1	33,01	32,80	325.520.969,30	(11.114.942,52, 15.878.498,32, 20.642.036,12)
Project2	46,03	45,89	586.104.153,00	(22.278.985,03, 25.992.996,32, 34.677.207,69)
Project3	5,17	5,02	26.100,00	(-8.733,71, -10.917,14, -13.100,56)

7.5 Calculations of Fuzzy TOPSIS

Ten questions of BSC survey results are defined as ten selection criteria. This survey is applied to three top managers of the firm who have communication with customers, bank management and also employees they answered from four perspectives. Questionnaire for fuzzy TOPSIS is prepared to receive the individual weights of attributes as partly given in Table C.1, Table C.2. The questionnaires are applied to the three top managers who were applied to first survey. Table 7.6 is used for determining the importance degree of each attribute with respect to the goal. For scoring the alternatives the linguistic terms are given in Table 7.7.

Table 7.6 The Importance Degrees

Lowest	0, 0, 0.1
Very Low	0, 0.1, 0.3
Low	0.1, 0.3, 0.5
Medium	0.3, 0.5, 0.7
High	0.5, 0.7, 0.9
Very High	0.7, 0.9, 1.0
Highest	0.9, 1.0, 1.0

Table 7.7 The Scores

Lowest	0, 0, 1
Very Low	0, 1, 3
Low	1, 3, 5
Medium	3, 5, 7
High	5, 7, 9
Very High	7, 9, 10
Highest	9, 10, 10

At first, the second step of our model this is same with the fuzzy hierarchical fuzzy TOPSIS is executed. Third step did not applied also we used the hierarchical TOPSIS because we could not determine the sub-attributes because of top managers could not have more time for this study. After the collection of evaluations from 3 respondents, $\tilde{I}_{MA}$ is derived and given in Tables 7.8. Then, the fuzzy present values of alternatives' incomes after market introduction, the present values of investment costs and the crisp values of alternatives' time for evaluation(taken from the concerned department of the company) are illustrated in Table 7.9 The annual interest rate in Turkey is 12.13% for 2012 in July.

Table 7.8 $\tilde{I}_{MA}$ the Importance Degrees of Main Attributes with Respect to Best Project Goal

	Best Project
Decreasing expenses	(0,63, 0,77, 0,93)
Increasing number of customers	(0,70, 0,90, 1,00)
Make firm known in market	(0,43, 0,63, 0,80)
Technological additive	(0,63, 0,77, 0,90)
Operation time income	(0,63, 0,83, 0,97)
Compliance with the current system	(0,47, 0,57, 0,73)
Competitive advantage	(0,70, 0,83, 0,97)
Marketing potential	(0,57, 0,70, 0,87)
Providing quick and easy service	(0,83, 0,90, 1,00)
FROV	(0,57, 0,77, 0,90)

Steps 4 and 5 are applied to the data in Table 7.9 and all FROV values for each of the values for each of the alternatives are found and shown in Table 7.10 also FROV values were given in Table 7.5.

Table 7.9 Economic and time Values of Alternatives

Projects	PV of project income after market introduction	PV of investment cost	Time
	$\tilde{S}_0$	$\tilde{X}_0$	T
Project 1	(260000000, 300000000 ,400000000)	(340000, 400000, 520000)	3
Project 2	(470000000, 550000000, 700000000)	(1600000, 2000000, 2500000)	3
Project 3	(20000,25000,30000)	(14000, 16000, 22000)	3

Table 7.10 Results of computation

Projects	FROV
Project 1	(11.114.942,52, 15.878.498,32, 20.642.036,12)
Project 2	(22.278.985,03, 25.992.996,32, 34.677.207,69)
Project 3	(-8.733,71, -10.917,14, -13.100,56)

The calculated and illustrated data in Table 7.10 and the evaluations of respondents are combined to produce $\tilde{I}_A$ in Table 7.11 in accordance with Step 8.

Table 7.11 $\tilde{I}_A$ the Scores of Alternatives with Respect to Attributes

	Project1	Project2	Project3
DE	(3,33, 4,67, 6,00)	(5,00, 7,00, 8,33)	(6,33, 8,00, 9,00)
INC	(5,66, 7,67, 9,00)	(6,33, 8,00, 9,00)	(1,00, 2,00, 3,67)
MFKM	(7,66, 9,00, 9,67)	(9,00, 10,00, 10,00)	(0, 0,67, 2,33)
TA	(6,00, 7,00, 7,67)	(6,00, 7,00, 7,67)	(7,67, 9,00, 9,67)
OTI	(5,67, 7,67, 9,00)	(5,00, 7,00, 8,67)	(7,67, 9,00, 9,67)
CCS	(5,67, 7,67, 9,00)	(4,67, 6,00, 7,00)	(5,33, 6,67, 7,67)
CA	(7,67, 9,33, 10,00)	(9,00, 10,00, 10,00)	(5,00, 7,00, 8,33)
MP	(5,67, 7,67, 9,00)	(7,00, 9,00, 10,00)	(3,00, 5,00, 7,00)
PQES	(6,33, 7,67, 8,33)	(6,00, 7,00, 7,67)	(4,00, 5,00, 6,00)
FROV	Table 7.10 shows FROV values for Project1	Table 7.10 shows FROV values for Project2	Table 7.10 shows FROV values for Project3

The tables to obtain v_{ij} , D_{ij}^{*}, and D_{ij}^{-} are given in Table C.3, Table C.4, Table C.5.

Table 7.12 Distances from Ideal Solution

Projects	S_i^*	S_i^-	C_i	Normalized C_i
Project 1:	1,182708	2,389472	0,668911	0,396514
Project 2:	0,638041	2,914591	0,820403	0,486315
Project 3:	2,845864	0,701118	0,197666	0,117171

As mentioned in previous sections hierarchical TOPSIS cannot be applied as it. There were no sub-attributes. We cannot define sub attributes because of top managers less time. Only fuzzy TOPSIS applied on main attributes and give scores for them for each projects

According to the Table 7.12 given above, Project2 will be the selected one. The company wants to develop new internet banking system with new technologies.

$$Project2 > Project1 > Project3$$

8 CONCLUSION

Project selection is becoming more popular subject in the world. The projects which are selected to implement by firms make them popular. A new and big opportunity can be provided by new projects. Selecting right project at right time was become an important subject for researchers. So many methods used and also so many new projects developed to find the critic answer of question 'Which project must we select'. In any kind of sector firms started to work with researchers. New organizations established which are just working about selecting projects.

In today's competitive banking sector it is important to have new project before nobody else has done or to do the right project on right time. Also selecting processes and method is as important as implementing the projects. The pros and cons must be calculated and every detail must be carefully analyzed. The correct strategy will give success to company. With the right strategy right selection will be done. Recently BSC became more popular to convert company's mission to strategy four perspectives. In this study BSC is used to define the strategy of firm for defining the criteria and selecting the project. A survey applied to top managers who have all four perspective of BSC. Criteria defined from the result of survey.

All of technology projects are more risky than other projects because the labor work and the infrastructure are more expensive. New technology projects can bring banks big profit or may cause big loss. Under the uncertainty it is difficult to make selection but using the fuzzy set theory, decision makers have more descriptive power to describe uncertain project information. In this study FROV is used it is believed that FROV can improve the valuation of risky projects. TOPSIS model is integrated by FROV.

Three projects are evaluated with new offered model. After applying all equations of each method projects are ranked according to the distance from ideal solution as $\mathrm{Project2} > \mathrm{Project1} > \mathrm{Project3}$. Second project 'New Faced Internet Banking' is

selected. In the future may be first project can be implemented because its values are close to second project.

For further research BSC survey can be applied with more questions so criteria number will increase after applying survey logistic regression analysis may be use to examine the relationship between one or two independent variables new criteria can be used like innovativeness to obtain more detail. Because of the uncertainty about the true value of a numerical item for example r or T values for this study it can be important to find out how the solution derived from the model would change if the numerical value assigned were changed to other plausible values for that reason may be sensitivity analysis may be applied for r and T values in future researches. Also hierarchical TOPSIS is mentioned but there were not any sub-attribute because of less time of top managers. Model can be improved with sub-attributes. ANP method in which criteria have connection between each other can be used or problem can be solved using ANP so comparison can be made between two methods.

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APPENDIX A

Questionnaire for BSC survey

Q1. Before or after the implementing the projects what kind of behaviour is expecting?

a) Protection of current status of expenses and costs
b) Reduce expenses and costs
c) Increase expenses and costs
d) No prediction can be made before implementing the project

Q2. Which property of projects provides financial income?

a) Protection of current status of expenses and costs
b) Detailing the transaction process
c) Increasing number of customer
d) Use of the newest technologies

Q3. How then are expected to affect the company's stance on the market after the end of the projects?

a) The newest technology user title is provided
b) Make firm known in the market
c) Increase prestige of firm
d) Have no effect

Q4. What kinds of benefits for employees are expected from projects?

a) End as soon as possible and provide employee to work for other projects
b) Create less work load.
c) Be routinely and have no effect
d) Add new knowledge about new technology to employee to self-improvement

Q5. What is expected from projects to improve the existing environment?

a) Used newest technology
b) Reducing the transaction numbers and provide operation income
c) Have no effect on current environment
d) Be easy to integrate with the current environment

Q6. What ease and accelerate implementing the projects?

a) Compliance with the current system
b) Latest technology to be used
c) Has few step
d) Easiness and quickness have no effect

Q7. What is expected from project to have forward-looking market share?

a) To be used in every company
b) Restructure of project which is used before by other companies
c) Competitive advantage
d) No such property can be had

Q8. What is expected from projects to have placed in global?

a) Not cater to the global
b) Latest technology to be used
c) Finish before other companies
d) Have marketing potential

Q9. What kind of benefits for customers are expecting after finishing the projects?

a) No increase of complaints
b) Provide quick and easy service
c) Offer latest technology system
d) No increase expected

Table A.1 Results of BSC survey

Questions	Manager1	Manager2	Manager3
Q1	B	B	B
Q2	C	C	C
Q3	B	B	C
Q4	A	D	D
Q5	B	B	B
Q6	A	A	A
Q7	C	C	C
Q8	C	D	D
Q9	B	B	B

APPENDIX B

Table B.1 I, C, for $\tilde{X}$ and $\tilde{S}_0$ FROV

Projects	I	C	$\tilde{S}_0$	$\tilde{X}$
Proje1	325.520.969,26	39.375,00	325.481.594,26	435.375,00
Proje2	586.104.153,04	149.875,00	585.954.278,04	2.090.007,50
Proje3	26.100,00	562,50	25.537,50	17.968,75

Table B.2 Fuzzy numbers of $\tilde{X}$ for FROV

$\tilde{X}$ Fuzzy values of Projects	a_1	a_2	a_3	a_4
Project1	304.500	435.000	435.000	565.500
Project2	1.600.000	2.000.000	200.000	250.000
Project3	14.000	17.500	17.500	21.000

Table B.3 Fuzzy numbers of $\tilde{S}_0$ for FROV

$\tilde{S}_0$ Fuzzy Values of Projects	a_1	a_2	a_3	a_4
Project1	227.500.000	325.000.000	325.000.000	422.500.000
Project2	470.000.000	550.000.000	550.000.000	700.000.000
Project3	20.000	25.000	25.000	30.000

APPENDIX C

Questionnaire for hierarchical fuzzy TOPSIS

With respect to the overall goal "selection of best project" (see Table C.1),

Q1. What degree of importance do you assign to the main attribute *Decreasing expenses (DE)*?

Q2. What degree of importance do you assign to the main attribute *Increasing number of customers (INC)*?

Q3. What degree of importance do you assign to the main attribute *Make firm known in marketing (MFKM)*?

Q4. What degree of importance do you assign to the main attribute *Technological additive (TA)*?

Q5. What degree of importance do you assign to the main attribute *Operation time income (OTI)*?

Q6. What degree of importance do you assign to the main attribute *Compliance with the current system (CCS)*?

Q7. What degree of importance do you assign to the main attribute *Competitive advantage (CA)*?

Q8. What degree of importance do you assign to the main attribute *Marketing potential (MP)*?

Q9. What degree of importance do you assign to the main attribute *Providing quick and easy service (PQES)*?

Q10. What degree of importance do you assign to the main attribute *Fuzzy real option value (FROV)*?

Table C.1 Importance of main attribute respect to goal according to managers

Questions	Attributes	Importance		
		Manager1	**Manager2**	**Manager3**
Q1	DE	Highest	High	High
Q2	INC	Very High	Very High	Very High
Q3	MFKM	Medium	Medium	Very High
Q4	TA	Medium	Very High	Highest
Q5	OTI	High	Very High	Very High
Q6	CCS	Highest	Very Low	High
Q7	CA	Very High	Highest	High
Q8	MP	Medium	Highest	High
Q9	PQES	Very High	Highest	Highest
Q10	FROV	Very High	Medium	Very High

Table C.2 Scores of the attributes respect to the goal

Questions	Attributes		Scores		
			Manager1	**Manager2**	**Manager3**
		Project1	Low	Highest	Very Low
Q1	DE	Project2	Low	Very High	Very High
		Project3	Medium	Highest	Very High
		Project1	Very High	Medium	Very High
Q2	INC	Project2	Very High	Medium	Highest
		Project3	Low	Lowest	Medium
		Project1	Highest	Highest	High
Q3	MFKM	Project2	Highest	Highest	Very High
		Project3	Very Low	Lowest	Very Low
		Project1	Very Low	Highest	Highest
Q4	TA	Project2	Very Low	Highest	Highest
		Project3	High	Highest	Highest
		Project1	Medium	Very High	Very High
Q5	OTI	Project2	Medium	High	Very High
		Project3	High	Highest	Highest
		Project1	Very High	Very High	Medium
Q6	CCS	Project2	Very High	Very High	Lowest
		Project3	Very Low	Highest	Very High
		Project1	Very High	Very High	Highest
Q7	CA	Project2	Highest	Very High	Highest
		Project3	Very High	Highest	Very High
		Project1	Very High	Very High	Very High
Q8	MP	Project2	Very High	Highest	Very High
		Project3	Medium	Low	Medium
		Project1	Low	Medium	Highest
Q9	PQES	Project2	Very Low	Very High	Highest
		Project3	Medium	Medium	Highest

Table C.3 v_{ij}

	DE	INC	MFKM	TA	OTI
Project1	(0,33, 0,44, 0,62)	(0,63, 0,86, 1,00)	(0,37, 0,57, 0,77)	(0,49, 0,59, 0,71)	(0,47, 0,71, 0,89)
Project2	(0,50, 0,67, 0,86)	(0,70, 0,90, 1,00)	(0,43, 0,63, 0,80)	(0,49, 0,59, 0,71)	(0,41, 0,65, 0,86)
Project3	(0,63, 0,76, 0,93)	(0,11, 0,23, 0,41)	(0,00, 0,04, 0,19)	(0,63, 0,76, 0,90)	(0,63, 0,83, 0,96)
	CCS	**CA**	**MP**	**PQES**	**FROV**
Project1	(0,46, 0,56, 0,73)	(0,60, 0,70, 0,77)	(0,45, 0,60, 0,77)	(0,83, 0,90,1,00)	(0,28, 0,46, 0,54)
Project2	(0,38, 0,44, 0,57)	(0,70, 0,83, 0,96)	(0,56, 0,70, 0,86)	(0,79, 0,82, 0,92)	(0,56, 0,76, 0,90)
Project3	(0,43, 0,49, 0,62)	(0,39, 0,58,0,80)	(0,24, 0,39, 0,60)	(0,52, 0,59, 0,72)	(0,00, 0,00, 0,00)

Table C.4 D_{ij}^{*}

	DE	INC	MFKM	TA	OTI
Project1	0,31	0,05	0,05	0,17	0,12
Project2	0,10	0,00	0,00	0,17	0,18
Project3	0,00	0,62	0,55	0,00	0,00
	CCS	**CA**	**MP**	**PQES**	**FROV**
Project1	0,00	0,07	0,10	0,00	0,32
Project2	0,13	0,00	0,00	0,07	0,00
Project3	0,08	0,25	0,30	0,30	0,75

Table C.5 D_{ij}^{-}

	DE	INC	MFKM	TA	OTI
Project1	0,00	0,58	0,50	0,00	0,05
Project2	0,21	0,62	0,55	0,00	0,00
Project3	0,31	0,00	0,00	0,17	0,18
	CCS	**CA**	**MP**	**PQES**	**FROV**
Project1	0,13	0,19	0,20	0,30	0,44
Project2	0,00	0,25	0,30	0,23	0,75
Project3	0,05	0,00	0,00	0,00	0,00

BIOGRAPHICAL SKETCH

Özlem Afacan was born in Manisa on January 9, 1984. She completed the high school in Akhisar Anatolian High School, in 2002. She received her B. Sc. degree in Computer Engineering from Ege University, Izmir, in 2006. Since 2007, she is in the M. Sc. program in Industrial Engineering of Galatasaray University. For the completion of the program he has studied on "Fuzzy Multi-attribute Valuation of New Software Projects Via Fuzzy Real Options Using Balanced Scorecard". She wrote her first academic paper in 2012 with Asst. Prof. Abdullah Çağrı Tolga.