USING AN INTEGRATED FUZZY MCDM METHOD WITH BALANCED SCORECARD FOR R&D PROJECT PERFORMANCE ASSESSMENT

(AR-GE PROJELERİNİN PERFORMANS DEĞERLENDİRMESİNDE DENGELİ KURUMSAL KARNE VE ENTEGRE BULANIK ÇOK ÖLÇÜTLÜ KARAR VERME YÖNTEMLERİNİN KULLANILMASI)

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List of Symbols

AHP	: Analytic Hierarchy Process
ANP	: Analytic Network Process
BSC	: Balanced Scorecard
CPCR	: The Commercial Performance wrt Completion Ratio
CPI	: Cost Performance Index
CS	: Customer Satisfaction
DANP	: DEMATEL-based Analytic Network Process
DEA	: Data Envelopment Analysis
DEMATEL	: Decision Making Trial and Evaluation Laboratory
EVM	: Earned Value Management
GPPT	: Getting Process Payment in Time
GSD	: Global Software Development
IJV	: International Joint Ventures
IN	: Innovation
INRM	: Influential Network Relation Map
IP	: Image Processing
JS	: Employee /Job Satisfaction
MCDA	: Multi Criteria Decision Analysis
MCDM	: Multi Criteria Decision Making
NPD	: New Product Development
PBEA	: Project Balance Evaluation Approach

PC : Project Costs

PCA : Principal Component Analysis

PCPT : Probability of Completing Project in Time

PCS : Probability of Commercial Success

PMPT : Probability of Making Progress in Technology

PPS : Project Performance Scorecard

PTS : Probability of Technical Success

RAS : Radar Systems

R&D : Research and Development

RFS : Radio Frequency Systems

ROR : Rate of Return

RS : Responsiveness

SAW : Simple Additive Weighting

SPI : Schedule Performance Index

SPP : The Success of Purchasing Process

SQ : Service and Quality

SS : Sensor Systems

TL : Timeliness

TS : Training and Skills

TT : Technology Transfer

TOPSIS : Technique for Order Preference by Similarity to Ideal Solution

WDI : Weighted Displaced Ideal

WP : Weighted Product

$\tilde{A}$: Fuzzy Direct Influence Matrix

c : Sum of Columns of Total Influence Matrix

$\widetilde{D}$: Normalized Fuzzy Direct Influence Matrix

I : Identity Matrix

r : Sum of Rows of Total Influence Matrix

s : Normalization Factor

$\tilde{T}$: Fuzzy Total Influence Matrix

$\tilde{T}_C$: Normalized Fuzzy Total Influence Matrix

$\tilde{T}_D$: Total Influence Relationship Matrix of the Dimensions

$\tilde{W}$: Unweighted Supermatrix

$\tilde{W}^{\alpha}$: Weighted Supermatrix

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Abstract

The performance assessment of research and development (R&D) projects problem is a very complex and austere issue for project managers and there are few studies on this challenging problem in literature. Hence, a new method is intended to propose and it uses balanced scorecard (BSC) perspectives including an extra perspective, called uncertainty, as a basis and it uses an integrated fuzzy multi criteria decision making (MCDM) approach that effaces the quantitative assessment shortcoming of BSC, in order to evaluate the performance of R&D projects in different stages of their life cycle on the scope of company vision and strategies.

The fuzzy MCDM method integrates fuzzy Decision Making Trial and Evaluation Laboratory (DEMATEL), that builds an influential network relation map (INRM) for identifying dependencies between criteria and fuzzy DEMATEL-based analytic network process (DANP), that is used to find the global weights of criteria. The proposed framework applied to a project that is carried out in a well-known R&D institution in TURKEY and the derived results have shown that in the absence of sufficient data, performance criteria included in BSC approach can be consolidated with the help of fuzzy DEMATEL and fuzzy DANP techniques and the proposed method is a successful tool for project performance assessment.

Résumé

L'évaluation de la performance de la recherche et de développement (R&D) prévoit un problème très complexe et austère pour les gestionnaires de projets et il y a peu d'études sur ce problème difficile dans la littérature. C'est pourquoi nous avons l'intention de proposer une nouvelle méthode qui utilise la carte de pointage équilibrée (BSC) perspectives, y compris un point de vue supplémentaire, appelé incertitude, comme une base. Il utilise un multi-critères floue décisionnel intégré (MCDM) approche qui efface l'évaluation quantitative lacune de BSC, afin d'évaluer la performance de la R&D des projets à différents stades de leur cycle de vie sur le champ de vision et les stratégies société.

La méthode de MCDM floue intègre une décision floue à faire de première instance et le Laboratoire d'évaluation (DEMATEL), qui construit une relation de réseau carte influent (INRM) pour identifier les dépendances entre les critères et floue processus réseau analytique basé DEMATEL (DANP), qui est utilisé pour trouver le poids mondial des critères. Le cadre proposé a été appliquée à un projet qui est réalisé dans un R bien connu et une institution A en Turquie. Les résultats obtenus ont montré que les critères de performance inclus dans l'approche BSC peuvent être consolidés à l'aide de DEMATEL floue et techniques de DANP flous et la méthode proposée est un outil efficace pour l'évaluation de la performance du projet.

Özet

Araştırma ve geliştirme (Ar-Ge) projelerinin performans değerlendirmesi, üzerine çok az araştırma yapılmış karmaşık ve çetin bir problemdir. Bu nedenle çalışmamızda, dengeli kurumsal karne (DKK) yöntemini temel alan ve entegre edilmiş bulanık çok ölçütlü karar verme yönteminden oluşan bir yapı önerilmiştir. Bu yöntem ile Ar-Ge projelerinin performanslarının, kurum vizyon ve stratejileri ışığında değerlendirilmesi amaçlanmıştır.

Kullanılan bulanık çok ölçütlü karar verme yönteminde; kriterler arasındaki bağımlılıkların tanımlanması amacıyla uygulanılacak "tesirli ağsal ilişki haritası" nı oluşturan bulanık DEMATEL (Decision Making Trial and Evaluation Laboratory) yöntemi ile kriterlerin global ağırlıklarını bulmak amacıyla yararlanılan bulanık DEMATEL tabanlı analitik ağ süreci (DANP) yöntemi entegre edilmiştir. Önerilen yapı Türkiye'nin tanınan Ar-Ge enstitülerinden birinde yürütülmekte olan bir projeye uygulanmıştır. Elde edilen sonuçlar, yeterli verinin olmadığı durumlarda DKK yöntemi içindeki performans kriterlerinin, bulanık DEMATEL ve bulanık DANP teknikleri yardımıyla konsolide edilebildiğini ve önerilen yöntemin proje performans değerlendirmesi için başarılı bir araç olduğunu göstermiştir.

1 Introduction

In literature of the traditional performance measurement approach, the triple constraints methodology of project performance management (time, cost, scope) is usually mentioned (Shenhar & Levy, 1997; Atkinson, 1999; Shenhar et al., 2001; Nelson, 2005) and the most popular way to measure these constraints is using earned value management (EVM) technique. EVM enables managers to see the current state of projects and allows them to make forecasting on performance of projects (Recently: Acebes et al., 2014; Chen, 2014; Lindsay et al., 2014; Hunter et al., 2014). However, this methodology is inadequate in terms of complexity and multi-dimensional structure of R&D projects.

Project performance assessment problem is a challenging management problem faced by project managers and it is a harder issue for R&D type projects on account of their complexity and high uncertainty. Hence, it is essential to manage R&D projects by using analytic approaches and by monitoring them in details. The assessment must involve multiple criteria measuring (suitability to the organization's vision and strategies, probability of making progress in technology, etc.). Once the criteria are determined, we should weight them for indicating the preferred emphasis of the company. Ideas and conclusions often have to exchange for data, and performance measures can be determined only qualitatively. While quantitative measures, like rate of-return (ROR), are sometimes hard to determine, qualitative metrics, like innovation and employee satisfaction, are potentially important. The shortcoming of reliable quantitative measures is particularly visible in R&D companies and qualitative measures often take a larger portion in the assessment. In spite of these difficulties, performance of R&D projects should be evaluated.

This study is inspired from project monitoring and assessment problem that faced by a well-known R&D institution in TURKEY. This institution's operations are implemented on projects that cover the development of some essential hardware and software products. The current project assessment system of the institution involves in triple constraints of project performance management (time, cost, scope), however, all performance criteria that are related to the performance of R&D projects must be taken into consideration for assessment system.

A new method, aimed to evaluate on-going R&D projects' performance in different stages of their life cycle (initiation, planning, execution or closing stages) in order to see how projects are successful in terms of company vision and strategies, is proposed. The proposed method implements a new perspective called uncertainty (Eilat et al., 2008) in order to emphasize the risky and vague nature of R&D projects, in addition to the four perspectives of BSC (Kaplan & Norton, 1996). On the basis of BSC method the performance criteria were determined by literature review and by experts' opinions. Fuzzy extension of DEMATEL (Gabus & Fontela, 1972) technique is used, in order to determine the influential relationship among criteria.

To decrement the restrictions of analytic hierarchy process (AHP) and build a method for defining complicated network relationships, analytic network process (ANP) was developed by Saaty (1996). However, the comparison matrices and survey questionnaire of ANP were very arduous. Thus, DANP technique was proposed by Chen et al. (2011) in order to deal with the difficulty of implementing ANP. Fuzzy extension of DANP (Lu et al., 2013) is integrated in an effort to reflect the real-world situation better for determining the local and global weights of BSC perspectives and criteria. The reason for using fuzzy extensions of these methods is to deal with the vagueness of experts' thought and expressions. Based on the assessment, management has to decide which on-going projects should be continued, or which resources should be associated with every selected or continued project.

The rest of the study is organized as follows: Section 2 provides a literature review; Section 3 explains the applied methodology and the proposed model while Section 4 discusses a case study in an R&D institution. Finally Section 5 gives some concluding remarks.

2 Literature Review

There are many researches on project performance assessment but a few of them are on R&D type project performance assessment. Literature review covers the studies that published between 2005 and 2014. Articles that discuss R&D project performance assessment issue are shown in **bold** and *italic* font in Table 2.1a-Table 2.1b-Table 2.1c-Table 2.1d-Table 2.1e. Moreover, literature review is performed for science indexed journal papers in Web of Science and also “Project Performance - Assessment”, “Project Performance - Evaluation”, “Project Performance - Measurement”, “Project Performance - Ranking”, “Project Performance - Scaling” and “Project Performance - Appraisal” are used as keywords.

Table 2.1a Review of the articles about project performance assessment (after 2005)

Author	Goal	Technique(s)	Practice
Nance (2005)	To show that multistakeholder evaluation is more appropriate to the research setting than evaluations based on a single stakeholder’s perspective, is more reliable than the use of expert judgments alone, and provides more information than recommended sewer performance indicators.	Statistics, Sewer Performance Index	Real Case
Raffo (2005)	To present a ‘forward-looking’ decision support framework that integrates up-to-date metrics data with simulation models of the software development process in order to support the software project management control function.	MCDM, Control Limits	Real Case
Swink et al. (2005)	***To demonstrate a new approach to the operationalization of holistic new product development project performance.***	***Data envelopment analysis (DEA)***	***Real Case***
Dawood & Sikka (2006)	To develop a suitable measurement framework to identify and analyse key performance indicators for 4D applications.	Hit Rate Analysis, Statistics	Real Case

Table 2.1b Review of the articles about project performance assessment (after 2005)

Author	Goal	Technique(s)	Practice
Jordan & Segelod (2006)	***To investigate the relationship between product innovativeness and groups of outcomes flowing from the computer software product development process and the associated knowledge acquisition process.***	***Statistics***	***Real Case***
Zoomers (2006)	To contribute to the discussion about how to make development interventions more effective by analyzing the factors contributing to the success or failure of rural development projects.	Statistics	Real Case
Naveh et al. (2007)	***To develop a model that conceptualizes and brings empirical evidence for the relationship between formality, discretion and R&D project performance***	***Statistics***	***Real Case***
Wickramatillake et al. (2007)	To measure the performance within the supply chain of a large scale project.	CPI, SPI and Statistics	Real Case
Barclay (2008)	To evaluate and measure IS project performance that seek to address this problem while moving away from the reliance on the traditional assessment method (time, cost, specifications).	Project Performance Scorecard (PPS)	Real Case
Leu & Lin (2008)	To refine and improve the performance of traditional earned value method (EVM) by the introduction of statistical control chart techniques.	Statistical Process Control	Real Case
Rankin et al. (2008)	To support the measurement of the performance of the Canadian construction industry.	Radar Charts and Box plots	Real Case
Blindenbach-Driessen et al. (2010)	***To assess the performance of new product and new service development projects.***	***Statistics***	***Real Case***
Lauras et al. (2010)	To facilitate project performance analysis via a multi-criteria approach.	Multi-Criteria Decision Analysis (MCDA)	Real Case
Tohumcu & Karasakal (2010)	***To evaluate the performance of R&D projects.***	***ANP, DEA***	***Real Case***

Table 2.1c Review of the articles about project performance assessment (after 2005)

Author	Goal	Technique(s)	Practice
Anastasopoulos et al. (2011)	To investigate the influence of project and contract attributes (such as the expected project duration, work type, and project size) on public-private partnership (PPP) project performance.	Statistics	Real Case
Cao & Hoffman (2011)	To develop a two-step approach that allows designing a new project performance evaluation system.	DEA	Real Case
Cha & Kim (2011)	To define a quantitative performance measurement system and establish the evaluation criteria by identifying 18 key performance indicators, focusing on residential building projects.	Quantitative Analysis	Real Case
Lacerda et al. (2011)	To present a framework to create a better understanding of the context and aid the portfolio management process.	MCDA	Real Case
Marques et al. (2011)	To propose a new multi-dimensional project performance measurement system that would enable managers to deal with the volume of data.	MACBETH	Illustrative
Naeni & Salehipour (2011)	To present an approach to deal with fuzzy earned value indices.	Fuzzy Earned Value, Alpha Cut Method	Illustrative
Ozorhon et al. (2011)	To propose a multidimensional performance measure for international joint ventures in construction.	Statistics	Real Case
Shen & Hsieh (2011)	To enhance the evaluation quality of project performance based on fuzzy aggregation weight effect.	MCDM	Real Case
Tennant et al. (2011)	To set out to challenge the conventional discourse of team working and test the hypothesis that construction site management team working and project performance is unrelated.	Statistics	Real Case
Caous et al. (2012)	***To propose a measure (index) of expected risks to evaluate and follow up the performance analysis of research projects involving financial and adequate structure parameters for its development.***	***Ulcer index***	***Real Case***

Table 2.1d Review of the articles about project performance assessment (after 2005)

Author	Goal	Technique(s)	Practice
Haponava & Al-Jibouri (2012)	To propose a generic system for measuring process performance.	Quantitative Analysis	Real Case
Hwang et al. (2012)	To propose an application of customized ındustry-specific metrics to assessment of capital projects performances.	Statistics	Real Case
Willis & Rankin (2012)	To demonstrate a linkage between construction industry maturity and performance using a newly developed maturity model, the Construction Industry Macro Maturity Model.	Construction Industry Macro Maturity Model	Real Case
Aliverdi et al. (2013)	To study on the earned value technique's capability in reporting accepted level of deviation by applying statistical quality control charts to monitor earned value indices.	Statistics	Real Case
Fu & Ou (2013)	To propose a new method of project performance evaluation, by which project performance data can be better understood.	Principal Component Analysis (PCA), DEA	Real Case
Hashemi et al. (2013)	To show the traditional methods and to offer an alternative method using a modified version of the balanced evaluation approach (i.e. BSC tool) and EVM to evaluate project performance.	BSC, EVM	-
Hung & Chou (2013)	***To evaluate project performance and explores the relationship between project performance and resource commitment and organizational diversity.***	***DEA, analytical hierarchy process (AHP)***	***Real Case***
Lee & Yu (2013)	To develop composite indicator using utility function and fuzzy theory.	Fuzzy integral, Monte Carlo approach	Real Case
Phadnis & Kulshrestha (2013)	To measure irrigation service performance using a few key selected indicators.	Scorecard	Real Case
Slavek et al. (2013)	To identify a set of software project performance measures and influence factors used by software development projects so that a valid comparison of performance can be made among completed projects.	Quantitative Analysis	Real Case

Table 2.1e Review of the articles about project performance assessment (after 2005)

Author	Goal	Technique(s)	Practice
Zavadskas et al. (2013)	To illustrate how to assess a projects' execution efficiency by mean of the aggregated indicator in particular company.	Analytical Hierarchy Process (AHP)	Real Case
Palacios et al. (2014)	To provide an overview of the implications of global software development (GSD) for software project managers by analyzing project performance from different perspectives such as the 360-degree feedback evaluation.	360-degree feedback	Real Case

Nance (2005) disscussed a performance evaluation system of condominial sewer projects based on multistakeholder perspective that uses median chi-square test and sewer performance index technique for performance evaluation. The results show that performance evaluations by maintenance staff members were consistently more critical than those of other stakeholders, and as a group, maintenance staff members had high internal agreement and project area residents also displayed high internal agreement in their evaluations of performance. Moreover, compared with the other stakeholders studied, engineering staff members had the lowest internal agreement about performance and the lowest response rates. Raffo (2005) represented a model based on MCDM technique and outcome based control limits to provide predictions of project performance and the impact of various management decisions. The result of his study indicated that the approach directly supports the ability to quantitatively monitor and evaluate software projects. Swink et al. (2005) proposed a framework based on DEA technique to demonstrate a new approach to the operationalization of holistic new product development (NPD) project performance. This study’s results showed that performance outcomes are proved more strongly in highly effectual projects when compared to ineffectual projects and the significance of project management experience, balanced management commitment, and cross-functional integration in achieving high levels of NPD project efficiency.

In another study, Dawood & Sikka (2006) intended to develop a suitable measurement framework to identify and analyse key performance indicators for 4D applications. The study showed that a majority of managers believe that the use of 4D planning has helped them in risk management in schedule programme, reducing the amount of rework and reduction in overall project duration. Jordan & Segelod (2006) evaluated projects' performance in order to investigate the relationship between product innovativeness and groups of outcomes flowing from the computer software product development process and the associated knowledge acquisition process. The results showed that highly innovative products show higher project performance for all measures of project performance compared with less innovative products. In 2006, Zoomers (2006) made another research on the performance of rural development project in Asia, Latin America and Africa. Zoomers (2006) intended to make a distinction between the successful projects and failures, and indicated the possibilities and restrictions of evaluating project performance. The results of the study proved that rural development project performance very much relies on whether interferences 'keep track' with local precedences and trends and this is much more important than 'measuring output'.

When we came to 2007, there is another study on R&D project performance management that published by Naveh (2007) who intended to develop a model that conceptualizes and brings empirical evidence for the relationship between formality, discretion and R&D project performance while measuring these projects performance. Wickramatillake et al. (2007) made a research in order to explore the performance measurement methodology used by a real case company, namely Vanderlande Industries Ltd, for cost and progress capture for in-house production, resale material and third party supplied material, in an effort to measure performance of the supply chain of a large scale project. The result indicates that it was a very difficult task to measure the progress of the supply chain, particularly for the resale and subcontracted activities. This was mainly due to payment schemes and cost processing criteria.

In the following year, Barclay (2008) proposed a framework based on balanced scorecard in order to measure the information systems projects performance. The result of the study proved that the PPS is an implementable and workable tool that can be incorporated into a project to monitor and control the stakeholders' objectives. In the same year, Leu & Lin (2008) studied on statistical process control techniques for project performance evaluation and the results indicate that applying SPC control chart principles to EVM opens up many areas of research (one needs to continue to analyze and compare various types of SPC control charts, better understanding of cause and effect relationships on construction performance patterns is needed, for on-going projects, their project performance data and related causes are available; however, these pieces of information relate to the past). Rankin et al. (2008) made a research to facilitate the comparison of the performance of the Canadian construction industry with that of other countries in a manner that is consistent with the definition of industry performance and competitiveness. The results showed that standard set of metrics, and collection and reporting methods for the performance of the Canadian construction industry that are useful as the basis of a broad benchmarking program.

In 2010, Blindenbach-Driessen et al. (2010) proposed another method based on statistical techniques, which aims to evaluate the performance of NPD projects. Their results proved that especially the more abstract items of performance, such as the perceptions of quality, captured knowledge, competitive advantage, gained reputation, and customer satisfaction, suffer from random error. Blindenbach-Driessen et al. (2010) recommended using either the stand-alone models for operational performance and product performance or the mixed model whereby the project leader assesses operational performance and the innovation manager the product performance of an innovation project. Lauras et al. (2010) proposed a new method to facilitate project performance analysis via a multi-criteria approach. The result of his study indicated that there is a significant impact of performance indicator interdependency on the proposition; links between research into project classification and choices for relative KPI weighting could be studied; and the possibility of cross-aggregated analysis oriented in pairs could be studied. Tohumcu & Karasakal (2010) proposed another model based on ANP and DEA for the performance evaluation of R&D projects. The case study's results showed that proposed method is flexible to modify the performance criteria and sub-criteria and can be implemented in any organization by making the necessary changes.

Anastasopoulos et al. (2011) proposed a new framework to investigate the influence of project and contract attributes (such as the expected project duration, work type, and project size) on public-private partnership (PPP) project performance. The results showed that for a 90% level of confidence, the data from the international and United States contracts yield results that are not significantly different from each other, from a statistical viewpoint and agencies tend to be concerned that if they continue to adopt PPP for their project delivery, they may lose valuable in-house expertise. Cao & Hoffman (2011) proposed a new method based on DEA to develop a two-step approach that allows designing a new project performance evaluation system. The results showed that the proposed project evaluation system is a good reference point for companies whose goal is to improve their engineering projects performance and, to reduce cost and schedule overruns. Cha & Kim (2011) implemented a study in order to define a quantitative performance measurement system and establish the evaluation criteria by identifying 18 key performance indicators, focusing on residential building projects. The research finding is "the metric system developed in this study is very premature. To be more useful in the industry, the system should cover a specific target project, i.e., residential projects, commercial projects, industrial projects". Lacerda et al. (2011) presented a framework to create a better understanding of the context and aid the portfolio management process. The results showed that the framework supports the ordinal and cardinal measurement of the project performance, making it possible to compare and rank proposals, as well as providing a process to improve project proposals. In another study, Marques et al. (2011) proposed a new multi-dimensional project performance measurement system that would enable managers to deal with the volume of data. The results showed that the project has to be of major scope and sufficiently well structured to be of interest when using the proposed method. Naeni & Salehipour (2011) proposed a new approach in order to to deal with fuzzy earned value indices for measuring project performance. The results indicated that the developed approach is more practical than the traditional earned value. Ozorhon et al. (2011) proposed a multidimensional performance measure for international joint ventures (IJV) in construction. The results showed that all proposed indicators are valid measures of IJV performance and that they correspond to different dimensions of performance. In the same year, Shen & Hsieh (2011) developed an approach to enhance the evaluation quality of project performance based on fuzzy aggregation weight effect. The results of this study showed that the proposed approach facilitate the managers or the decision-makers to achieve the analysis with the consideration of quality enhancement about decision-making like as performance evaluation or project evaluation. In the same year, Tennant et al. (2011) studied to set out to challenge the conventional discourse of team working and test the hypothesis that construction site management team working and project performance is unrelated and to use a customized suite of key performance indicators sympathetic to project performance is used to measure project success. The results of the study proved that statistical examination of the data demonstrates a marked correlation between the two variables. Although the results authenticate the universally acclaimed wisdom; teams and performance are inextricably linked, secondary analysis expose widespread contradictions between the rhetoric of team working and the action of practice.

In the following year, Caous et al. (2012) proposed a different framework based on ulcer index and the case study's results proved that the proposed model supports importantly to the analysis of risk and planning as well as to the definition of necessary investments that consider contingency actions with benefits to the different stakeholders. In another study, Haponava & Al-Jibouri (2012) proposed a generic system for measuring process performance based on quantitative analysis by using acronym DIRECT (Documentation of the process, integration of the process, review of the process, experience of the stakeholders involved, Communication and Traceability). The results showed that the proposed system produces relatively accurate indications of actual performance of construction projects. Hwang et al. (2012) proposed an application to develop industry-specific performance metrics tuned to pharmaceutical processes and to analyze project performance based upon the developed metrics. The results indicated that statistical analyses provide sufficient evidence to support that project performance may differ by project type and that meaningful differences can be quantified. In the same year, Willis & Rankin (2012) offered a new framework to demonstrate a linkage between construction industry maturity and performance. The findings are the New Brunswick construction industry was better performing than the Guyana construction industry, with respect to the metrics: "cost predictability-construction", "cost predictability-tender award" and "cost predictability-scope change" and the basis of the demonstrated linkage between construction industry maturity and performance is that higher maturity results in more effective and consistent implementation of the industry's regulations and management practices, which translates to a greater level of achievement of project performance objectives.

More recently, Aliverdi et al. (2013) studied on the earned value technique's capability in reporting accepted level of deviation by applying statistical quality control charts to monitor earned value indices. The results showed that the proposed approach improves substantially the project controlling scheme and enhances the capability of earned value technique. In the same year, Fu & Ou (2013) proposed a new approach of project performance evaluation method based on PCA and DEA techniques. The results indicated that by combining PCA and DEA in evaluating the performance of energy projects, there was an improved evaluation of projects over simply using DEA data alone. Hashemi et al. (2013) proposed a new approach, is an integration of BSC and EVM, called the project balance evaluation approach (PBEA). The results showed that without a prospective strategic outlook on project organization, the chance of success of a given project is diminished. Hung & Chou (2013) proposed a framework that based on DEA and AHP to evaluate project performance and explores the relationship between project performance and resource commitment and organizational diversity. In another study, Lee & Yu (2013) proposed a new method based on fuzzy integral in order to develop composite indicators by a utility function for normalizing, a fuzzy measure for weighting, and a fuzzy integral for aggregating. The findings are the measurement reliability of the proposed normalization method (1.96) is greater than that of the two different normalization methods (10.44 and 2.8, respectively) and the measurement accuracy of the proposed aggregation method is greater than those of the four different aggregation methods (the simple additive weighting (SAW) method, the weighted product (WP) method, the weighted displaced ideal (WDI) method, and the technique for order preference by similarity to ideal solution (TOPSIS) method). Phadnis & Kulshrestha (2013) proposed a new approach based on scorecard in order to measure irrigation service performance using a few key selected indicators. The finding is the presented study highlights the necessity of a rigorous and indepth study of performance that may aid planners, policy makers and system managers to ensure that the system demonstrates sustainable operational practices. Slavek et al. (2013) made a study in order to identify a set of software project performance measures and influence factors used by software development projects so that a valid comparison of performance can be made between completed projects. The results showed that the terms and definition presented can be used by four type of organizations (beginning a measurement program intended for increasing professional standards of the firm, standardizing the way measures are defined already across the enterprise, conducting benchmarking between projects within and outside of organization, and comparing their performance with projects that have submitted their data to proprietary and public project performance repositories). In another research, Zavadskas et al. (2013) made a study in order to illustrate how to assess a projects' execution efficiency by mean of the aggregated indicator in particular company. Results showed that by using the aggregated indicators it is easy to compare the projects, the received impartial information is useful for strategic planning, quality management, for solving the tasks of resource allocation, motivational project evaluation.

In the following year, Palacios et al. (2014) provided an overview of the implications of global software development (GSD) for software project managers by analyzing project performance from different perspectives such as the 360-degree feedback evaluation. The finding of the study is performance of GSD projects is lower than in-house projects, but apart from that, the study revealed that there are also negative consequences for software project managers, which need to be taken into account.

As shown in Table 2.1a, Table 2.1b, Table 2.1c, Table 2.1d and Table 2.1e, there are considerable amount of articles on project performance between 2005 and 2014, but a few of them are about R&D project performance assessment (in **bold** and *italic* font in Table Table 2.1a-Table 2.1b-Table 2.1c-Table 2.1d-Table 2.1e) and none of them uses fuzzy DEMATEL and fuzzy DANP. In this study we propose a method so as to efface this limitation.

3 Methodology

3.1 Balanced scorecard

BSC is a strategy based performance management tool that can be used by managers to monitor the execution of duties by the staff within their responsibility and to monitor the results arising from these actions. To evaluate the enchantment of project proposals, or the performance of on-going or completed projects, appropriate criteria should be determined. At least, it should involve criteria that are most significant for managers. To determine the criteria set for R&D project assessment, a model based on the BSC approach is used.

The proposed BSC method looks at five perspectives—the four original perspectives of BSC (financial, customer, internal-business processes, learning and growth) and uncertainty perspective. Uncertainty, which we inspired from Ravi et al. (2005), exists in the nature of R&D projects.

3.1.1 Financial perspective

The financial perspective examines the bottom-line contribution of the project in monetary terms. It reflects the profitability, cash flow, cost, budget, etc. The financial objectives serve as the focus for the objectives and measures in all the other scorecard perspectives. Every measure in the scorecard should be part of a cause-and-effect relationship to improve financial performance (Ravi et al., 2005).

3.1.2 Customer perspective

The customer perspective of our BSC for R&D projects takes into account stakeholder satisfaction with the project process and the final outcomes. The customer is interested in the responsiveness, timeliness, service and quality that the project provides. This perspective can include measures taken from customer surveys, focus groups, complaints, delivery statistics, etc. The question to ask is “how successful are the projects from customers’ point of view?” Time to market, quality, and performance, as well as the way the customer is treated and the way his expectations are satisfied, are all relevant to evaluate the projects (Ravi et al., 2005).

3.1.3 The internal-business processes perspective

This perspective measures the contribution of the project to the core competencies of the organization. It addresses the degree to which the proposed project supports the organization’s mission and strategic objectives. It is assumed that the top management has determined the strategic direction of the organization beforehand. The strategic fit can be expressed as a judgment ranging from strong to peripheral or it can use more detailed measures. The question asked is “what should the organization excel at?” If the organization wants to expand its range of core capacities into a new field, it must establish specific measures to reflect this (Ravi et al., 2005).

3.1.4 The learning and growth perspective

In today’s global competitive environment, organizations are constantly looking for further performance improvements to keep pace with competition. The objective in the learning and growth perspective is to provide the infrastructure to enable the objectives of the above three perspectives. When the evaluation is solely based on the short-term financial perspective, it is often difficult to sustain investments to enhance the capability of the human resources, systems, and organizational processes. Hence, this perspective looks at the long-range growth impact of the project (Ravi et al., 2005).

3.1.5 The uncertainty perspective

The uncertainty perspective is included to the study as a nature of R&D projects. The term of uncertainty is essential for R&D type projects and in order to have more accurate results it should not be omitted. This perspective includes measures such as the probability of technical success and the probability of commercial success, which are critical measures in evaluating R&D projects. These measures are estimated either directly in the scale of 0–1, or indirectly through operational and market-related measures. The probability for technical success includes measures such as technical "gap," program complexity, technology skill base, and availability of people and facilities. The probability for commercial success includes measures such as market need, market maturity, competitive intensity, commercial applications development skills, commercial assumptions and regulatory impact (Ravi et al., 2005).

3.2 Fuzzy DEMATEL for constructing network relations map (NRM)

Fuzzy set theory (Zadeh, 1965) is widely used by researchers (Büyüközkan & Çifçi, 2012; Daş & Göçken, 2014; Liao & Kao, 2014; etc.) to handle with the vagueness of decision makers opinions. During the assessment phase, the linguistic variables, in the form of sentences or phrases in a natural language, can be more affective to implement. These linguistic terms can be actively transformed into quantitative expressions and decision makers can efficiently use them in order to express their opinion. In practice, triangular fuzzy numbers are widely used to transform the linguistic terms into numbers.

The DEMATEL technique is a practical and useful tool, especially for visualizing the structure of complex causal relationships with matrices or diagrams. The matrices or diagrams show a contextual relation among the elements of the system, in which a numeral represents the strength of influence of each element. Thus, the DEMATEL technique is able to convert the relationship between the causes and effects of criteria into an intelligible structural model of systems (Wei et al., 2010).

In this study, we combined these two popular techniques as fuzzy DEMATEL. In literature, fuzzy DEMATEL is a widely used technique on various topics; green supply chain (Büyüközkan & Çifçi, 2012; Lin, 2013; Lu et al., 2014), Clinical Decision Support System (Jeng & Tzeng, 2012), collaborative product design (Wang & Chen, 2012), human resources (Chou et al., 2012), truck selection (Baykasoğlu et al., 2013), etc. The steps of fuzzy DEMATEL are as follows:

Step 1: Build fuzzy direct influence matrix. Experts are asked to make pairwise comparisons in order to obtain the influences and direction of criteria on each other. These comparisons are shown as matrix $\check{A}$, in which $\tilde{a}_{ij} = (l_{ij}, m_{ij}, u_{ij})$, is donated as the degree of to that factor *i* will have on factor *j*. For comparisons a linguistic scale is used that is shown in Table 3.1(Li, 1999).

Table 3.1 Linguistic scale of project performance assessment

Linguistic Scale	Triangular Fuzzy Numbers
No effect (No)	(0, 0, 0.25)
Low effect (VL)	(0, 0.25, 0.5)
Medium effect (L)	(0.25, 0.5, 0.75)
High effect (H)	(0.5, 0.75, 1)
Very High (VH)	(0.75, 1, 1)

Step 2: Obtain the normalized fuzzy direct influence matrix. On the base of the fuzzy direct influence matrix, we obtain normalized fuzzy direct influence matrix by Eq. (3.1) and Eq. (3.2).

$$s = 1/\max_{1 \le i \le n} \sum_{j=1}^{n} u_{ij} \tag{3.1}$$

$$\tilde{D} = s\tilde{A} \tag{3.2}$$

Step 3: Acquire fuzzy total-influence matrix. After the normalized fuzzy direct influence matrix $\tilde{D}$ is obtained, the fuzzy total influence matrix can be obtained using Eq. (3.3).

$$\tilde{T} = \tilde{D}(I - \tilde{D})^{-1} \tag{3.3}$$

Firstly, we obtain three crisp matrices extracted from $\tilde{D} = (D_l, D_m, D_u)$ and acquire fuzzy total influence matrix by calculating each crisp matrix using Eq. (3.3) as follows; $T_l = D_l(I - D_l)^{-1}$, $T_m = D_m(I - D_m)^{-1}$ and $T_u = D_u(I - D_u)^{-1}$. In Eq. (3.3), ***I*** denotes the identity matrix.

3.2.1 Defuzzification

We must transform the fuzzy numbers of $\tilde{T}$ into crisp numbers before obtaining INRM. Hence we use the algorithm for the defuzzification of triangular fuzzy numbers introduced by Opricovic & Tzeng (2003). We can describe this algorithm as follows:

Let our fuzzy numbers be $\tilde{X} = (a_i, b_i, c_i, d_i)$, here $b = c$ and i = 1,...,n. Firstly, we define $a_{\min} = \min_i(a_i)$, $d_{\max} = \max_i(d_i)$ and $\Delta = d_{\max} - a_{\min}$. After that, we perform the following equation $\tilde{X} = \Delta^{-1}(a_i - a_{\min}, b_i - a_{\min}, c_i - a_{\min}, d_i - a_{\min})$. Then, we compute the normalized values for the left x_i^l by and the right x_i^r as shown in Eq. (3.4) and Eq. (3.5).

$$x_i^l = \frac{b_i}{1 + b_i - a_i} \tag{3.4}$$

$$x_i^r = \frac{d_i}{1 + d_i - c_i} \tag{3.5}$$

From x_i^l and x_i^r, the normalized crisp values x_i can be obtained by Eq. (3.6).

$$x_i = \frac{x_i^l \mu(x_i^l) + x_i^r \mu(x_i^r)}{\mu(x_i^l) + \mu(x_i^r)} \tag{3.6}$$

In Eq. (3.6) $\mu(x_i^l) = 1 - x_i^l$ and $\mu(x_i^r) = x_i^r$. If we apply them to Eq. (3.6), it turns into Eq. (3.7).

$$x_i = \frac{x_i^l(1 - x_i^l) + (x_i^r)^2}{(1 - x_i^l) + (x_i^r)} \tag{3.7}$$

Finally, the crisp number is obtained as shown in Eq. (3.8).

$$x_i^{cr} = \Delta x_i + a_{\min} \tag{3.8}$$

Step 4: Obtaining INRM after the defuzzification and analyzing results.

The sum of rows $\sum_{j=1}^{n} t_{ij} = t_i$ and the sum of columns $\sum_{i=1}^{n} t_{ij} = t_j$ are calculated and are shown as vector $r = (r_1, \ldots, r_n)'$ and vector $c = (c_1, \ldots, c_n)'$, the use of superscript denotes transpose. The horizontal axis of INRM is obtained by adding r to c, that express the importance of the criterion. Identically, the vertical axis of INRM is obtained by extracting c from r, that separates criteria into two category (a cause group and an effect group). Typically, if $r - c$ is positive, the criterion is a member of cause group and if it is negative, the criterion is a member of effect group. Hence, we can acquire INRM graph by mapping the dataset of crisp vectors ($r+c, r-c$). To obtain an appropriate map, we set the *median* of each group as a threshold value (Wu et al., 2011b). This threshold value is used for filtering minor effects presented in each group. Threshold value is important because if it is too low, INRM will be too complex and if it is too high, many criteria will be shown as independent criteria.

3.3 Fuzzy DANP for finding the influential weights in each criterion

DANP technique is a combination of ANP and DEMATEL techniques, and this technique is more effective to implement than ANP. In this study, we will apply the fuzzy extension of DANP technique, which is a new approach and doesn't have many applications in literature. Su et al. (2012) used fuzzy DANP for cloud computing and Lu et al. (2013) used for green innovation. In our proposed approach for R&D project performance assessment, we will use Lu et al. (2013) study's steps as reference. The steps of the technique are as follows;

Step 1: Normalizing each dimension/cluster with the total degree of influence acquired from $\tilde{T}$ using fuzzy DEMATEL technique, represented in Eq. (3.9) and Eq. (3.10).

$$\tilde{T}_c = \begin{array}{c} \\ D_1 \\ \\ D_i \\ \\ D_n \end{array} \begin{array}{c} c_{11} \\ c_{12} \\ \vdots \\ c_{i1} \\ c_{i2} \\ c_{n1} \\ \vdots \\ c_{nm_n} \end{array} \overset{\begin{array}{cccc} D_1 & D_j & & D_n \\ c_{11}...c_{1m_1} & c_{j1}...c_{jmj} & \cdots & c_{n1}...c_{nm_n} \end{array}}{\begin{bmatrix} \tilde{T}_c^{11} & \cdots & \tilde{T}_c^{1j} & \cdots & \tilde{T}_c^{1n} \\ \vdots & & \vdots & & \vdots \\ \tilde{T}_c^{i1} & \cdots & \tilde{T}_c^{ij} & \cdots & \tilde{T}_c^{in} \\ \vdots & & \vdots & & \vdots \\ \tilde{T}_c^{m1} & \cdots & \tilde{T}_c^{nj} & \cdots & \tilde{T}_c^{nn} \end{bmatrix}} = (T_c^l, T_c^m, T_c^u) \tag{3.9}$$

$$\tilde{T}_c^{\alpha} = \begin{array}{c} \\ D_1 \\ \\ D_i \\ \\ D_n \end{array} \begin{array}{c} c_{11} \\ c_{12} \\ \vdots \\ c_{i1} \\ c_{i2} \\ c_{n1} \\ \vdots \\ c_{nm_n} \end{array} \overset{\begin{array}{cccc} D_1 & D_j & & D_n \\ c_{11}...c_{1m_1} & c_{j1}...c_{jmj} & \cdots & c_{n1}...c_{nm_n} \end{array}}{\begin{bmatrix} \tilde{T}_c^{\alpha 11} & \cdots & \tilde{T}_c^{\alpha 1j} & \cdots & \tilde{T}_c^{\alpha 1n} \\ \vdots & & \vdots & & \vdots \\ \tilde{T}_c^{\alpha i1} & \cdots & \tilde{T}_c^{\alpha ij} & \cdots & \tilde{T}_c^{\alpha in} \\ \vdots & & \vdots & & \vdots \\ \tilde{T}_c^{\alpha m1} & \cdots & \tilde{T}_c^{\alpha nj} & \cdots & \tilde{T}_c^{\alpha nn} \end{bmatrix}} = (T_c^{\alpha l}, T_c^{\alpha m}, T_c^{\alpha u}) \tag{3.10}$$

Step 2: The total influence matrix is converted into a supermatrix and this supermatrix allows us to acquire the unweighted supermatrix as shown in Eq. (3.11).

$$\tilde{W} = (\tilde{T}_c)' = \begin{array}{c} \\ D_1 \\ \\ D_i \\ \\ D_n \end{array} \begin{array}{c} c_{11} \\ c_{12} \\ \vdots \\ c_{i1} \\ c_{i2} \\ c_{n1} \\ \vdots \\ c_{nm_n} \end{array} \overset{\begin{array}{cccc} D_1 & D_j & & D_n \\ c_{11}...c_{1m_1} & c_{j1}...c_{jmj} & \cdots & c_{n1}...c_{nm_n} \end{array}}{\begin{bmatrix} \tilde{W}^{11} & \cdots & \tilde{W}^{i1} & \cdots & \tilde{W}^{n1} \\ \vdots & & \vdots & & \vdots \\ \tilde{W}^{1j} & \cdots & \tilde{W}^{ij} & \cdots & \tilde{W}^{nj} \\ \vdots & & \vdots & & \vdots \\ \tilde{W}^{1n} & \cdots & \tilde{W}^{in} & \cdots & \tilde{W}^{nn} \end{bmatrix}} = (W^l, W^m, W^u) \tag{3.11}$$

Step 3: In this step, we will have the weighted supermatrix by multiplying it with the total influence relationship matrix of the dimensions $\tilde{T}_D$ as shown in Eq. (3.14). But, before this operation we should normalize $\tilde{T}_D$ (Eq. (3.12)) with the total degree of influence as shown in Eq. (3.13). The total degree of influence can be calculated by $t_D^i = \sum_{j=1}^{m} t_D^{ij}$, where i = 1,…,m.

$$\tilde{T}_D = \begin{bmatrix} \tilde{t}_D^{11} & \cdots & \tilde{t}_D^{1j} & \cdots & \tilde{t}_D^{1n} \\ \vdots & & \vdots & & \vdots \\ \tilde{t}_D^{i1} & \cdots & \tilde{t}_D^{ij} & \cdots & \tilde{t}_D^{in} \\ \vdots & & \vdots & & \vdots \\ \tilde{t}_D^{n1} & \cdots & \tilde{t}_D^{nj} & \cdots & \tilde{t}_D^{nn} \end{bmatrix} = (T_D^l, T_D^m, T_D^u) \tag{3.12}$$

$$\begin{aligned} \tilde{T}_D^{\alpha 1} &= \begin{bmatrix} \tilde{t}_D^{11l} / d_1^l & \cdots & \tilde{t}_D^{1jl} / d_1^l & \cdots & \tilde{t}_D^{1nl} / d_1^l \\ \vdots & & \vdots & & \vdots \\ \tilde{t}_D^{i1l} / d_i^l & \cdots & \tilde{t}_D^{ijl} / d_i^l & \cdots & \tilde{t}_D^{inl} / d_i^l \\ \vdots & & \vdots & & \vdots \\ \tilde{t}_D^{n1l} / d_n^l & \cdots & \tilde{t}_D^{njl} / d_n^l & \cdots & \tilde{t}_D^{nnl} / d_n^l \end{bmatrix} \\ &= \begin{bmatrix} \tilde{t}_D^{\alpha 11l} & \cdots & \tilde{t}_D^{\alpha 1jl} & \cdots & \tilde{t}_D^{\alpha 1nl} \\ \vdots & & \vdots & & \vdots \\ \tilde{t}_D^{\alpha i1l} & \cdots & \tilde{t}_D^{\alpha ijl} & \cdots & \tilde{t}_D^{\alpha inl} \\ \vdots & & \vdots & & \vdots \\ \tilde{t}_D^{\alpha n1l} & \cdots & \tilde{t}_D^{\alpha njl} & \cdots & \tilde{t}_D^{\alpha nnl} \end{bmatrix} \end{aligned} \tag{3.13}$$

We can also reach matrix $T_D^{\alpha m}$ and $T_D^{\alpha u}$. After normalizing $\tilde{T}_D = (T_D^l, T_D^m, T_D^u)$, we can multiply it with $\tilde{W}$ (unweighted supermatrix) as in $W^{\alpha l} = T_D^{\alpha l} W^l$, $W^{\alpha m} = T_D^{\alpha m} W^m$ and $W^{\alpha u} = T_D^{\alpha u} W^u$.

$$W^{\alpha l} = \begin{bmatrix} \tilde{t}_D^{\alpha 11l} x W^{11l} & \cdots & \tilde{t}_D^{\alpha i1l} x W^{i1l} & \cdots & \tilde{t}_D^{\alpha n1l} x W^{n1l} \\ \vdots & & \vdots & & \vdots \\ \tilde{t}_D^{\alpha 1jl} x W^{1jl} & \cdots & \tilde{t}_D^{\alpha ijl} x W^{ijl} & \cdots & \tilde{t}_D^{\alpha njl} x W^{njl} \\ \vdots & & \vdots & & \vdots \\ \tilde{t}_D^{\alpha 1nl} x W^{1nl} & \cdots & \tilde{t}_D^{\alpha inl} x W^{inl} & \cdots & \tilde{t}_D^{\alpha nnl} x W^{nnl} \end{bmatrix} \tag{3.14}$$

Step 4: Reach the fuzzy DANP. Limit the weighted supermatrix by multiplying it to an adequately large power until it gains stability. This operation should be done for $W^{\alpha l}, W^{\alpha m}$ and $W^{\alpha u}$ by using $\lim_{\varphi \to \infty}(W^{\alpha .})$.

3.4 DELPHI method

The Delphi method was suggested at the beginning of the Cold War to presume the effect of technology on war.

Various approaches were, tried; still the defects of classical forecasting methods, like theoretical approach, quantitative models or trend extrapolation, in fields where absolute scientific laws have not been generated yet, quickly became noticeable. To overcome these defects, the Delphi method was generated by Project RAND during the 1950-1960s by Dalkey & Helmer (1963). It has been used ever since, together with different mutations and reformulations.

Delphi is a systematic forecasting method that contains composed interaction among a group of experts on an issue. This technique generally contains at least two rounds of experts answering queries and making explanation for their answer. After each round, a facilitator provides an anonymous summary of the experts' forecasts from the previous round as well as the reasons they provided for their judgments. Thus, experts are encouraged to revise their earlier answers in light of the replies of other members of their panel. Finally, the process is stopped after a pre-defined stop criterion (e.g. number of rounds, achievement of consensus, stability of results) and the mean or median scores of the final rounds determine the results.

Delphi method keeps its popularity and researchers use this method in their studies. Such as, Steen et al. (2014) used a five round Delphi study in order to define optimal palliative care in dementia and as a result, the first definition of palliative care in dementia based on evidence and consensus have been provided. Brenner et al. (2014) used Delphi method in order to reach consensus on the priorities for children's nursing. They applied a three round Delphi survey to participants and as a result they found that the top three priorities are recognition and care of the deteriorating child, safe transfer of the critically ill child between acute health care facilities, and the child and family's perceptions of care at the evening of life.

In this study Delphi method is used to generate pairwise comparison matrices in order to determine the local weights of strategies, BSC perspectives and performance indicators are also used for creating direct relation matrices of DEMATEL method in order to find network relationship.

3.5 Proposed method

The proposed method is formed of 8 main steps (shown in Fig. 3.1) and the details of which are as follows:

Step 1: Establishment of a performance assessment team composed of experts and determination of business vision.

Step 2: Determination of the strategies to be pursued so as to achieve the business vision by using DELPHI method.

Step 3: Determination of BSC perspectives and the performance criteria by using DELPHI method.

Step 4: Structure the BSC model hierarchically (vision, strategies, BSC perspectives, and performance criteria).

Step 5: Determine the INRM of perspectives (dimensions) and criteria by using fuzzy DEMATEL, explained in Section 3.2.

Step 6: Calculate the global weights for the performance criteria. Global performance criteria weights are computed by using fuzzy DANP explained in Section 3.3 and transform these weights by using defuzzification method into crisp numbers.

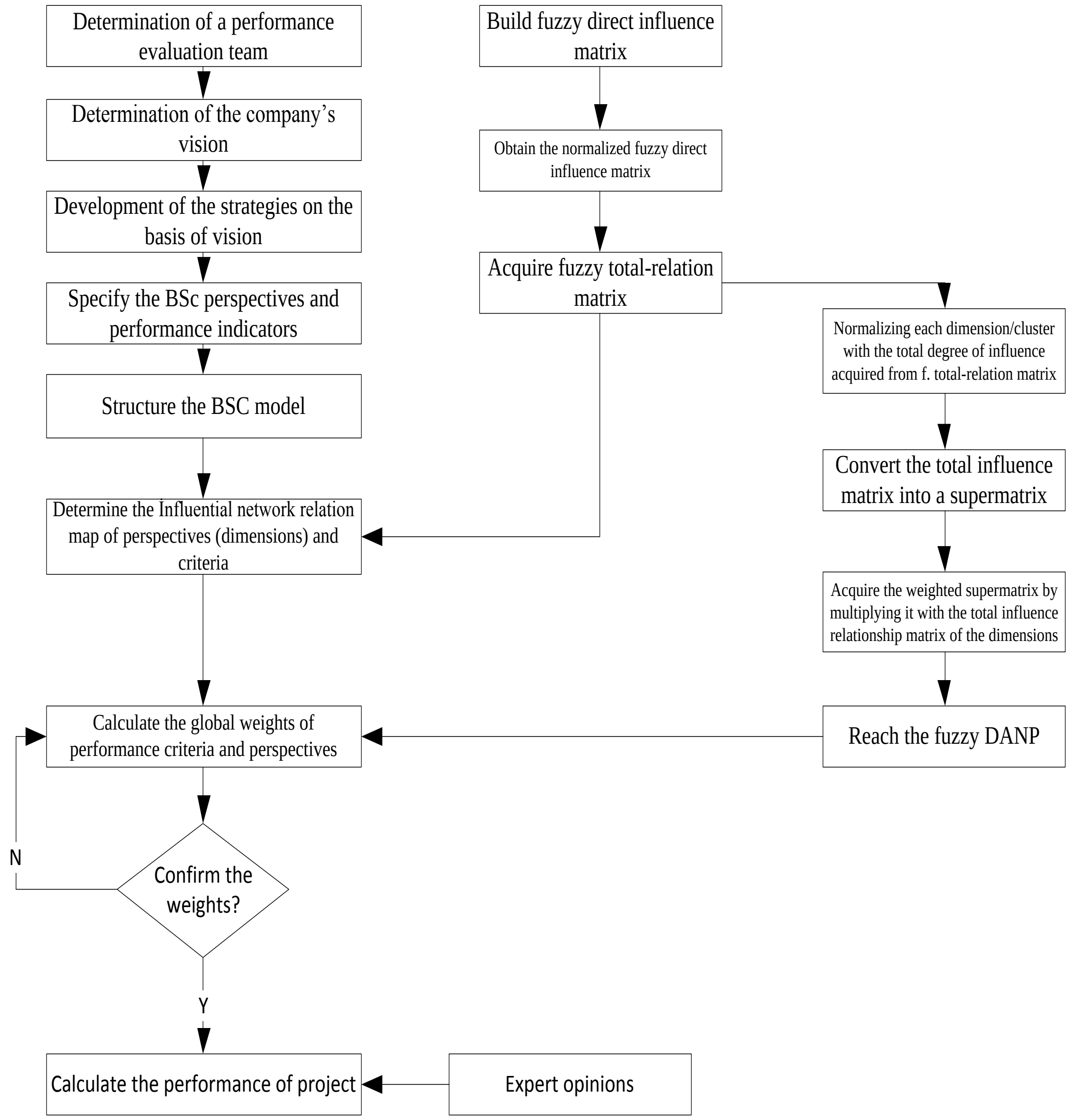

Figure 3.1 Flow diagram of the proposed method

Step 7: Measure the performance criteria by using experts' opinions about the project. The scale, used for measuring each criterion (Table 3.2).

Step 8: Calculation of the performance of the project.

Table 3.2 Linguistic scale of project performance assessment

Linguistic Scale	Triangular Fuzzy Numbers
Very High (VH)	(1, 1, 1)
High (H)	(0.50, 0.75 ,1)
Medium (M)	(0.25, 0.5, 0.75)
Low (L)	(0, 0.25, 0.50)
Very Low (VL)	(0, 0, 0)

4 Case Study: Implementation of the model for an R&D project in Institution A

4.1 Case study company: Institution A

For the implementation of the proposed method, we choose a well-known R&D institution (we call it "Institution A") in Turkey and as a subject, a chosen project that we call "Project X", is used. Institution A is the leading agency for management, funding and conduct of research in Turkey. It was established in 1963 with a mission to advance science and technology, conduct research and support Turkish researchers. Institution A supports innovation, academic and industrial R&D studies and also in line with national priorities develops scientific and technological policies and manages R&D institutes, sustaining research, technology and development studies. Moreover, Institution A supports research projects implemented in universities and other public and private organizations, conducts research on strategic areas, develops support programs for public and private sectors, publishes scientific journals and books, coordinates science and community activities and supports students through their educations. Institution A conducts over a hundred projects on various scopes (physics, materials science, genetic, sensor systems, etc.) with more than 1,500 researchers.

The current project assessment system of Institution A involves in triple constraints of project performance management (time, cost, scope), however assessment system for R&D projects must take into consideration of all performance criteria that are related to the R&D projects' performance. Hence, it is obvious that there is no systematic performance assessment system in Institution A and it is a very big problem needs to be solved. Because, if we think about the strategic importance of Insttution A, establishing a well-designed performance assessment system is an inevitable and vital issue for carrying out the projects under control.

4.2 Implementation of the proposed method

The following parts of the study are about the implementation of the proposed method's steps and the obtained relevant results.

Step 1: The performance assessment team is established by 5 people whom are shown in Table 4.1.

Table 4.1 Performance assessment team

Title	Job	Experience
Electrical and Electronics Engineer	Project Manager	8 years
Industrial Engineer	Quality Manager	5 years
Electrical and Electronics Engineer	Project Monitoring and Evaluation Office Member	6 years
Electronics Engineer	Algorithm Developer	3 years
Industrial Engineer	Project Monitoring and Evaluation Office Member	3 years

The vision of the institution is taken from its web site as "to become a focal point in technology, to use knowledge and technology as an effective tool, and in global competition, to ensure the deserved success of our country".

Step 2: The strategies are determined with the assessment team, in the light of strategic planning document of Institution A, as follows;

- To make technical improvement in critical technologies that are not specialized by our country, in order to reduce the dependence of our country to other countries.
- To perform technology transfer attempts in areas that are needed to specialize by our country and to transfer the specialized technologies to industry.
- To support the continuous technical education of individuals in order to have trained man-power.

Step 3: The BSC perspectives and performance criteria are as follows (see Table 4.2a and Table 4.2b).

8 of the indicators shown in Table 4.2a and Table 4.2b were collected from literature survey and assessment team determined 12 of them as institution specified indicators in light of their experience.

Financial Perspective:

- *Getting process payment in time (GPPT):* Institution A has some customers that want some specific products via project contracts and pay contract remunerations periodically. Hence, it is a critical performance indicator for a project to get these remunerations in time.
- *Project costs (PC):* Total amount of money that was spent by the project.
- *The commercial performance wrt completion ratio (CPCR):* The ratio of money that earned and spent by project.
- *The success of purchasing process (SPP):* In order to produce the deserved product, projects must purchase some supplies. As this process is very important to complete project in term of contract, projects' purchasing performance (to be in allocated budget) is a significant indicator on overall project performance. They must manage this process delicately.

Table 4.2a BSC perspectives and performance indicators

No	Criteria	References	Institution Specified
		Finance (F)	
1	Getting process payment in time (GPPT)		X
2	Project costs (PC)	(Naveh, 2007)	
3	The commercial performance wrt completion ratio (CPCR)		X
4	The success of purchasing process (SPP)		X

Table 4.2b BSC perspectives and performance indicators

No	Criteria	References	Institution Specified
		Customer (C)	
5	Customer Satisfaction (CS)	(Ravi et al., 2005; Eilat et al., 2008; Yüksel & Dağdeviren, 2010; Tseng, 2010; Wu, 2011a; Bentes et al., 2012)	
6	Service and Quality (SQ)	(Tseng, 2010; Chen et al., 2011)	
7	Responsiveness (RS)		X
8	Punctuality (P) - Timeliness (TL)		X
		Internal Business Processes (IBP)	
9	Image Processing (IP)		X
10	Sensor systems (SS)		X
11	Radar Systems (RAS)		X
12	RF Systems (RFS)		X
		Learning & Growth	
13	Employee /Job Satisfaction (JS):	(Eilat et al., 2008; Yüksel & Dağdeviren, 2010; Wu, 2011a; Zavadskas et al., 2013)	
14	Training and Skills (TS)	(Yüksel & Dağdeviren, 2010; Bentes et al., 2012)	
15	Innovation (IN)	(Lee et al., 2008; Tseng, 2010; Yüksel & Dağdeviren, 2010; Zavadskas et al., 2013)	
16	Technology Transfer (TT)		X
		Uncertainty (U)	
17	Probability of Technical Success (PTS)	(Eilat et al., 2008)	
18	Probability of Making Progress In Technology (PMPT)		X
19	Probability of Completing Project in Time (PCPT)		X
20	Probability of Commercial Success (PCS)	(Eilat et al., 2008)	

Customer Perspective:

- *Customer Satisfaction (CS):* The feedback of the customer about project (Surveys,etc.).
- *Service and Quality (SQ):* The robustness of the product and the quality of after-sale services.
- *Responsiveness (RS):* In order to produce the deserved product, projects must purchase some supplies. As this process is very important to complete project in term of contract, projects' purchasing performance is a significant indicator on overall project performance. They must manage this process delicately.

- *Timeliness (TL):* As well as RS, punctuality is a significant performance indicator too. If the project can't solve customer's problem and provide their needs in deserved time, Trust issues will arise and it will harm the willing of customer on working with Institution A.

Internal Bussiness Proccesses Perspective:

Institution A has determined some areas of expertise like image processing, sensor systems, radar systems and rf systems as strategic areas of technology. Hence, it is a significant performance indicator to gain experience and to improve institution's ability on these areas while satisfying customers' needs.

- *Image Processing (IP):* The capability on image processing domain.
- *Sensor systems (SS):* The capability on sensor systems domain.
- *Radar Systems (RAS):* The capability on radar systems domain.
- *RF Systems (RFS):* The capability on RF systems domain.

Learning & Growth Perspective:

- *Employee /Job Satisfaction (JS):* The motivation and eagerness of employee on work .
- *Training and Skills (TS):* The amount of training receiving by project stuff and improvement on their skills.

- *Innovation (IN):* The degree of making progresses on technology.
- *Technology Transfer (TT):* The probability of transferring the acquired knowledge, on technology, to industry or the probability of transferring the needed knowledge, on technology, from other countries.

Uncertainty Perspective:

- *Probability of Technical Success (PTS):* The chance of being technically successful on project.

- *Probability of Making Progress in Technology (PMPT):* The main reason of implementing R&D activities to make progress in technology and if a project can make progress in technology instead of reproducing it, it will be a greater success for project. Hence it must be taken into consideration while evaluating a project's performance.

- *Probability of Completing Project in Time (PCPT)*: While evaluating a project's performance, probability of completing project in time must be calculated and must be taken into consideration. Because, it is directly related with customer's satisfaction and we can't claim a project as good while it is behind the schedule. Hence PCPT is a significant indicator for project performance assessment.
- *Probability of Commercial Success (PCS)*: The chance of making profit on project.

Step 4: The hierarchical structure of the BSC model is given in Table 4.1.

Step 5: In order to obtain INRM we applied the steps of DEMATEL to perspectives and criteria. The obtained results of each step can be seen in Table 4.3 – Table 4.12.

DEMATEL steps for BSC perspectives;

Step 1: The fuzzy direct influence matrix of perspectives is built by experts' opinion. Assessment team is asked to make comparisons to obtain the influences and direction of perspectives on each other (See Table 4.3).

Table 4.3 Fuzzy direct influence matrix (Step 1)

	F			C			IBP			LG			U		
F	0	0	0	0.25	0.50	0.75	0.50	0.75	1.00	0.50	0.75	1.00	0.25	0.50	0.75
C	0.75	1.00	1.00	0	0	0	0.50	0.75	1.00	0.50	0.75	1.00	0.50	0.75	1.00
IBP	0.25	0.50	0.75	0.25	0.50	0.75	0	0	0	0.50	0.75	1.00	0.75	1.00	1.00
LG	0.25	0.50	0.75	0.25	0.50	0.75	0.50	0.75	1.00	0	0	0	0.50	0.75	1.00
U	0.50	0.75	1.00	0.50	0.75	1.00	0.25	0.50	0.75	0.25	0.50	0.75	0	0	0

Step 2: The normalized fuzzy direct influence matrix is obtained by using fuzzy direct influence matrix (See Table 4.4). Eq. 3.1 and Eq. 3.2 are used for this purpose.

Table 4.4 Normalized fuzzy direct influence matrix (Step 2)

	F			C			IBP			LG			U		
F	0.00	0.00	0.00	0.06	0.13	0.19	0.13	0.19	0.25	0.13	0.19	0.25	0.06	0.13	0.19
C	0.19	0.25	0.25	0.00	0.00	0.00	0.13	0.19	0.25	0.13	0.19	0.25	0.13	0.19	0.25
IBP	0.06	0.13	0.19	0.06	0.13	0.19	0.00	0.00	0.00	0.13	0.19	0.25	0.19	0.25	0.25
LG	0.06	0.13	0.19	0.06	0.13	0.19	0.13	0.19	0.25	0.00	0.00	0.00	0.13	0.19	0.25
U	0.13	0.19	0.25	0.13	0.19	0.25	0.06	0.13	0.19	0.06	0.13	0.19	0.00	0.00	0.00

Step 3: The fuzzy total influence matrix is derived from normalized fuzzy direct influence matrix by using Eq. 3.3 (See Table 4.5).

Table 4.5 Fuzzy total-influence matrix (Step 3)

	F			C			IBP			LG			U		
F	0.06	0.30	1.62	0.10	0.37	1.70	0.18	0.46	1.92	0.18	0.46	1.92	0.14	0.44	1.88
C	0.26	0.58	2.01	0.07	0.32	1.71	0.21	0.53	2.11	0.21	0.53	2.11	0.22	0.56	2.11
IBP	0.13	0.44	1.78	0.12	0.40	1.70	0.07	0.32	1.71	0.19	0.48	1.91	0.25	0.55	1.92
LG	0.12	0.42	1.78	0.11	0.38	1.70	0.18	0.46	1.91	0.06	0.30	1.71	0.19	0.49	1.92
U	0.19	0.47	1.84	0.17	0.42	1.75	0.13	0.42	1.89	0.13	0.42	1.89	0.07	0.33	1.73

Step 4: The fuzzy total influence matrix is defuzzified by using the defuzzification algorithm mentioned in Section 3.2.1 (See Table 4.5).

Table 4.6 Total-influence matrix (After defuzzification)

	F	C	IBP	LG	U
F	0.52	0.59	***0.70***	***0.70***	***0.68***
C	***0.80***	0.56	***0.78***	***0.78***	***0.80***
IBP	0.66	0.61	0.56	***0.71***	***0.77***
LG	0.64	0.60	***0.70***	0.54	***0.72***
U	***0.69***	0.64	***0.66***	***0.66***	0.56

Median = 0.66 * Values in bold and italic font are greater and equal to threshold value.

Step 5: The sum of rows and columns are calculated in order to obtain INRM in Table 4.7.

Table 4.7 The sum of influences giving and received

	r	c	r+c	r-c
F	3.20	3.31	6.51	-0.11
C	3.71	3.01	6.72	0.71
IBP	3.31	3.40	6.71	-0.09
LG	3.20	3.39	6.59	-0.19
U	3.21	3.53	6.74	-0.32

DEMATEL steps for performance criteria;

Steps, applied for BSC perspectives, are also used for performance criteria of proposed method. It can be seen in Table 4.8a-Table 4.12.

Table 4.8a Fuzzy direct influence matrix of criteria (Step 1)

	GPPT	PC	CPCR	SPP	CS	SQ	RS	TL	IP	SS	RAS	RFS	JS	TS	IN	TT	PTS	PMPT	PCPT	PCS
GPPT	0.000 0.000 0.000	0.000 0.000 0.250	0.750 1.000 1.000	0.250 0.500 0.750	0.000 0.000 0.250	0.000 0.000 0.250	0.000 0.000 0.250	0.000 0.000 0.250	0.000 0.000 0.250	0.000 0.000 0.250	0.000 0.000 0.250	0.000 0.000 0.250	0.500 0.750 1.000	0.000 0.000 0.250	0.000 0.000 0.250	0.250 0.500 0.750	0.500 0.750 1.000	0.750 1.000 1.000	0.500 0.750 1.000	0.750 1.000 1.000
PC	0.000 0.000 0.250	0.000 0.000 0.000	0.750 1.000 1.000	0.500 0.750 1.000	0.750 1.000 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.250 0.500 0.750	0.000 0.000 0.250	0.000 0.000 0.250	0.000 0.000 0.250	0.000 0.000 0.250	0.500 0.750 1.000	0.500 0.750 1.000	0.250 0.500 0.750	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.750 1.000 1.000
CPCR	0.750 1.000 1.000	0.000 0.000 0.250	0.000 0.000 0.000	0.500 0.750 1.000	0.750 1.000 1.000	0.000 0.000 0.250	0.000 0.000 0.250	0.000 0.000 0.250	0.000 0.000 0.250	0.000 0.000 0.250	0.000 0.000 0.250	0.000 0.000 0.250	0.500 0.750 1.000	0.500 0.750 1.000	0.000 0.000 0.250	0.500 0.750 1.000	0.750 1.000 1.000	0.500 0.750 1.000	0.750 1.000 1.000	0.750 1.000 1.000
SPP	0.750 1.000 1.000	0.750 1.000 1.000	0.500 0.750 1.000	0.000 0.000 0.000	0.500 0.750 1.000	0.250 0.500 0.750	0.250 0.500 0.750	0.250 0.500 0.750	0.250 0.500 0.750	0.250 0.500 0.750	0.250 0.500 0.750	0.250 0.500 0.750	0.250 0.500 0.750	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.750 1.000 1.000	0.750 1.000 1.000
CS	0.750 1.000 1.000	0.250 0.500 0.750	0.250 0.500 0.750	0.000 0.000 0.250	0.000 0.000 0.000	0.000 0.000 0.250	0.000 0.000 0.250	0.000 0.000 0.250	0.000 0.000 0.250	0.000 0.000 0.250	0.000 0.000 0.250	0.000 0.000 0.250	0.750 1.000 1.000	0.250 0.500 0.750	0.500 0.750 1.000	0.500 0.750 1.000	0.750 1.000 1.000	0.750 1.000 1.000	0.250 0.500 0.750	0.500 0.750 1.000
SQ	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.000 0.000 0.250	0.750 1.000 1.000	0.000 0.000 0.000	0.500 0.750 1.000	0.500 0.750 1.000	0.250 0.500 0.750	0.250 0.500 0.750	0.250 0.500 0.750	0.250 0.500 0.750	0.250 0.500 0.750	0.250 0.500 0.750	0.250 0.500 0.750	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000
RS	0.750 1.000 1.000	0.000 0.250 0.500	0.250 0.500 0.750	0.000 0.000 0.250	0.750 1.000 1.000	0.500 0.750 1.000	0.000 0.000 0.000	0.750 1.000 1.000	0.000 0.250 0.500	0.000 0.250 0.500	0.000 0.250 0.500	0.000 0.250 0.500	0.000 0.250 0.500	0.000 0.000 0.250	0.000 0.250 0.500	0.000 0.250 0.500	0.250 0.500 0.750	0.000 0.000 0.250	0.500 0.750 1.000	0.500 0.750 1.000
TL	0.750 1.000 1.000	0.250 0.500 0.750	0.500 0.750 1.000	0.500 0.750 1.000	0.750 1.000 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.000 0.000 0.000	0.000 0.250 0.500	0.000 0.250 0.500	0.000 0.250 0.500	0.000 0.250 0.500	0.000 0.000 0.250	0.000 0.000 0.250	0.000 0.250 0.500	0.000 0.000 0.250	0.250 0.500 0.750	0.250 0.500 0.750	0.750 1.000 1.000	0.500 0.750 1.000
IP	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.000 0.000 0.250	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.000 0.000 0.000	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.000 0.000 0.250	0.000 0.000 0.250	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000
SS	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.000 0.000 0.250	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.250 0.500 0.750	0.000 0.000 0.000	0.500 0.750 1.000	0.250 0.500 0.750	0.000 0.000 0.250	0.000 0.000 0.250	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000

Table 4.8b Fuzzy direct influence matrix of criteria (Step 1)

	GPPT	PC	CPCR	SPP	CS	SQ	RS	TL	IP	SS	RAS	RFS	JS	TS	IN	TT	PTS	PMPT	PCPT	PCS
RAS	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.000 0.000 0.250	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.250 0.500 0.750	0.250 0.500 0.750	0.000 0.000 0.000	0.250 0.500 0.750	0.000 0.000 0.250	0.000 0.000 0.250	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000
RFS	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.000 0.000 0.250	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.250 0.500 0.750	0.500 0.750 1.000	0.500 0.750 1.000	0.000 0.000 0.000	0.000 0.000 0.250	0.000 0.000 0.250	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000
JS	0.750 1.000 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.750 1.000 1.000	0.750 1.000 1.000	0.750 1.000 1.000	0.750 1.000 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.000 0.000 0.000	0.250 0.500 0.750	0.500 0.750 1.000	0.500 0.750 1.000	0.750 1.000 1.000	0.750 1.000 1.000	0.750 1.000 1.000	0.500 0.750 1.000
TS	0.750 1.000 1.000	0.500 0.750 1.000	0.250 0.500 0.750	0.500 0.750 1.000	0.750 1.000 1.000	0.750 1.000 1.000	0.750 1.000 1.000	0.750 1.000 1.000	0.750 1.000 1.000	0.750 1.000 1.000	0.750 1.000 1.000	0.750 1.000 1.000	0.500 0.750 1.000	0.000 0.000 0.000	0.750 1.000 1.000	0.500 0.750 1.000	0.750 1.000 1.000	0.750 1.000 1.000	0.750 1.000 1.000	0.500 0.750 1.000
IN	0.000 0.000 0.250	0.500 0.750 1.000	0.000 0.000 0.250	0.000 0.000 0.250	0.500 0.750 1.000	0.250 0.500 0.750	0.000 0.250 0.500	0.000 0.250 0.500	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.750 1.000 1.000	0.250 0.500 0.750	0.000 0.000 0.000	0.750 1.000 1.000	0.750 1.000 1.000	0.750 1.000 1.000	0.250 0.500 0.750	0.000 0.250 0.500
TT	0.000 0.000 0.250	0.500 0.750 1.000	0.000 0.000 0.250	0.000 0.000 0.250	0.000 0.000 0.250	0.000 0.000 0.250	0.000 0.000 0.250	0.000 0.000 0.250	0.000 0.000 0.250	0.000 0.000 0.250	0.000 0.000 0.250	0.000 0.000 0.250	0.250 0.500 0.750	0.000 0.000 0.250	0.250 0.500 0.750	0.000 0.000 0.000	0.000 0.000 0.250	0.000 0.000 0.250	0.000 0.000 0.250	0.500 0.750 1.000
PTS	0.750 1.000 1.000	0.500 0.750 1.000	0.750 1.000 1.000	0.000 0.000 0.250	0.750 1.000 1.000	0.500 0.750 1.000	0.000 0.250 0.500	0.000 0.250 0.500	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.000 0.000 0.000	0.500 0.750 1.000	0.750 1.000 1.000	0.500 0.750 1.000
PMPT	0.500 0.750 1.000	0.500 0.750 1.000	0.500 0.750 1.000	0.000 0.000 0.250	0.500 0.750 1.000	0.500 0.750 1.000	0.000 0.250 0.500	0.000 0.250 0.500	0.750 1.000 1.000	0.750 1.000 1.000	0.750 1.000 1.000	0.750 1.000 1.000	0.750 1.000 1.000	0.750 1.000 1.000	0.750 1.000 1.000	0.750 1.000 1.000	0.750 1.000 1.000	0.000 0.000 0.000	0.500 0.750 1.000	0.500 0.750 1.000
PCPT	0.750 1.000 1.000	0.500 0.750 1.000	0.750 1.000 1.000	0.000 0.000 0.250	0.750 1.000 1.000	0.250 0.500 0.750	0.000 0.000 0.250	0.000 0.000 0.250	0.000 0.000 0.250	0.000 0.000 0.250	0.000 0.000 0.250	0.000 0.000 0.250	0.500 0.750 1.000	0.000 0.250 0.500	0.000 0.250 0.500	0.250 0.500 0.750	0.500 0.750 1.000	0.500 0.750 1.000	0.000 0.000 0.000	0.750 1.000 1.000
PCS	0.000 0.000 0.250	0.500 0.750 1.000	0.000 0.000 0.250	0.250 0.500 0.750	0.000 0.250 0.500	0.000 0.000 0.250	0.000 0.000 0.250	0.000 0.000 0.250	0.250 0.500 0.750	0.250 0.500 0.750	0.250 0.500 0.750	0.250 0.500 0.750	0.500 0.750 1.000	0.250 0.500 0.750	0.000 0.250 0.500	0.250 0.500 0.750	0.500 0.750 1.000	0.250 0.500 0.750	0.250 0.500 0.750	0.000 0.000 0.000

Table 4.9a Normalized fuzzy direct influence matrix of criteria (Step 2)

	GPPT	PC	CPCR	SPP	CS	SQ	RS	TL	IP	SS
GPPT	0.000 0.000 0.000	0.000 0.000 0.013	0.040 0.053 0.053	0.013 0.027 0.040	0.000 0.000 0.013	0.000 0.000 0.013	0.000 0.000 0.013	0.000 0.000 0.013	0.000 0.000 0.013	0.000 0.000 0.013
PC	0.000 0.000 0.013	0.000 0.000 0.000	0.040 0.053 0.053	0.027 0.040 0.053	0.040 0.053 0.053	0.027 0.040 0.053	0.027 0.040 0.053	0.013 0.027 0.040	0.000 0.000 0.013	0.000 0.000 0.013
CPCR	0.040 0.053 0.053	0.000 0.000 0.013	0.000 0.000 0.000	0.027 0.040 0.053	0.040 0.053 0.053	0.000 0.000 0.013	0.000 0.000 0.013	0.000 0.000 0.013	0.000 0.000 0.013	0.000 0.000 0.013
SPP	0.040 0.053 0.053	0.040 0.053 0.053	0.027 0.040 0.053	0.000 0.000 0.000	0.027 0.040 0.053	0.013 0.027 0.040	0.013 0.027 0.040	0.013 0.027 0.040	0.013 0.027 0.040	0.013 0.027 0.040
CS	0.040 0.053 0.053	0.013 0.027 0.040	0.013 0.027 0.040	0.000 0.000 0.013	0.000 0.000 0.000	0.000 0.000 0.013	0.000 0.000 0.013	0.000 0.000 0.013	0.000 0.000 0.013	0.000 0.000 0.013
SQ	0.027 0.040 0.053	0.027 0.040 0.053	0.027 0.040 0.053	0.000 0.000 0.013	0.040 0.053 0.053	0.000 0.000 0.000	0.027 0.040 0.053	0.027 0.040 0.053	0.013 0.027 0.040	0.013 0.027 0.040
RS	0.040 0.053 0.053	0.000 0.013 0.027	0.013 0.027 0.040	0.000 0.000 0.013	0.040 0.053 0.053	0.027 0.040 0.053	0.000 0.000 0.000	0.040 0.053 0.053	0.000 0.013 0.027	0.000 0.013 0.027
TL	0.040 0.053 0.053	0.013 0.027 0.040	0.027 0.040 0.053	0.027 0.040 0.053	0.040 0.053 0.053	0.027 0.040 0.053	0.027 0.040 0.053	0.000 0.000 0.000	0.000 0.013 0.027	0.000 0.013 0.027
IP	0.027 0.040 0.053	0.027 0.040 0.053	0.027 0.040 0.053	0.000 0.000 0.013	0.027 0.040 0.053	0.027 0.040 0.053	0.027 0.040 0.053	0.027 0.040 0.053	0.000 0.000 0.000	0.027 0.040 0.053
SS	0.027 0.040 0.053	0.027 0.040 0.053	0.027 0.040 0.053	0.000 0.000 0.013	0.027 0.040 0.053	0.027 0.040 0.053	0.027 0.040 0.053	0.027 0.040 0.053	0.013 0.027 0.040	0.000 0.000 0.000

	RAS	RFS	JS	TS	IN	TT	PTS	PMPT	PCPT	PCS
GPPT	0.000 0.000 0.013	0.000 0.000 0.013	0.027 0.040 0.053	0.000 0.000 0.013	0.000 0.000 0.013	0.013 0.027 0.040	0.027 0.040 0.053	0.040 0.053 0.053	0.027 0.040 0.053	0.040 0.053 0.053
PC	0.000 0.000 0.013	0.000 0.000 0.013	0.027 0.040 0.053	0.027 0.040 0.053	0.013 0.027 0.040	0.027 0.040 0.053	0.027 0.040 0.053	0.027 0.040 0.053	0.027 0.040 0.053	0.040 0.053 0.053
CPCR	0.000 0.000 0.013	0.000 0.000 0.013	0.027 0.040 0.053	0.027 0.040 0.053	0.000 0.000 0.013	0.027 0.040 0.053	0.040 0.053 0.053	0.027 0.040 0.053	0.040 0.053 0.053	0.040 0.053 0.053
SPP	0.013 0.027 0.040	0.013 0.027 0.040	0.013 0.027 0.040	0.027 0.040 0.053	0.027 0.040 0.053	0.027 0.040 0.053	0.027 0.040 0.053	0.027 0.040 0.053	0.040 0.053 0.053	0.040 0.053 0.053
CS	0.000 0.000 0.013	0.000 0.000 0.013	0.040 0.053 0.053	0.013 0.027 0.040	0.027 0.040 0.053	0.027 0.040 0.053	0.040 0.053 0.053	0.040 0.053 0.053	0.013 0.027 0.040	0.027 0.040 0.053
SQ	0.013 0.027 0.040	0.013 0.027 0.040	0.013 0.027 0.040	0.013 0.027 0.040	0.013 0.027 0.040	0.027 0.040 0.053	0.027 0.040 0.053	0.027 0.040 0.053	0.027 0.040 0.053	0.027 0.040 0.053
RS	0.000 0.013 0.027	0.000 0.013 0.027	0.000 0.013 0.027	0.000 0.000 0.013	0.000 0.013 0.027	0.000 0.013 0.027	0.013 0.027 0.040	0.000 0.000 0.013	0.027 0.040 0.053	0.027 0.040 0.053
TL	0.000 0.013 0.027	0.000 0.013 0.027	0.000 0.000 0.013	0.000 0.000 0.013	0.000 0.013 0.027	0.000 0.000 0.013	0.013 0.027 0.040	0.013 0.027 0.040	0.040 0.053 0.053	0.027 0.040 0.053
IP	0.027 0.040 0.053	0.027 0.040 0.053	0.000 0.000 0.013	0.000 0.000 0.013	0.027 0.040 0.053	0.027 0.040 0.053	0.027 0.040 0.053	0.027 0.040 0.053	0.027 0.040 0.053	0.027 0.040 0.053
SS	0.027 0.040 0.053	0.013 0.027 0.040	0.000 0.000 0.013	0.000 0.000 0.013	0.027 0.040 0.053	0.027 0.040 0.053	0.027 0.040 0.053	0.027 0.040 0.053	0.027 0.040 0.053	0.027 0.040 0.053

Table 4.9b Normalized fuzzy direct influence matrix of criteria (Step 2)

	GPPT	PC	CPCR	SPP	CS	SQ	RS	TL	IP	SS
RAS	0.027 0.040 0.053	0.027 0.040 0.053	0.027 0.040 0.053	0.000 0.000 0.013	0.027 0.040 0.053	0.027 0.040 0.053	0.027 0.040 0.053	0.027 0.040 0.053	0.013 0.027 0.040	0.013 0.027 0.040
RFS	0.027 0.040 0.053	0.027 0.040 0.053	0.027 0.040 0.053	0.000 0.000 0.013	0.027 0.040 0.053	0.027 0.040 0.053	0.027 0.040 0.053	0.027 0.040 0.053	0.013 0.027 0.040	0.027 0.040 0.053
JS	0.040 0.053 0.053	0.027 0.040 0.053	0.027 0.040 0.053	0.027 0.040 0.053	0.040 0.053 0.053	0.040 0.053 0.053	0.040 0.053 0.053	0.040 0.053 0.053	0.027 0.040 0.053	0.027 0.040 0.053
TS	0.040 0.053 0.053	0.027 0.040 0.053	0.013 0.027 0.040	0.027 0.040 0.053	0.040 0.053 0.053	0.040 0.053 0.053	0.040 0.053 0.053	0.040 0.053 0.053	0.040 0.053 0.053	0.040 0.053 0.053
IN	0.000 0.000 0.013	0.027 0.040 0.053	0.000 0.000 0.013	0.000 0.000 0.013	0.027 0.040 0.053	0.013 0.027 0.040	0.000 0.013 0.027	0.000 0.013 0.027	0.027 0.040 0.053	0.027 0.040 0.053
TT	0.000 0.000 0.013	0.027 0.040 0.053	0.000 0.000 0.013	0.000 0.000 0.013	0.000 0.000 0.013	0.000 0.000 0.013	0.000 0.000 0.013	0.000 0.000 0.013	0.000 0.000 0.013	0.000 0.000 0.013
PTS	0.040 0.053 0.053	0.027 0.040 0.053	0.040 0.053 0.053	0.000 0.000 0.013	0.040 0.053 0.053	0.027 0.040 0.053	0.000 0.013 0.027	0.000 0.013 0.027	0.027 0.040 0.053	0.027 0.040 0.053
PMPT	0.027 0.040 0.053	0.027 0.040 0.053	0.027 0.040 0.053	0.000 0.000 0.013	0.027 0.040 0.053	0.027 0.040 0.053	0.000 0.013 0.027	0.000 0.013 0.027	0.040 0.053 0.053	0.040 0.053 0.053
PCPT	0.040 0.053 0.053	0.027 0.040 0.053	0.040 0.053 0.053	0.000 0.000 0.013	0.040 0.053 0.053	0.013 0.027 0.040	0.000 0.000 0.013	0.000 0.000 0.013	0.000 0.000 0.013	0.000 0.000 0.013
PCS	0.000 0.000 0.013	0.027 0.040 0.053	0.000 0.000 0.013	0.013 0.027 0.040	0.000 0.013 0.027	0.000 0.000 0.013	0.000 0.000 0.013	0.000 0.000 0.013	0.013 0.027 0.040	0.013 0.027 0.040

	RAS	RFS	JS	TS	IN	TT	PTS	PMPT	PCPT	PCS
RAS	0.000 0.000 0.000	0.013 0.027 0.040	0.000 0.000 0.013	0.000 0.000 0.013	0.027 0.040 0.053	0.027 0.040 0.053	0.027 0.040 0.053	0.027 0.040 0.053	0.027 0.040 0.053	0.027 0.040 0.053
RFS	0.027 0.040 0.053	0.000 0.000 0.000	0.000 0.000 0.013	0.000 0.000 0.013	0.027 0.040 0.053	0.027 0.040 0.053	0.027 0.040 0.053	0.027 0.040 0.053	0.027 0.040 0.053	0.027 0.040 0.053
JS	0.027 0.040 0.053	0.027 0.040 0.053	0.000 0.000 0.000	0.013 0.027 0.040	0.027 0.040 0.053	0.027 0.040 0.053	0.040 0.053 0.053	0.040 0.053 0.053	0.040 0.053 0.053	0.027 0.040 0.053
TS	0.040 0.053 0.053	0.040 0.053 0.053	0.027 0.040 0.053	0.000 0.000 0.000	0.040 0.053 0.053	0.027 0.040 0.053	0.040 0.053 0.053	0.040 0.053 0.053	0.040 0.053 0.053	0.027 0.040 0.053
IN	0.027 0.040 0.053	0.027 0.040 0.053	0.040 0.053 0.053	0.013 0.027 0.040	0.000 0.000 0.000	0.040 0.053 0.053	0.040 0.053 0.053	0.040 0.053 0.053	0.013 0.027 0.040	0.000 0.013 0.027
TT	0.000 0.000 0.013	0.000 0.000 0.013	0.013 0.027 0.040	0.000 0.000 0.013	0.013 0.027 0.040	0.000 0.000 0.000	0.000 0.000 0.013	0.000 0.000 0.013	0.000 0.000 0.013	0.027 0.040 0.053
PTS	0.027 0.040 0.053	0.027 0.040 0.053	0.027 0.040 0.053	0.027 0.040 0.053	0.027 0.040 0.053	0.027 0.040 0.053	0.000 0.000 0.000	0.027 0.040 0.053	0.040 0.053 0.053	0.027 0.040 0.053
PMPT	0.040 0.053 0.053	0.040 0.053 0.053	0.040 0.053 0.053	0.040 0.053 0.053	0.040 0.053 0.053	0.040 0.053 0.053	0.040 0.053 0.053	0.000 0.000 0.000	0.027 0.040 0.053	0.027 0.040 0.053
PCPT	0.000 0.000 0.013	0.000 0.000 0.013	0.027 0.040 0.053	0.000 0.013 0.027	0.000 0.013 0.027	0.013 0.027 0.040	0.027 0.040 0.053	0.027 0.040 0.053	0.000 0.000 0.000	0.040 0.053 0.053
PCS	0.013 0.027 0.040	0.013 0.027 0.040	0.027 0.040 0.053	0.013 0.027 0.040	0.000 0.013 0.027	0.013 0.027 0.040	0.027 0.040 0.053	0.013 0.027 0.040	0.013 0.027 0.040	0.000 0.000 0.000

Table 4.10a Fuzzy total-influence matrix of criteria (Step 3)

	GPPT	PC	CPCR	SPP	CS	SQ	RS	TL	IP	SS
GPPT	0.010 0.027 0.086	0.008 0.025 0.104	0.047 0.076 0.137	0.016 0.038 0.093	0.010 0.029 0.104	0.006 0.019 0.089	0.003 0.013 0.077	0.003 0.012 0.076	0.005 0.017 0.079	0.006 0.017 0.029
PC	0.017 0.047 0.137	0.013 0.042 0.130	0.052 0.092 0.174	0.032 0.057 0.129	0.056 0.101 0.183	0.036 0.071 0.161	0.033 0.064 0.145	0.020 0.051 0.131	0.008 0.027 0.108	0.008 0.028 0.040
CPCR	0.053 0.089 0.153	0.012 0.035 0.121	0.012 0.034 0.102	0.031 0.054 0.116	0.052 0.088 0.158	0.008 0.025 0.103	0.005 0.018 0.089	0.005 0.018 0.088	0.007 0.022 0.091	0.007 0.023 0.034
SPP	0.056 0.105 0.189	0.054 0.101 0.197	0.043 0.090 0.190	0.006 0.022 0.088	0.045 0.097 0.199	0.024 0.066 0.163	0.021 0.057 0.146	0.020 0.057 0.143	0.021 0.058 0.145	0.022 0.059 0.058
CS	0.050 0.084 0.148	0.023 0.058 0.143	0.024 0.059 0.137	0.004 0.015 0.077	0.012 0.036 0.105	0.008 0.026 0.101	0.005 0.019 0.088	0.004 0.018 0.086	0.008 0.023 0.090	0.008 0.023 0.034
SQ	0.042 0.088 0.184	0.038 0.083 0.191	0.040 0.085 0.185	0.005 0.019 0.098	0.055 0.104 0.193	0.010 0.036 0.120	0.033 0.066 0.153	0.033 0.066 0.151	0.019 0.054 0.140	0.020 0.055 0.055
RS	0.049 0.085 0.149	0.006 0.041 0.128	0.021 0.057 0.137	0.003 0.013 0.075	0.047 0.085 0.154	0.030 0.060 0.137	0.003 0.017 0.074	0.042 0.067 0.123	0.002 0.029 0.099	0.002 0.030 0.030
TL	0.052 0.091 0.161	0.021 0.060 0.152	0.037 0.076 0.162	0.030 0.053 0.119	0.051 0.092 0.168	0.032 0.064 0.148	0.030 0.058 0.134	0.004 0.020 0.081	0.004 0.033 0.109	0.004 0.034 0.034
IP	0.043 0.086 0.184	0.039 0.082 0.191	0.041 0.084 0.186	0.005 0.017 0.096	0.044 0.090 0.194	0.037 0.073 0.171	0.034 0.065 0.154	0.034 0.065 0.151	0.007 0.026 0.101	0.034 0.067 0.068
SS	0.042 0.084 0.189	0.038 0.080 0.197	0.040 0.082 0.191	0.005 0.016 0.099	0.043 0.088 0.199	0.036 0.071 0.176	0.033 0.064 0.158	0.033 0.063 0.156	0.019 0.051 0.144	0.007 0.026 0.070

	RAS	RFS	JS	TS	IN	TT	PTS	PMPT	PCPT	PCS
GPPT	0.006 0.017 0.081	0.006 0.017 0.080	0.035 0.065 0.135	0.006 0.019 0.081	0.006 0.021 0.093	0.021 0.054 0.132	0.037 0.069 0.147	0.048 0.079 0.143	0.036 0.068 0.145	0.050 0.083 0.152
PC	0.008 0.029 0.111	0.008 0.028 0.110	0.040 0.081 0.172	0.035 0.068 0.148	0.023 0.062 0.154	0.040 0.084 0.185	0.044 0.090 0.190	0.042 0.085 0.183	0.042 0.087 0.186	0.056 0.103 0.196
CPCR	0.008 0.023 0.094	0.007 0.023 0.093	0.039 0.075 0.152	0.034 0.062 0.131	0.009 0.030 0.109	0.038 0.076 0.162	0.054 0.093 0.166	0.041 0.078 0.161	0.053 0.090 0.162	0.055 0.094 0.171
SPP	0.022 0.060 0.149	0.022 0.059 0.147	0.028 0.075 0.173	0.035 0.071 0.158	0.038 0.082 0.181	0.042 0.093 0.203	0.046 0.100 0.208	0.045 0.096 0.202	0.057 0.109 0.204	0.059 0.115 0.215
CS	0.008 0.024 0.093	0.008 0.023 0.091	0.051 0.086 0.150	0.020 0.049 0.117	0.035 0.067 0.143	0.038 0.075 0.160	0.053 0.091 0.163	0.052 0.089 0.158	0.025 0.064 0.147	0.039 0.079 0.167
SQ	0.020 0.056 0.144	0.020 0.055 0.142	0.026 0.069 0.167	0.020 0.054 0.141	0.022 0.065 0.162	0.040 0.087 0.196	0.043 0.094 0.201	0.042 0.090 0.195	0.042 0.091 0.198	0.044 0.096 0.209
RS	0.002 0.030 0.102	0.002 0.029 0.101	0.008 0.041 0.121	0.003 0.018 0.088	0.003 0.035 0.116	0.006 0.043 0.132	0.022 0.062 0.149	0.009 0.035 0.120	0.035 0.073 0.159	0.036 0.077 0.166
TL	0.004 0.034 0.112	0.004 0.033 0.110	0.010 0.035 0.120	0.006 0.024 0.099	0.006 0.041 0.127	0.009 0.038 0.132	0.025 0.070 0.163	0.024 0.067 0.157	0.050 0.093 0.172	0.040 0.084 0.180
IP	0.035 0.067 0.156	0.034 0.066 0.154	0.013 0.041 0.142	0.007 0.027 0.115	0.036 0.075 0.175	0.041 0.086 0.197	0.044 0.092 0.202	0.042 0.088 0.196	0.043 0.089 0.199	0.045 0.094 0.209
SS	0.034 0.066 0.161	0.020 0.052 0.145	0.013 0.040 0.146	0.007 0.026 0.118	0.035 0.073 0.180	0.040 0.084 0.202	0.043 0.089 0.208	0.041 0.086 0.201	0.041 0.087 0.204	0.044 0.092 0.215

Table 4.10b Fuzzy total-influence matrix of criteria (Step 3)

	GPPT	PC	CPCR	SPP	CS	SQ	RS	TL	IP	SS
RAS	0.041 0.082 0.175	0.038 0.079 0.182	0.040 0.081 0.176	0.005 0.016 0.091	0.042 0.087 0.184	0.036 0.070 0.162	0.032 0.063 0.146	0.032 0.063 0.144	0.019 0.051 0.133	0.020 0.052 0.039
RFS	0.042 0.085 0.182	0.039 0.081 0.189	0.041 0.083 0.183	0.005 0.017 0.095	0.043 0.089 0.191	0.037 0.072 0.169	0.033 0.064 0.152	0.033 0.064 0.150	0.020 0.052 0.138	0.034 0.066 0.068
JS	0.064 0.118 0.204	0.045 0.098 0.213	0.048 0.102 0.206	0.034 0.063 0.147	0.065 0.123 0.215	0.055 0.100 0.189	0.050 0.089 0.170	0.050 0.089 0.168	0.037 0.077 0.168	0.038 0.079 0.076
TS	0.066 0.124 0.207	0.048 0.104 0.216	0.037 0.094 0.197	0.034 0.064 0.148	0.067 0.129 0.218	0.058 0.105 0.192	0.053 0.094 0.173	0.053 0.094 0.171	0.052 0.093 0.171	0.053 0.096 0.090
IN	0.015 0.047 0.136	0.040 0.084 0.181	0.014 0.045 0.137	0.004 0.016 0.088	0.043 0.090 0.182	0.025 0.064 0.151	0.009 0.043 0.123	0.008 0.042 0.121	0.035 0.068 0.145	0.036 0.070 0.067
TT	0.002 0.008 0.071	0.029 0.049 0.115	0.002 0.009 0.072	0.002 0.006 0.053	0.003 0.012 0.077	0.002 0.008 0.067	0.002 0.007 0.060	0.001 0.006 0.059	0.002 0.007 0.060	0.002 0.007 0.020
PTS	0.058 0.106 0.192	0.042 0.089 0.201	0.056 0.103 0.194	0.006 0.021 0.102	0.059 0.111 0.202	0.039 0.079 0.178	0.010 0.045 0.137	0.009 0.045 0.135	0.036 0.071 0.159	0.037 0.073 0.073
PMPT	0.048 0.100 0.195	0.046 0.096 0.203	0.046 0.096 0.196	0.007 0.023 0.104	0.050 0.105 0.205	0.043 0.086 0.181	0.013 0.051 0.139	0.012 0.050 0.136	0.051 0.089 0.161	0.052 0.091 0.086
PCPT	0.051 0.085 0.151	0.035 0.069 0.157	0.050 0.084 0.153	0.005 0.016 0.079	0.050 0.087 0.158	0.019 0.049 0.128	0.004 0.017 0.090	0.004 0.017 0.088	0.005 0.020 0.091	0.006 0.021 0.033
PCS	0.009 0.033 0.115	0.034 0.071 0.160	0.009 0.032 0.117	0.016 0.038 0.102	0.010 0.049 0.136	0.007 0.027 0.107	0.005 0.022 0.094	0.005 0.021 0.092	0.018 0.047 0.118	0.018 0.048 0.048

	RAS	RFS	JS	TS	IN	TT	PTS	PMPT	PCPT	PCS
RAS	0.007 0.026 0.098	0.019 0.051 0.134	0.013 0.040 0.135	0.007 0.026 0.109	0.035 0.072 0.166	0.039 0.083 0.187	0.042 0.088 0.192	0.041 0.084 0.186	0.041 0.086 0.189	0.043 0.091 0.199
RFS	0.034 0.067 0.154	0.007 0.026 0.101	0.013 0.041 0.140	0.007 0.027 0.114	0.036 0.074 0.173	0.040 0.085 0.194	0.043 0.090 0.200	0.042 0.087 0.193	0.042 0.088 0.196	0.044 0.093 0.207
JS	0.039 0.080 0.173	0.038 0.078 0.170	0.018 0.056 0.147	0.024 0.063 0.156	0.041 0.090 0.194	0.047 0.104 0.218	0.064 0.124 0.225	0.062 0.119 0.217	0.063 0.122 0.221	0.053 0.115 0.232
TS	0.054 0.097 0.176	0.052 0.094 0.173	0.046 0.098 0.200	0.011 0.039 0.119	0.057 0.108 0.198	0.050 0.109 0.222	0.067 0.131 0.228	0.065 0.125 0.221	0.066 0.127 0.224	0.055 0.121 0.236
IN	0.037 0.071 0.150	0.036 0.069 0.147	0.051 0.089 0.166	0.020 0.053 0.131	0.013 0.041 0.117	0.054 0.099 0.185	0.055 0.103 0.188	0.054 0.099 0.183	0.028 0.075 0.173	0.017 0.066 0.171
TT	0.002 0.007 0.061	0.002 0.007 0.060	0.016 0.037 0.098	0.002 0.008 0.061	0.015 0.035 0.095	0.003 0.011 0.066	0.004 0.013 0.082	0.003 0.012 0.079	0.003 0.011 0.080	0.030 0.051 0.121
PTS	0.037 0.074 0.164	0.036 0.072 0.161	0.043 0.087 0.187	0.035 0.070 0.159	0.039 0.083 0.184	0.045 0.095 0.207	0.022 0.064 0.161	0.047 0.098 0.206	0.058 0.110 0.208	0.048 0.103 0.218
PMPT	0.053 0.092 0.166	0.052 0.090 0.163	0.056 0.103 0.189	0.049 0.085 0.161	0.055 0.102 0.186	0.060 0.114 0.209	0.064 0.120 0.214	0.024 0.066 0.158	0.049 0.104 0.210	0.050 0.109 0.221
PCPT	0.006 0.021 0.093	0.005 0.020 0.092	0.038 0.074 0.152	0.007 0.037 0.107	0.007 0.040 0.121	0.024 0.062 0.151	0.040 0.079 0.166	0.039 0.077 0.162	0.012 0.037 0.112	0.053 0.092 0.171
PCS	0.018 0.049 0.122	0.018 0.048 0.119	0.033 0.066 0.148	0.017 0.046 0.118	0.007 0.042 0.124	0.021 0.060 0.151	0.036 0.075 0.166	0.022 0.061 0.150	0.022 0.062 0.151	0.010 0.038 0.121

Table 4.11 Total-influence matrix of criteria (After defuzzification)

	GPPT	PC	CPCR	SPP	CS	SQ	RS	TL	IP	SS	RAS	RFS	JS	TS	IN	TT	PTS	PMPT	PCPT	PCS
GPPT	0.036	0.038	***0.084***	0.046																
PC	0.061	0.056	***0.101***	***0.068***																
CPCR	***0.096***	0.049	0.045	***0.063***																
SPP	***0.112***	***0.111***	***0.102***	0.032																
CS					0.047	0.038	0.029	0.029												
SQ					***0.112***	0.049	***0.079***	***0.079***												
RS					***0.093***	***0.071***	0.025	***0.075***												
TL					***0.100***	***0.077***	0.069	0.029												
IP									0.038	0.061	***0.080***	***0.079***								
SS									***0.066***	0.032	***0.080***	***0.066***								
RAS									0.063	0.045	0.038	***0.064***								
RFS									***0.065***	0.060	***0.080***	0.038								
JS													0.069	***0.076***	***0.102***	***0.115***				
TS													***0.108***	0.052	***0.116***	***0.119***				
IN													***0.098***	0.064	0.052	***0.108***				
TT													0.046	0.015	0.044	0.019				
PTS																	0.077	***0.110***	***0.119***	***0.115***
PMPT																	***0.127***	0.078	***0.114***	***0.119***
PCPT																	***0.090***	0.088	0.049	***0.101***
PCS																	0.087	0.073	0.074	0.051

Medians of each cluster (respectively) = 0.062, 0.70, 0.63, 0.73, 0.89

Table 4.12 The sum of influences giving and received

	r	c	r+c	r-c
GPPT	0.203	0.305	0.508	-0.102
PC	0.286	0.253	0.540	0.033
CPCR	0.253	0.332	0.584	-0.079
SPP	0.357	0.209	0.566	0.147
CS	0.143	0.352	0.495	-0.209
SQ	0.319	0.235	0.555	0.084
RS	0.264	0.203	0.467	0.061
TL	0.275	0.211	0.486	0.064
IP	0.259	0.232	0.491	0.027
SS	0.244	0.199	0.443	0.046
RAS	0.210	0.278	0.488	-0.068
RFS	0.243	0.247	0.491	-0.004
JS	0.362	0.321	0.683	0.041
TS	0.394	0.207	0.601	0.187
IN	0.322	0.314	0.636	0.009
TT	0.124	0.360	0.484	-0.237
PTS	0.420	0.382	0.802	0.039
PMPT	0.438	0.349	0.787	0.089
PCPT	0.328	0.356	0.684	-0.028
PCS	0.286	0.386	0.671	-0.100

The INRM is obtained by using Table 4.7 and Table 4.12 and it is implemented to BSC framework (shown in Fig. 4.1) and INRM is shown in Table 4.2.

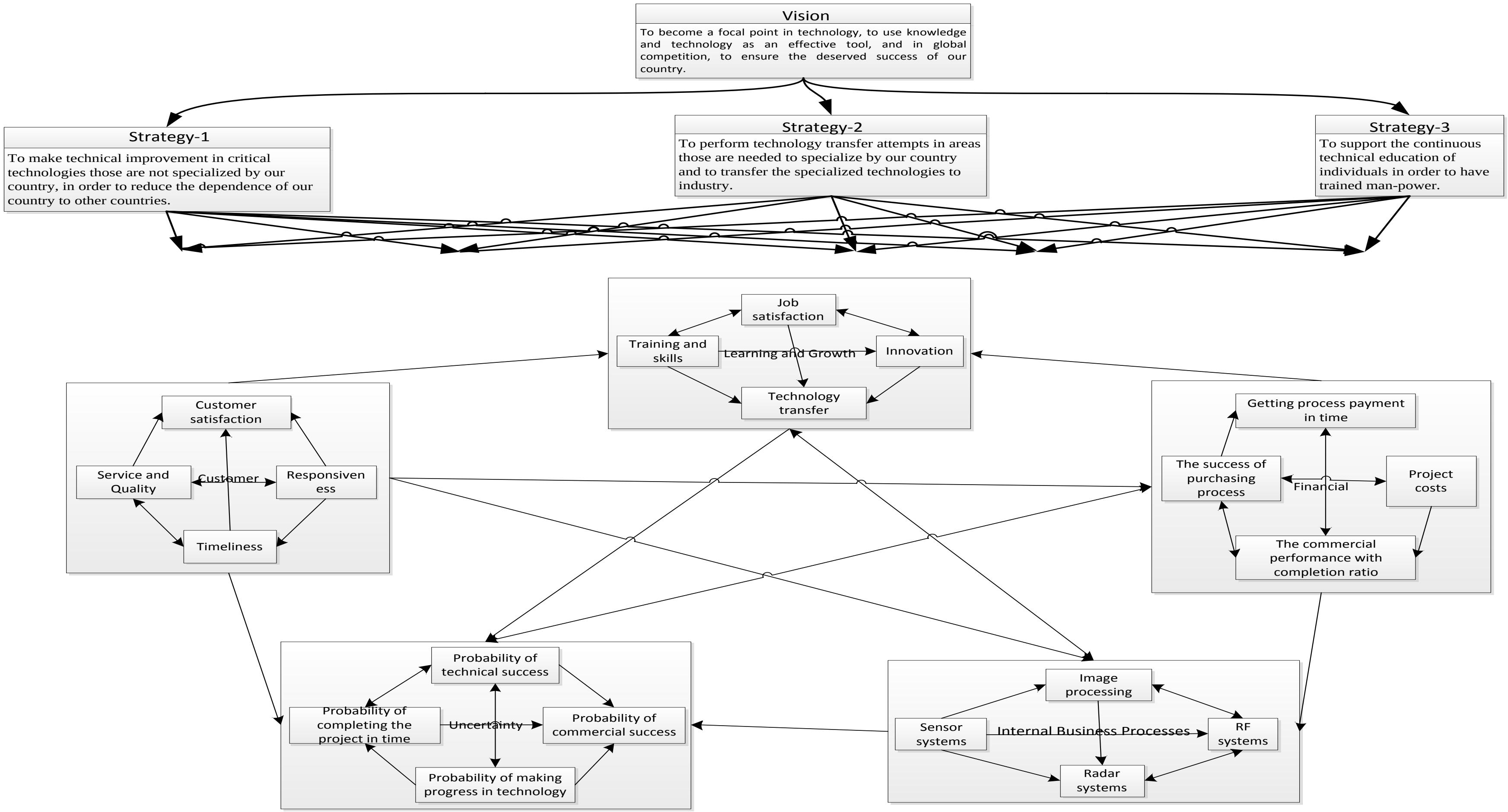

Figure 4.1 The implementation of hierarchical BSC framework

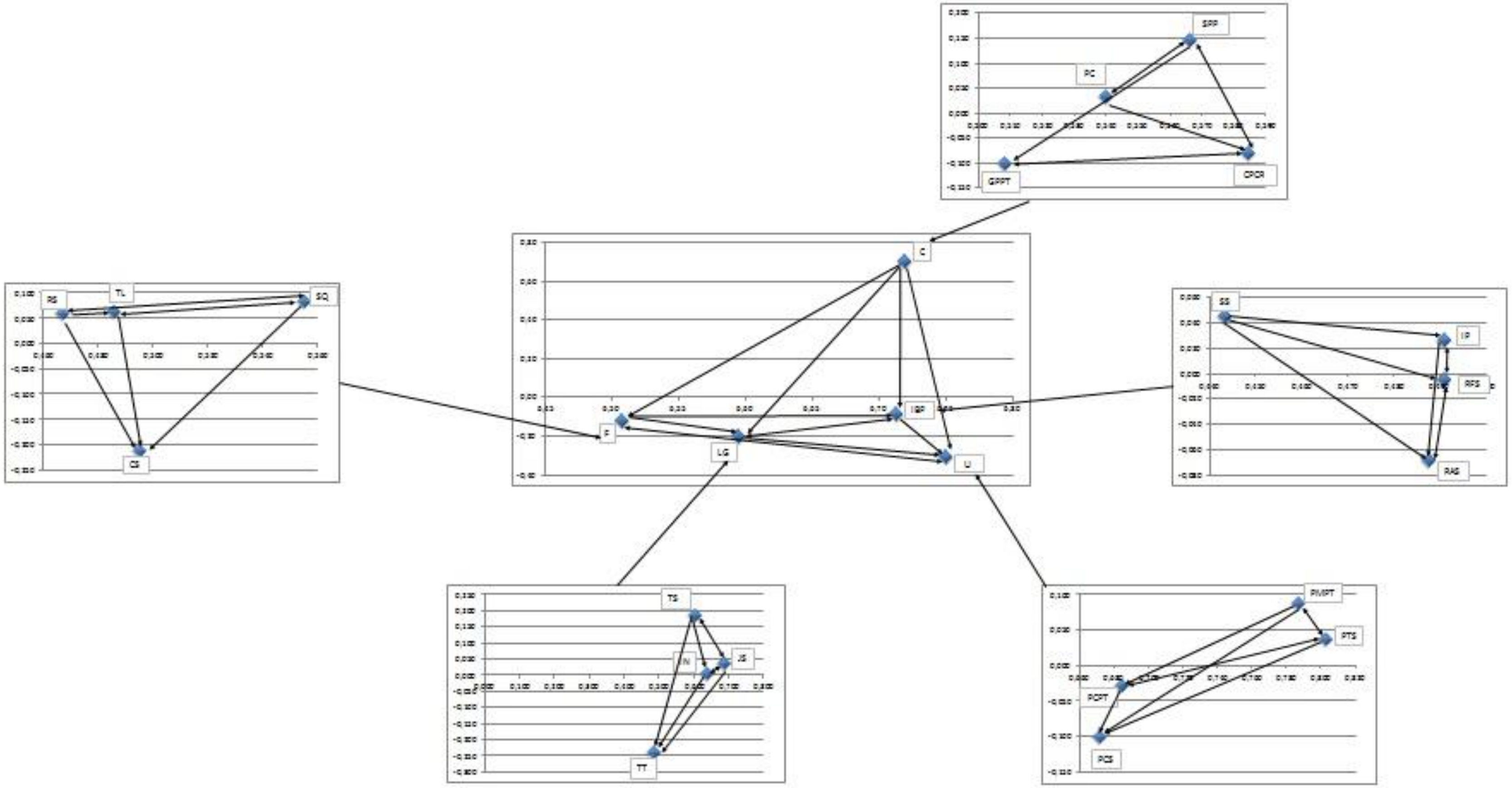

Figure 4.2 INRM of criteria and perspectives

Step 6: The global weights of criteria are obtained by using fuzzy DANP method, mentioned in Section 3.3 and the results of this technique's steps are shown in Table 4.13a - Table 4.20.

- Firstly, we normalize fuzzy total-influence matrix of criteria by using Eq. 3.9 and Eq. 3.10 (see Table 4.13a-Table 4.13b).
- After that, we convert the normalized total influence matrix into an unweighted supermatrix by using Eq. 3.11 (see Table 4.14a-Table 4.14b).
- In third step, we multiply the unweighted supermatrix with the total influence relationship matrix of dimensions in order to obtain weighted supermatrix (see Table 4.15a-Table 4.15b).
- We limit the weighted supermatrix by multiplying it to an adequately large power and calculate limited supermatrix (see Table 4.16a-Table 4.16b). Finally, we obtain the global weights from limited supermatrix.

Table 4.13a Normalized fuzzy total influence matrix of criteria (Step 1)

	GPPT	PC	CPCR	SPP	CS	SQ	RS	TL	IP	SS
GPPT	0.120 0.164 0.204	0.099 0.151 0.247	0.580 0.457 0.326	0.201 0.228 0.223	0.460 0.396 0.301	0.268 0.256 0.257	0.138 0.175 0.222	0.134 0.173 0.219	0.245 0.245 0.294	0.252 0.252 0.106
PC	0.151 0.199 0.240	0.113 0.175 0.229	0.454 0.385 0.305	0.283 0.241 0.227	0.386 0.352 0.295	0.249 0.248 0.260	0.228 0.221 0.234	0.136 0.179 0.211	0.245 0.245 0.293	0.252 0.252 0.109
CPCR	0.493 0.420 0.310	0.108 0.163 0.246	0.112 0.162 0.208	0.287 0.254 0.236	0.747 0.590 0.360	0.116 0.169 0.235	0.069 0.121 0.204	0.068 0.120 0.201	0.245 0.245 0.293	0.252 0.252 0.109
SPP	0.354 0.330 0.285	0.338 0.317 0.297	0.268 0.284 0.287	0.040 0.068 0.132	0.408 0.351 0.306	0.220 0.239 0.251	0.188 0.206 0.224	0.184 0.204 0.220	0.245 0.245 0.290	0.252 0.252 0.116
CS	0.497 0.390 0.292	0.226 0.269 0.284	0.233 0.271 0.271	0.044 0.070 0.152	0.405 0.368 0.276	0.282 0.261 0.267	0.161 0.188 0.231	0.152 0.183 0.226	0.245 0.245 0.293	0.252 0.252 0.109
SQ	0.336 0.321 0.280	0.303 0.300 0.290	0.319 0.309 0.282	0.043 0.070 0.149	0.421 0.382 0.313	0.076 0.132 0.194	0.252 0.244 0.248	0.251 0.243 0.245	0.245 0.245 0.291	0.252 0.252 0.115
RS	0.620 0.432 0.304	0.072 0.207 0.262	0.266 0.293 0.280	0.041 0.068 0.154	0.387 0.372 0.316	0.248 0.262 0.280	0.023 0.073 0.152	0.341 0.294 0.252	0.245 0.245 0.299	0.252 0.252 0.090
TL	0.369 0.325 0.271	0.149 0.213 0.256	0.266 0.272 0.272	0.216 0.190 0.201	0.435 0.394 0.316	0.275 0.275 0.278	0.258 0.247 0.252	0.033 0.083 0.154	0.245 0.245 0.298	0.252 0.252 0.093
IP	0.333 0.320 0.280	0.308 0.305 0.291	0.322 0.313 0.283	0.037 0.063 0.146	0.296 0.307 0.289	0.250 0.249 0.255	0.228 0.222 0.230	0.227 0.221 0.226	0.064 0.117 0.211	0.312 0.294 0.143
SS	0.333 0.320 0.280	0.308 0.305 0.291	0.322 0.313 0.283	0.037 0.063 0.146	0.296 0.307 0.289	0.250 0.249 0.255	0.228 0.222 0.230	0.227 0.221 0.226	0.242 0.263 0.276	0.088 0.135 0.135

	RAS	RFS	JS	TS	IN	TT	PTS	PMPT	PCPT	PCS
GPPT	0.255 0.255 0.303	0.248 0.248 0.298	0.513 0.409 0.306	0.091 0.121 0.184	0.085 0.132 0.210	0.311 0.339 0.300	0.217 0.232 0.251	0.280 0.264 0.244	0.212 0.227 0.247	0.291 0.278 0.259
PC	0.255 0.255 0.301	0.248 0.248 0.296	0.291 0.274 0.261	0.254 0.231 0.225	0.164 0.211 0.234	0.291 0.284 0.281	0.238 0.246 0.251	0.226 0.233 0.243	0.230 0.239 0.247	0.306 0.283 0.260
CPCR	0.255 0.255 0.301	0.248 0.248 0.296	0.326 0.308 0.274	0.279 0.257 0.236	0.077 0.124 0.197	0.318 0.312 0.293	0.268 0.261 0.251	0.201 0.220 0.244	0.260 0.253 0.246	0.271 0.266 0.259
SPP	0.255 0.255 0.299	0.248 0.248 0.294	0.198 0.234 0.243	0.246 0.221 0.221	0.261 0.254 0.253	0.295 0.291 0.284	0.223 0.238 0.251	0.216 0.229 0.243	0.274 0.260 0.246	0.287 0.273 0.259
CS	0.255 0.255 0.301	0.248 0.248 0.296	0.355 0.310 0.263	0.138 0.178 0.205	0.243 0.241 0.251	0.265 0.271 0.281	0.312 0.283 0.256	0.307 0.276 0.249	0.148 0.197 0.232	0.233 0.245 0.263
SQ	0.255 0.255 0.300	0.248 0.248 0.294	0.239 0.251 0.251	0.187 0.197 0.211	0.206 0.235 0.244	0.369 0.317 0.294	0.253 0.253 0.251	0.244 0.242 0.243	0.246 0.246 0.247	0.258 0.259 0.260
RS	0.255 0.255 0.308	0.248 0.248 0.303	0.368 0.299 0.265	0.165 0.129 0.192	0.169 0.258 0.253	0.298 0.313 0.289	0.214 0.252 0.251	0.087 0.141 0.202	0.343 0.297 0.267	0.357 0.310 0.280
TL	0.255 0.255 0.307	0.248 0.248 0.302	0.335 0.257 0.251	0.188 0.172 0.206	0.180 0.296 0.265	0.297 0.276 0.277	0.180 0.223 0.242	0.173 0.213 0.234	0.360 0.295 0.256	0.287 0.269 0.268
IP	0.316 0.298 0.326	0.308 0.291 0.320	0.133 0.179 0.226	0.076 0.117 0.183	0.371 0.328 0.278	0.419 0.375 0.313	0.253 0.253 0.251	0.244 0.242 0.243	0.245 0.246 0.247	0.258 0.259 0.260
SS	0.424 0.336 0.309	0.246 0.266 0.280	0.133 0.179 0.226	0.076 0.117 0.183	0.371 0.328 0.278	0.419 0.375 0.313	0.253 0.253 0.251	0.244 0.242 0.243	0.245 0.246 0.247	0.258 0.259 0.260

Table 4.13b Normalized fuzzy total influence matrix of criteria (Step 1)

	GPPT			PC			CPCR			SPP			CS			SQ			RS			TL			IP			SS			RAS			RFS			JS			TS			IN			TT			PTS			PMPT			PCPT			PCS		
RAS	0.333	0.320	0.280	0.308	0.305	0.291	0.322	0.313	0.283	0.037	0.063	0.146	0.296	0.307	0.289	0.250	0.249	0.255	0.228	0.222	0.230	0.227	0.221	0.226	0.293	0.281	0.328	0.302	0.288	0.097	0.108	0.146	0.243	0.297	0.285	0.332	0.133	0.179	0.226	0.076	0.117	0.183	0.371	0.328	0.278	0.419	0.375	0.313	0.253	0.253	0.251	0.244	0.242	0.243	0.245	0.246	0.247	0.258	0.259	0.260
RFS	0.333	0.320	0.280	0.308	0.305	0.291	0.322	0.313	0.283	0.037	0.063	0.146	0.296	0.307	0.289	0.250	0.249	0.255	0.228	0.222	0.230	0.227	0.221	0.226	0.207	0.247	0.299	0.357	0.312	0.146	0.362	0.316	0.335	0.074	0.125	0.220	0.133	0.179	0.226	0.076	0.117	0.183	0.371	0.328	0.278	0.419	0.375	0.313	0.253	0.253	0.251	0.244	0.242	0.243	0.245	0.246	0.247	0.258	0.259	0.260
JS	0.334	0.311	0.266	0.238	0.258	0.276	0.253	0.267	0.268	0.175	0.164	0.191	0.293	0.306	0.290	0.250	0.249	0.255	0.228	0.223	0.229	0.229	0.222	0.226	0.245	0.245	0.286	0.252	0.252	0.129	0.255	0.255	0.295	0.248	0.248	0.290	0.140	0.178	0.205	0.182	0.203	0.218	0.317	0.289	0.271	0.361	0.331	0.305	0.265	0.259	0.251	0.257	0.248	0.243	0.260	0.253	0.247	0.219	0.239	0.259
TS	0.357	0.320	0.270	0.261	0.270	0.281	0.200	0.245	0.256	0.182	0.165	0.193	0.293	0.305	0.289	0.250	0.250	0.255	0.229	0.223	0.230	0.229	0.223	0.226	0.245	0.245	0.280	0.252	0.252	0.147	0.255	0.255	0.289	0.248	0.248	0.284	0.280	0.275	0.271	0.069	0.111	0.162	0.345	0.305	0.268	0.305	0.309	0.300	0.265	0.259	0.251	0.257	0.249	0.243	0.259	0.253	0.247	0.218	0.240	0.259
IN	0.207	0.246	0.250	0.546	0.437	0.335	0.192	0.235	0.253	0.054	0.081	0.162	0.506	0.376	0.316	0.293	0.268	0.261	0.103	0.179	0.214	0.098	0.177	0.210	0.245	0.245	0.285	0.252	0.252	0.132	0.255	0.255	0.294	0.248	0.248	0.289	0.368	0.318	0.277	0.147	0.187	0.219	0.091	0.144	0.195	0.394	0.351	0.308	0.359	0.299	0.263	0.353	0.290	0.256	0.180	0.219	0.242	0.107	0.192	0.239
TT	0.049	0.107	0.227	0.831	0.687	0.370	0.069	0.124	0.233	0.051	0.083	0.169	0.368	0.350	0.294	0.256	0.250	0.255	0.210	0.208	0.228	0.166	0.192	0.223	0.245	0.245	0.296	0.252	0.252	0.099	0.255	0.255	0.305	0.248	0.248	0.300	0.449	0.407	0.306	0.056	0.085	0.190	0.410	0.384	0.297	0.084	0.124	0.207	0.094	0.148	0.226	0.081	0.136	0.218	0.074	0.131	0.220	0.751	0.586	0.336
PTS	0.357	0.332	0.279	0.259	0.278	0.291	0.346	0.323	0.281	0.039	0.067	0.149	0.506	0.396	0.310	0.334	0.283	0.273	0.082	0.161	0.210	0.078	0.159	0.206	0.245	0.245	0.286	0.252	0.252	0.131	0.255	0.255	0.294	0.248	0.248	0.289	0.263	0.260	0.254	0.218	0.209	0.216	0.243	0.247	0.249	0.276	0.284	0.281	0.126	0.170	0.204	0.269	0.262	0.259	0.331	0.293	0.262	0.274	0.275	0.275
PMPT	0.328	0.316	0.279	0.312	0.305	0.291	0.314	0.306	0.281	0.047	0.073	0.149	0.426	0.360	0.310	0.363	0.293	0.273	0.108	0.174	0.210	0.104	0.172	0.206	0.245	0.245	0.279	0.252	0.252	0.150	0.255	0.255	0.288	0.248	0.248	0.283	0.255	0.254	0.254	0.221	0.211	0.216	0.251	0.252	0.250	0.274	0.283	0.281	0.342	0.301	0.267	0.127	0.165	0.196	0.261	0.261	0.262	0.271	0.273	0.275
PCPT	0.361	0.335	0.280	0.249	0.272	0.291	0.355	0.330	0.283	0.035	0.063	0.146	0.654	0.512	0.341	0.247	0.287	0.276	0.052	0.103	0.194	0.047	0.099	0.189	0.245	0.245	0.293	0.252	0.252	0.108	0.255	0.255	0.302	0.248	0.248	0.297	0.502	0.348	0.287	0.095	0.173	0.202	0.093	0.186	0.228	0.310	0.293	0.284	0.279	0.278	0.272	0.271	0.269	0.265	0.082	0.131	0.184	0.368	0.323	0.280
PCS	0.130	0.189	0.233	0.508	0.407	0.324	0.127	0.184	0.236	0.234	0.220	0.207	0.358	0.412	0.317	0.264	0.230	0.250	0.196	0.182	0.219	0.182	0.177	0.214	0.245	0.245	0.290	0.252	0.252	0.117	0.255	0.255	0.299	0.248	0.248	0.294	0.421	0.309	0.274	0.222	0.214	0.217	0.088	0.195	0.229	0.269	0.282	0.279	0.401	0.319	0.282	0.242	0.259	0.255	0.248	0.261	0.257	0.110	0.161	0.205

Table 4.14a Unweighted supermatrix of criteria (Step 2)

	GPPT	PC	CPCR	SPP	CS	SQ	RS	TL	IP	SS	RAS	RFS	JS	TS	IN	TT	PTS	PMPT	PCPT	PCS
GPPT	0.120 0.164 0.204	0.151 0.199 0.240	0.493 0.420 0.310	0.354 0.330 0.285	0.497 0.390 0.292	0.336 0.321 0.280	0.620 0.432 0.304	0.369 0.325 0.271	0.333 0.320 0.280	0.333 0.320 0.280	0.333 0.320 0.280	0.333 0.320 0.280	0.334 0.311 0.266	0.357 0.320 0.270	0.207 0.246 0.250	0.049 0.107 0.227	0.357 0.332 0.279	0.328 0.316 0.279	0.361 0.335 0.280	0.130 0.189 0.233
PC	0.099 0.151 0.247	0.113 0.175 0.229	0.108 0.163 0.246	0.338 0.317 0.297	0.226 0.269 0.284	0.303 0.300 0.290	0.072 0.207 0.262	0.149 0.213 0.256	0.308 0.305 0.291	0.308 0.305 0.291	0.308 0.305 0.291	0.308 0.305 0.291	0.238 0.258 0.276	0.261 0.270 0.281	0.546 0.437 0.335	0.831 0.687 0.370	0.259 0.278 0.291	0.312 0.305 0.291	0.249 0.272 0.291	0.508 0.407 0.324
CPCR	0.580 0.457 0.326	0.454 0.385 0.305	0.112 0.162 0.208	0.268 0.284 0.287	0.233 0.271 0.271	0.319 0.309 0.282	0.266 0.293 0.280	0.266 0.272 0.272	0.322 0.313 0.283	0.322 0.313 0.283	0.322 0.313 0.283	0.322 0.313 0.283	0.253 0.267 0.268	0.200 0.245 0.256	0.192 0.235 0.253	0.069 0.124 0.233	0.346 0.323 0.281	0.314 0.306 0.281	0.355 0.330 0.283	0.127 0.184 0.236
SPP	0.201 0.228 0.223	0.283 0.241 0.227	0.287 0.254 0.236	0.040 0.068 0.132	0.044 0.070 0.152	0.043 0.070 0.149	0.041 0.068 0.154	0.216 0.190 0.201	0.037 0.063 0.146	0.037 0.063 0.146	0.037 0.063 0.146	0.037 0.063 0.146	0.175 0.164 0.191	0.182 0.165 0.193	0.054 0.081 0.162	0.051 0.083 0.169	0.039 0.067 0.149	0.047 0.073 0.149	0.035 0.063 0.146	0.234 0.220 0.207
CS	0.460 0.396 0.301	0.386 0.352 0.295	0.747 0.590 0.360	0.408 0.351 0.306	0.405 0.368 0.276	0.421 0.382 0.313	0.387 0.372 0.316	0.435 0.394 0.316	0.296 0.307 0.289	0.296 0.307 0.289	0.296 0.307 0.289	0.296 0.307 0.289	0.293 0.306 0.290	0.293 0.305 0.289	0.506 0.376 0.316	0.368 0.350 0.294	0.506 0.396 0.310	0.426 0.360 0.310	0.654 0.512 0.341	0.358 0.412 0.317
SQ	0.268 0.256 0.257	0.249 0.248 0.260	0.116 0.169 0.235	0.220 0.239 0.251	0.282 0.261 0.267	0.076 0.132 0.194	0.248 0.262 0.280	0.275 0.275 0.278	0.250 0.249 0.255	0.250 0.249 0.255	0.250 0.249 0.255	0.250 0.249 0.255	0.250 0.249 0.255	0.250 0.250 0.255	0.293 0.268 0.261	0.256 0.250 0.255	0.334 0.283 0.273	0.363 0.293 0.273	0.247 0.287 0.276	0.264 0.230 0.250
RS	0.138 0.175 0.222	0.228 0.221 0.234	0.069 0.121 0.204	0.188 0.206 0.224	0.161 0.188 0.231	0.252 0.244 0.248	0.023 0.073 0.152	0.258 0.247 0.252	0.228 0.222 0.230	0.228 0.222 0.230	0.228 0.222 0.230	0.228 0.222 0.230	0.228 0.223 0.229	0.229 0.223 0.230	0.103 0.179 0.214	0.210 0.208 0.228	0.082 0.161 0.210	0.108 0.174 0.210	0.052 0.103 0.194	0.196 0.182 0.219
TL	0.134 0.173 0.219	0.136 0.179 0.211	0.068 0.120 0.201	0.184 0.204 0.220	0.152 0.183 0.226	0.251 0.243 0.245	0.341 0.294 0.252	0.033 0.083 0.154	0.227 0.221 0.226	0.227 0.221 0.226	0.227 0.221 0.226	0.227 0.221 0.226	0.229 0.222 0.226	0.229 0.223 0.226	0.098 0.177 0.210	0.166 0.192 0.223	0.078 0.159 0.206	0.104 0.172 0.206	0.047 0.099 0.189	0.182 0.177 0.214
IP	0.245 0.245 0.294	0.245 0.245 0.293	0.245 0.245 0.293	0.245 0.245 0.290	0.245 0.245 0.293	0.245 0.245 0.291	0.245 0.245 0.299	0.245 0.245 0.298	0.064 0.117 0.211	0.242 0.263 0.276	0.293 0.281 0.328	0.207 0.247 0.299	0.245 0.245 0.286	0.245 0.245 0.280	0.245 0.245 0.285	0.245 0.245 0.296	0.245 0.245 0.286	0.245 0.245 0.279	0.245 0.245 0.293	0.245 0.245 0.290
SS	0.252 0.252 0.106	0.252 0.252 0.109	0.252 0.252 0.109	0.252 0.252 0.116	0.252 0.252 0.109	0.252 0.252 0.115	0.252 0.252 0.090	0.252 0.252 0.093	0.312 0.294 0.143	0.088 0.135 0.135	0.302 0.288 0.097	0.357 0.312 0.146	0.252 0.252 0.129	0.252 0.252 0.147	0.252 0.252 0.132	0.252 0.252 0.099	0.252 0.252 0.131	0.252 0.252 0.150	0.252 0.252 0.108	0.252 0.252 0.117

Table 4.14b Unweighted supermatrix of criteria (Step 2)

	GPPT	PC	CPCR	SPP	CS	SQ	RS	TL	IP	SS
RAS	0.255 0.255 0.303	0.255 0.255 0.301	0.255 0.255 0.301	0.255 0.255 0.299	0.255 0.255 0.301	0.255 0.255 0.300	0.255 0.255 0.308	0.255 0.255 0.307	0.316 0.298 0.326	0.424 0.336 0.309
RFS	0.248 0.248 0.298	0.248 0.248 0.296	0.248 0.248 0.296	0.248 0.248 0.294	0.248 0.248 0.296	0.248 0.248 0.294	0.248 0.248 0.303	0.248 0.248 0.302	0.308 0.291 0.320	0.246 0.266 0.280
JS	0.513 0.409 0.306	0.291 0.274 0.261	0.326 0.308 0.274	0.198 0.234 0.243	0.355 0.310 0.263	0.239 0.251 0.251	0.368 0.299 0.265	0.335 0.257 0.251	0.133 0.179 0.226	0.133 0.179 0.226
TS	0.091 0.121 0.184	0.254 0.231 0.225	0.279 0.257 0.236	0.246 0.221 0.221	0.138 0.178 0.205	0.187 0.197 0.211	0.165 0.129 0.192	0.188 0.172 0.206	0.076 0.117 0.183	0.076 0.117 0.183
IN	0.085 0.132 0.210	0.164 0.211 0.234	0.077 0.124 0.197	0.261 0.254 0.253	0.243 0.241 0.251	0.206 0.235 0.244	0.169 0.258 0.253	0.180 0.296 0.265	0.371 0.328 0.278	0.371 0.328 0.278
TT	0.311 0.339 0.300	0.291 0.284 0.281	0.318 0.312 0.293	0.295 0.291 0.284	0.265 0.271 0.281	0.369 0.317 0.294	0.298 0.313 0.289	0.297 0.276 0.277	0.419 0.375 0.313	0.419 0.375 0.313
PTS	0.217 0.232 0.251	0.238 0.246 0.251	0.268 0.261 0.251	0.223 0.238 0.251	0.312 0.283 0.256	0.253 0.253 0.251	0.214 0.252 0.251	0.180 0.223 0.242	0.253 0.253 0.251	0.253 0.253 0.251
PMPT	0.280 0.264 0.244	0.226 0.233 0.243	0.201 0.220 0.244	0.216 0.229 0.243	0.307 0.276 0.249	0.244 0.242 0.243	0.087 0.141 0.202	0.173 0.213 0.234	0.244 0.242 0.243	0.244 0.242 0.243
PCPT	0.212 0.227 0.247	0.230 0.239 0.247	0.260 0.253 0.246	0.274 0.260 0.246	0.148 0.197 0.232	0.246 0.246 0.247	0.343 0.297 0.267	0.360 0.295 0.256	0.245 0.246 0.247	0.245 0.246 0.247
PCS	0.291 0.278 0.259	0.306 0.283 0.260	0.271 0.266 0.259	0.287 0.273 0.259	0.233 0.245 0.263	0.258 0.259 0.260	0.357 0.310 0.280	0.287 0.269 0.268	0.258 0.259 0.260	0.258 0.259 0.260

	RAS	RFS	JS	TS	IN	TT	PTS	PMPT	PCPT	PCS
RAS	0.108 0.146 0.243	0.362 0.316 0.335	0.255 0.255 0.295	0.255 0.255 0.289	0.255 0.255 0.294	0.255 0.255 0.305	0.255 0.255 0.294	0.255 0.255 0.288	0.255 0.255 0.302	0.255 0.255 0.299
RFS	0.297 0.285 0.332	0.074 0.125 0.220	0.248 0.248 0.290	0.248 0.248 0.284	0.248 0.248 0.289	0.248 0.248 0.300	0.248 0.248 0.289	0.248 0.248 0.283	0.248 0.248 0.297	0.248 0.248 0.294
JS	0.133 0.179 0.226	0.133 0.179 0.226	0.140 0.178 0.205	0.280 0.275 0.271	0.368 0.318 0.277	0.449 0.407 0.306	0.263 0.260 0.254	0.255 0.254 0.254	0.502 0.348 0.287	0.421 0.309 0.274
TS	0.076 0.117 0.183	0.076 0.117 0.183	0.182 0.203 0.218	0.069 0.111 0.162	0.147 0.187 0.219	0.056 0.085 0.190	0.218 0.209 0.216	0.221 0.211 0.216	0.095 0.173 0.202	0.222 0.214 0.217
IN	0.371 0.328 0.278	0.371 0.328 0.278	0.317 0.289 0.271	0.345 0.305 0.268	0.091 0.144 0.195	0.410 0.384 0.297	0.243 0.247 0.249	0.251 0.252 0.250	0.093 0.186 0.228	0.088 0.195 0.229
TT	0.419 0.375 0.313	0.419 0.375 0.313	0.361 0.331 0.305	0.305 0.309 0.300	0.394 0.351 0.308	0.084 0.124 0.207	0.276 0.284 0.281	0.274 0.283 0.281	0.310 0.293 0.284	0.269 0.282 0.279
PTS	0.253 0.253 0.251	0.253 0.253 0.251	0.265 0.259 0.251	0.265 0.259 0.251	0.359 0.299 0.263	0.094 0.148 0.226	0.126 0.170 0.204	0.342 0.301 0.267	0.279 0.278 0.272	0.401 0.319 0.282
PMPT	0.244 0.242 0.243	0.244 0.242 0.243	0.257 0.248 0.243	0.257 0.249 0.243	0.353 0.290 0.256	0.081 0.136 0.218	0.269 0.262 0.259	0.127 0.165 0.196	0.271 0.269 0.265	0.242 0.259 0.255
PCPT	0.245 0.246 0.247	0.245 0.246 0.247	0.260 0.253 0.247	0.259 0.253 0.247	0.180 0.219 0.242	0.074 0.131 0.220	0.331 0.293 0.262	0.261 0.261 0.262	0.082 0.131 0.184	0.248 0.261 0.257
PCS	0.258 0.259 0.260	0.258 0.259 0.260	0.219 0.239 0.259	0.218 0.240 0.259	0.107 0.192 0.239	0.751 0.586 0.336	0.274 0.275 0.275	0.271 0.273 0.275	0.368 0.323 0.280	0.110 0.161 0.205

Table 4.15a Weighted supermatrix of criteria (Step 3)

	GPPT	PC	CPCR	SPP	CS	SQ	RS	TL	IP	SS
GPPT	0.025 0.033 0.040	0.032 0.040 0.047	0.103 0.084 0.061	0.074 0.066 0.056	0.119 0.085 0.062	0.080 0.070 0.059	0.148 0.094 0.064	0.088 0.071 0.057	0.067 0.063 0.057	0.067 0.063 0.057
PC	0.021 0.030 0.049	0.024 0.035 0.045	0.023 0.032 0.049	0.071 0.063 0.059	0.054 0.059 0.060	0.072 0.065 0.061	0.017 0.045 0.055	0.036 0.046 0.054	0.062 0.060 0.059	0.062 0.060 0.059
CPCR	0.121 0.091 0.064	0.095 0.077 0.060	0.023 0.032 0.041	0.056 0.057 0.057	0.056 0.059 0.057	0.076 0.067 0.060	0.064 0.064 0.059	0.064 0.059 0.057	0.065 0.062 0.058	0.065 0.062 0.058
SPP	0.042 0.045 0.044	0.059 0.048 0.045	0.060 0.051 0.047	0.008 0.014 0.026	0.011 0.015 0.032	0.010 0.015 0.031	0.010 0.015 0.033	0.052 0.041 0.042	0.007 0.012 0.030	0.007 0.012 0.030
CS	0.072 0.067 0.057	0.060 0.059 0.056	0.117 0.099 0.068	0.064 0.059 0.058	0.087 0.069 0.052	0.090 0.072 0.059	0.083 0.070 0.060	0.093 0.074 0.060	0.069 0.066 0.060	0.069 0.066 0.060
SQ	0.042 0.043 0.049	0.039 0.042 0.049	0.018 0.028 0.045	0.034 0.040 0.048	0.060 0.049 0.051	0.016 0.025 0.037	0.053 0.049 0.053	0.059 0.052 0.053	0.058 0.054 0.053	0.058 0.054 0.053
RS	0.022 0.029 0.042	0.036 0.037 0.044	0.011 0.020 0.039	0.029 0.035 0.042	0.034 0.035 0.044	0.054 0.046 0.047	0.005 0.014 0.029	0.055 0.046 0.048	0.053 0.048 0.048	0.053 0.048 0.048
TL	0.021 0.029 0.041	0.021 0.030 0.040	0.011 0.020 0.038	0.029 0.034 0.042	0.033 0.034 0.043	0.054 0.046 0.046	0.073 0.055 0.048	0.007 0.016 0.029	0.053 0.048 0.047	0.053 0.048 0.047
IP	0.019 0.027 0.039	0.019 0.027 0.039	0.019 0.027 0.039	0.019 0.027 0.039	0.018 0.031 0.041	0.018 0.031 0.041	0.018 0.031 0.042	0.018 0.031 0.042	0.009 0.018 0.031	0.034 0.040 0.040
SS	0.019 0.027 0.014	0.019 0.027 0.015	0.019 0.027 0.015	0.019 0.027 0.015	0.018 0.032 0.015	0.018 0.032 0.016	0.018 0.032 0.013	0.018 0.032 0.013	0.044 0.045 0.021	0.012 0.021 0.020

	RAS	RFS	JS	TS	IN	TT	PTS	PMPT	PCPT	PCS
GPPT	0.067 0.063 0.057	0.067 0.063 0.057	0.060 0.057 0.053	0.064 0.059 0.054	0.037 0.045 0.050	0.009 0.020 0.046	0.076 0.066 0.057	0.070 0.063 0.057	0.077 0.067 0.057	0.028 0.038 0.048
PC	0.062 0.060 0.059	0.062 0.060 0.059	0.043 0.048 0.056	0.047 0.050 0.057	0.098 0.081 0.067	0.150 0.127 0.074	0.055 0.056 0.060	0.066 0.061 0.060	0.053 0.054 0.060	0.108 0.082 0.066
CPCR	0.065 0.062 0.058	0.065 0.062 0.058	0.046 0.049 0.054	0.036 0.045 0.051	0.035 0.043 0.051	0.012 0.023 0.047	0.074 0.065 0.058	0.067 0.061 0.058	0.076 0.066 0.058	0.027 0.037 0.048
SPP	0.007 0.012 0.030	0.007 0.012 0.030	0.032 0.030 0.038	0.033 0.030 0.039	0.010 0.015 0.033	0.009 0.015 0.034	0.008 0.013 0.030	0.010 0.015 0.030	0.007 0.013 0.030	0.050 0.044 0.042
CS	0.069 0.066 0.060	0.069 0.066 0.060	0.059 0.060 0.057	0.059 0.060 0.057	0.102 0.074 0.062	0.074 0.069 0.058	0.070 0.064 0.058	0.059 0.058 0.058	0.091 0.083 0.064	0.050 0.067 0.059
SQ	0.058 0.054 0.053	0.058 0.054 0.053	0.050 0.049 0.050	0.050 0.049 0.050	0.059 0.053 0.051	0.052 0.049 0.050	0.046 0.046 0.051	0.050 0.048 0.051	0.034 0.047 0.051	0.037 0.037 0.047
RS	0.053 0.048 0.048	0.053 0.048 0.048	0.046 0.044 0.045	0.046 0.044 0.045	0.021 0.035 0.042	0.042 0.041 0.045	0.011 0.026 0.039	0.015 0.028 0.039	0.007 0.017 0.036	0.027 0.030 0.041
TL	0.053 0.048 0.047	0.053 0.048 0.047	0.046 0.044 0.044	0.046 0.044 0.044	0.020 0.035 0.041	0.033 0.038 0.044	0.011 0.026 0.038	0.014 0.028 0.038	0.007 0.016 0.035	0.025 0.029 0.040
IP	0.041 0.043 0.048	0.029 0.038 0.044	0.047 0.044 0.046	0.047 0.044 0.045	0.047 0.044 0.046	0.047 0.044 0.047	0.045 0.043 0.045	0.045 0.043 0.044	0.045 0.043 0.046	0.045 0.043 0.045
SS	0.042 0.044 0.014	0.050 0.048 0.021	0.048 0.045 0.021	0.048 0.045 0.024	0.048 0.045 0.021	0.048 0.045 0.016	0.046 0.044 0.021	0.046 0.044 0.023	0.046 0.044 0.017	0.046 0.044 0.018

Table 4.15b Weighted supermatrix of criteria (Step 3)

	GPPT	PC	CPCR	SPP	CS	SQ	RS	TL	IP	SS	RAS	RFS	JS	TS	IN	TT	PTS	PMPT	PCPT	PCS
RAS	0.020 0.028 0.040	0.020 0.028 0.040	0.020 0.028 0.040	0.020 0.028 0.040	0.019 0.032 0.042	0.019 0.032 0.042	0.019 0.032 0.043	0.019 0.032 0.043	0.044 0.045 0.047	0.059 0.051 0.045	0.015 0.022 0.035	0.050 0.048 0.049	0.048 0.046 0.047	0.048 0.046 0.046	0.048 0.046 0.047	0.048 0.046 0.049	0.047 0.044 0.046	0.047 0.044 0.045	0.047 0.044 0.047	0.047 0.044 0.047
RFS	0.019 0.027 0.040	0.019 0.027 0.040	0.019 0.027 0.040	0.019 0.027 0.039	0.018 0.031 0.041	0.018 0.031 0.041	0.018 0.031 0.042	0.018 0.031 0.042	0.043 0.044 0.047	0.034 0.041 0.041	0.041 0.043 0.048	0.010 0.019 0.032	0.047 0.044 0.047	0.047 0.044 0.046	0.047 0.044 0.046	0.047 0.044 0.048	0.046 0.043 0.045	0.046 0.043 0.044	0.046 0.043 0.046	0.046 0.043 0.046
JS	0.109 0.089 0.067	0.062 0.059 0.057	0.069 0.067 0.060	0.042 0.051 0.053	0.058 0.058 0.054	0.039 0.047 0.051	0.060 0.056 0.054	0.054 0.048 0.051	0.020 0.030 0.044	0.020 0.030 0.044	0.020 0.030 0.044	0.020 0.030 0.044	0.024 0.033 0.041	0.048 0.051 0.054	0.064 0.059 0.055	0.078 0.076 0.061	0.058 0.057 0.055	0.056 0.056 0.055	0.111 0.076 0.062	0.093 0.068 0.059
TS	0.019 0.026 0.040	0.054 0.050 0.049	0.059 0.056 0.052	0.052 0.048 0.048	0.022 0.033 0.042	0.030 0.037 0.043	0.027 0.024 0.039	0.031 0.032 0.042	0.012 0.020 0.036	0.012 0.020 0.036	0.012 0.020 0.036	0.012 0.020 0.036	0.031 0.038 0.044	0.012 0.021 0.032	0.025 0.035 0.044	0.010 0.016 0.038	0.048 0.046 0.047	0.049 0.046 0.047	0.021 0.038 0.044	0.049 0.047 0.047
IN	0.018 0.029 0.046	0.035 0.046 0.051	0.016 0.027 0.043	0.056 0.055 0.055	0.039 0.045 0.051	0.033 0.044 0.050	0.027 0.048 0.052	0.029 0.055 0.054	0.057 0.055 0.054	0.057 0.055 0.054	0.057 0.055 0.054	0.057 0.055 0.054	0.055 0.054 0.054	0.060 0.057 0.053	0.016 0.027 0.039	0.071 0.072 0.059	0.054 0.054 0.054	0.055 0.055 0.054	0.020 0.041 0.049	0.019 0.043 0.049
TT	0.066 0.074 0.065	0.062 0.062 0.061	0.068 0.068 0.064	0.063 0.063 0.062	0.043 0.050 0.057	0.060 0.059 0.060	0.048 0.058 0.059	0.048 0.051 0.057	0.064 0.063 0.061	0.064 0.063 0.061	0.064 0.063 0.061	0.064 0.063 0.061	0.062 0.062 0.061	0.053 0.058 0.060	0.068 0.065 0.061	0.015 0.023 0.041	0.061 0.062 0.061	0.060 0.062 0.061	0.068 0.064 0.061	0.059 0.062 0.060
PTS	0.075 0.071 0.066	0.082 0.076 0.066	0.092 0.080 0.066	0.077 0.073 0.066	0.097 0.080 0.065	0.079 0.071 0.064	0.067 0.071 0.064	0.056 0.063 0.062	0.069 0.067 0.063	0.069 0.067 0.063	0.069 0.067 0.063	0.069 0.067 0.063	0.068 0.066 0.061	0.068 0.066 0.061	0.092 0.076 0.064	0.024 0.038 0.055	0.031 0.041 0.048	0.083 0.073 0.063	0.068 0.068 0.064	0.098 0.078 0.067
PMPT	0.097 0.081 0.064	0.078 0.072 0.063	0.069 0.068 0.064	0.075 0.070 0.063	0.096 0.078 0.063	0.076 0.068 0.062	0.027 0.040 0.051	0.054 0.060 0.060	0.067 0.064 0.061	0.067 0.064 0.061	0.067 0.064 0.061	0.067 0.064 0.061	0.066 0.063 0.059	0.066 0.063 0.059	0.090 0.074 0.062	0.021 0.034 0.053	0.066 0.064 0.061	0.031 0.040 0.046	0.066 0.066 0.063	0.059 0.063 0.060
PCPT	0.073 0.070 0.064	0.079 0.073 0.064	0.090 0.078 0.064	0.095 0.080 0.064	0.046 0.056 0.059	0.077 0.069 0.063	0.107 0.084 0.068	0.112 0.083 0.065	0.067 0.066 0.062	0.067 0.066 0.062	0.067 0.066 0.062	0.067 0.066 0.062	0.066 0.064 0.060	0.066 0.064 0.060	0.046 0.056 0.059	0.019 0.033 0.053	0.081 0.072 0.062	0.064 0.064 0.062	0.020 0.032 0.043	0.060 0.064 0.061
PCS	0.100 0.085 0.068	0.106 0.087 0.068	0.093 0.082 0.068	0.099 0.084 0.068	0.073 0.069 0.067	0.080 0.073 0.066	0.111 0.087 0.071	0.089 0.076 0.068	0.070 0.069 0.065	0.070 0.069 0.065	0.070 0.069 0.065	0.070 0.069 0.065	0.056 0.061 0.063	0.056 0.061 0.063	0.027 0.049 0.058	0.192 0.149 0.081	0.067 0.067 0.065	0.066 0.067 0.065	0.090 0.079 0.066	0.027 0.039 0.048

Table 4.16a Limited supermatrix of criteria (Step 4)

	GPPT			PC			CPCR			SPP			CS			SQ			RS			TL			IP			SS		
GPPT	0.065	0.059	0.054	0.065	0.059	0.054	0.065	0.059	0.055	0.065	0.059	0.054	0.065	0.059	0.054	0.065	0.059	0.054	0.065	0.059	0.054	0.065	0.059	0.054	0.065	0.059	0.054	0.065	0.059	0.054
PCC	0.060	0.059	0.059	0.060	0.059	0.059	0.060	0.059	0.059	0.060	0.059	0.059	0.060	0.059	0.058	0.060	0.059	0.059	0.060	0.059	0.059	0.060	0.059	0.059	0.060	0.059	0.059	0.060	0.059	0.059
CPCR	0.060	0.057	0.055	0.060	0.057	0.055	0.060	0.057	0.055	0.060	0.057	0.055	0.060	0.057	0.055	0.060	0.057	0.055	0.060	0.057	0.055	0.060	0.057	0.055	0.060	0.057	0.055	0.060	0.057	0.055
SPP	0.024	0.024	0.035	0.024	0.024	0.035	0.024	0.024	0.035	0.024	0.024	0.035	0.024	0.024	0.035	0.024	0.024	0.035	0.024	0.024	0.035	0.024	0.024	0.035	0.024	0.024	0.035	0.024	0.024	0.035
CS	0.075	0.069	0.059	0.075	0.069	0.059	0.075	0.069	0.059	0.075	0.069	0.059	0.075	0.069	0.059	0.075	0.069	0.059	0.075	0.069	0.059	0.075	0.069	0.059	0.075	0.069	0.059	0.075	0.069	0.059
SQ	0.045	0.045	0.050	0.045	0.045	0.050	0.045	0.045	0.050	0.045	0.045	0.050	0.045	0.045	0.050	0.045	0.045	0.050	0.045	0.045	0.050	0.045	0.045	0.050	0.045	0.045	0.050	0.045	0.045	0.050
RS	0.031	0.035	0.043	0.031	0.035	0.043	0.031	0.035	0.043	0.031	0.035	0.043	0.031	0.035	0.043	0.031	0.035	0.043	0.031	0.035	0.043	0.031	0.035	0.043	0.031	0.035	0.043	0.031	0.035	0.043
TL	0.030	0.034	0.042	0.030	0.034	0.042	0.030	0.034	0.042	0.030	0.034	0.042	0.030	0.034	0.042	0.030	0.034	0.042	0.030	0.034	0.042	0.030	0.034	0.042	0.030	0.034	0.042	0.030	0.034	0.042
IP	0.033	0.036	0.043	0.033	0.036	0.043	0.033	0.036	0.043	0.033	0.036	0.043	0.033	0.036	0.043	0.033	0.036	0.043	0.033	0.036	0.043	0.033	0.036	0.043	0.033	0.036	0.043	0.033	0.036	0.043
SS	0.034	0.038	0.018	0.034	0.038	0.018	0.034	0.038	0.018	0.034	0.038	0.018	0.034	0.038	0.018	0.034	0.038	0.018	0.034	0.038	0.018	0.034	0.038	0.018	0.034	0.038	0.018	0.034	0.038	0.018

	RAS			RFS			JS			TS			IN			TT			PTS			PMPT			PCPT			PCS		
GPPT	0.065	0.059	0.054	0.065	0.059	0.054	0.065	0.059	0.054	0.065	0.059	0.054	0.065	0.059	0.054	0.065	0.059	0.054	0.065	0.059	0.054	0.065	0.059	0.054	0.065	0.059	0.054	0.065	0.059	0.054
PCC	0.060	0.059	0.059	0.060	0.059	0.059	0.060	0.059	0.059	0.060	0.059	0.059	0.060	0.059	0.059	0.060	0.059	0.059	0.060	0.059	0.059	0.060	0.059	0.059	0.060	0.059	0.059	0.060	0.059	0.058
CPCR	0.060	0.057	0.055	0.060	0.057	0.055	0.060	0.057	0.055	0.060	0.057	0.055	0.060	0.057	0.055	0.060	0.057	0.055	0.060	0.057	0.055	0.060	0.057	0.055	0.060	0.057	0.055	0.060	0.057	0.055
SPP	0.024	0.024	0.035	0.024	0.024	0.035	0.024	0.024	0.035	0.024	0.024	0.035	0.024	0.024	0.035	0.024	0.024	0.035	0.024	0.024	0.035	0.024	0.024	0.035	0.024	0.024	0.035	0.024	0.024	0.035
CS	0.075	0.069	0.059	0.075	0.069	0.059	0.075	0.069	0.059	0.075	0.069	0.059	0.075	0.069	0.059	0.075	0.069	0.059	0.075	0.069	0.059	0.075	0.069	0.059	0.075	0.069	0.059	0.075	0.069	0.059
SQ	0.045	0.045	0.050	0.045	0.045	0.050	0.045	0.045	0.050	0.045	0.045	0.050	0.045	0.045	0.050	0.045	0.045	0.050	0.045	0.045	0.050	0.045	0.045	0.050	0.045	0.045	0.050	0.045	0.045	0.050
RS	0.031	0.035	0.043	0.031	0.035	0.043	0.031	0.035	0.043	0.031	0.035	0.043	0.031	0.035	0.043	0.031	0.035	0.043	0.031	0.035	0.043	0.031	0.035	0.043	0.031	0.035	0.043	0.031	0.035	0.043
TL	0.030	0.034	0.042	0.030	0.034	0.042	0.030	0.034	0.042	0.030	0.034	0.042	0.030	0.034	0.042	0.030	0.034	0.042	0.030	0.034	0.042	0.030	0.034	0.042	0.030	0.034	0.042	0.030	0.034	0.042
IP	0.033	0.036	0.043	0.033	0.036	0.043	0.033	0.036	0.043	0.033	0.036	0.043	0.033	0.036	0.043	0.033	0.036	0.043	0.033	0.036	0.043	0.033	0.036	0.043	0.033	0.036	0.043	0.033	0.036	0.043
SS	0.034	0.038	0.018	0.034	0.038	0.018	0.034	0.038	0.018	0.034	0.038	0.018	0.034	0.038	0.018	0.034	0.038	0.018	0.034	0.038	0.018	0.034	0.038	0.018	0.034	0.038	0.018	0.034	0.038	0.018

Table 4.16b Limited supermatrix of criteria (Step 4)

	GPPT	PC	CPCR	SPP	CS	SQ	RS	TL	IP	SS	RAS	RFS	JS	TS	IN	TT	PTS	PMPT	PCPT	PCS
RAS	0.036 0.039 0.044	0.036 0.039 0.044	0.036 0.039 0.044	0.036 0.039 0.044	0.036 0.039 0.044	0.036 0.039 0.044	0.036 0.039 0.044	0.036 0.039 0.044	0.036 0.039 0.044	0.036 0.039 0.044	0.036 0.039 0.044	0.036 0.039 0.044	0.036 0.039 0.044	0.036 0.039 0.044	0.036 0.039 0.044	0.036 0.039 0.044	0.036 0.039 0.044	0.036 0.039 0.044	0.036 0.039 0.044	0.036 0.039 0.044
RFS	0.034 0.037 0.043	0.034 0.037 0.043	0.034 0.037 0.043	0.034 0.037 0.043	0.034 0.037 0.043	0.034 0.037 0.043	0.034 0.037 0.043	0.034 0.037 0.043	0.034 0.037 0.043	0.034 0.037 0.043	0.034 0.037 0.043	0.034 0.037 0.043	0.034 0.037 0.043	0.034 0.037 0.043	0.034 0.037 0.043	0.034 0.037 0.043	0.034 0.037 0.043	0.034 0.037 0.043	0.034 0.037 0.043	0.034 0.037 0.043
JS	0.061 0.056 0.054	0.061 0.056 0.054	0.061 0.056 0.054	0.061 0.056 0.054	0.061 0.056 0.054	0.061 0.056 0.054	0.061 0.056 0.054	0.061 0.056 0.054	0.061 0.056 0.054	0.061 0.056 0.054	0.061 0.056 0.054	0.061 0.056 0.054	0.061 0.056 0.054	0.061 0.056 0.054	0.061 0.056 0.054	0.061 0.056 0.054	0.061 0.056 0.054	0.061 0.056 0.054	0.061 0.056 0.054	0.061 0.056 0.054
TS	0.032 0.035 0.043	0.032 0.035 0.043	0.031 0.035 0.043	0.032 0.035 0.043	0.032 0.035 0.043	0.031 0.035 0.043	0.031 0.035 0.043	0.031 0.035 0.043	0.032 0.035 0.043	0.031 0.035 0.043	0.031 0.035 0.043	0.031 0.035 0.043	0.032 0.035 0.043	0.032 0.035 0.043	0.032 0.035 0.043	0.032 0.035 0.043	0.032 0.035 0.043	0.031 0.035 0.043	0.031 0.035 0.043	0.032 0.035 0.043
IN	0.040 0.048 0.051	0.040 0.048 0.051	0.040 0.048 0.051	0.040 0.048 0.051	0.040 0.048 0.051	0.040 0.048 0.051	0.040 0.048 0.051	0.040 0.048 0.051	0.040 0.048 0.051	0.040 0.048 0.051	0.040 0.048 0.051	0.040 0.048 0.051	0.040 0.048 0.051	0.040 0.048 0.051	0.040 0.048 0.051	0.040 0.048 0.051	0.040 0.048 0.051	0.040 0.048 0.051	0.040 0.048 0.051	0.040 0.048 0.051
TT	0.058 0.060 0.060	0.058 0.060 0.060	0.058 0.060 0.060	0.058 0.060 0.060	0.058 0.060 0.060	0.058 0.060 0.060	0.058 0.060 0.060	0.058 0.060 0.060	0.058 0.060 0.060	0.058 0.060 0.060	0.058 0.060 0.060	0.058 0.060 0.060	0.058 0.060 0.060	0.058 0.060 0.060	0.058 0.060 0.060	0.058 0.060 0.060	0.058 0.060 0.060	0.058 0.060 0.060	0.058 0.060 0.060	0.058 0.060 0.060
PTS	0.072 0.068 0.063	0.073 0.068 0.063	0.072 0.068 0.063	0.073 0.068 0.063	0.073 0.068 0.063	0.072 0.068 0.063	0.072 0.068 0.063	0.072 0.068 0.063	0.072 0.068 0.063	0.072 0.068 0.063	0.072 0.068 0.063	0.072 0.068 0.063	0.072 0.068 0.063	0.072 0.068 0.063	0.072 0.068 0.063	0.073 0.068 0.063	0.073 0.068 0.063	0.072 0.068 0.063	0.072 0.068 0.063	0.072 0.068 0.063
PMPT	0.066 0.063 0.060	0.066 0.063 0.060	0.066 0.063 0.060	0.066 0.063 0.060	0.066 0.063 0.060	0.066 0.063 0.060	0.066 0.063 0.060	0.066 0.063 0.060	0.066 0.063 0.060	0.066 0.063 0.060	0.066 0.063 0.060	0.066 0.063 0.060	0.066 0.063 0.060	0.066 0.063 0.060	0.066 0.063 0.060	0.066 0.063 0.060	0.066 0.063 0.060	0.066 0.063 0.060	0.066 0.063 0.060	0.066 0.063 0.060
PCPT	0.065 0.064 0.061	0.065 0.064 0.061	0.065 0.064 0.061	0.065 0.064 0.061	0.065 0.064 0.060	0.065 0.064 0.061	0.065 0.064 0.061	0.065 0.064 0.061	0.065 0.064 0.061	0.065 0.064 0.061	0.065 0.064 0.061	0.065 0.064 0.061	0.065 0.064 0.061	0.065 0.064 0.061	0.065 0.064 0.061	0.065 0.064 0.061	0.065 0.064 0.061	0.065 0.064 0.061	0.065 0.064 0.061	0.065 0.064 0.061
PCS	0.080 0.074 0.065	0.080 0.074 0.065	0.080 0.074 0.065	0.080 0.074 0.065	0.080 0.074 0.065	0.080 0.074 0.065	0.080 0.074 0.065	0.080 0.074 0.065	0.080 0.074 0.065	0.080 0.074 0.065	0.080 0.074 0.065	0.080 0.074 0.065	0.080 0.074 0.065	0.080 0.074 0.065	0.080 0.074 0.065	0.080 0.074 0.065	0.080 0.074 0.065	0.080 0.074 0.065	0.080 0.074 0.065	0.080 0.074 0.065

*In step 7-8 we will obtain the local and global weights of criteria by using Table 4.16a - Table 4.16b.

If we consider the significance of these criteria according to the global weights, we can order them as PCS > CS > PTS > PCPT > PMPT > TT > GPPT > PC > CPCR > JS > IN > SQ > RAS > SS > RFS > IP > RS > TS > TL > SPP. As we can see from this ranking, "probability of commercial success" is the most important criteria of all and it has the biggest role in Institution A in order to achieve its strategies. On the other hand, "success of purchasing process" is the least important criteria of all with the value of 0.024. In the light of this analogy, we can say that a project, in Institution A, must put an emphasis on "probability of commercial success" criteria more than other criteria.

Step 7-8: The assessment team makes decision about success rates of the criterion which have inadequate tangible data (Probability of technical success, Probability of making progress in technology, Job satisfaction, Technology transfer, etc.) by using DELPHI method, on the other hand, probability of completing the project in time and probability of commercial success criteria are assessed by using earned value analysis and the rest of the criteria are assessed by using collected data. The results can be seen in Table 4.17a-Table 4.17b.

Table 4.17a The global weights of criteria and performance score of Project X

Dimensions / Criteria	Local weight (based on global weights)	Global weights (based on fuzzy DANP)	Performance Scale	Project Performance
F	***0.2***			
GPPT	0.296	0.059	M	0.03
PC	0.296	0.059	L	0.01
CPCR	0.286	0.057	M	0.03
SPP	0.121	0.024	VL	0
C	***0.183***			
CS	0.377	0.069	H	0.05
SQ	0.246	0.045	M	0.02
RS	0.191	0.035	H	0.03
TL	0.186	0.034	H	0.03
IBP	***0.15***			
IP	0.24	0.036	H	0.03
SS	0.253	0.038	VH	0.04
RAS	0.26	0.039	H	0.03
RFS	0.247	0.037	VH	0.04

Table 4.17b The global weights of criteria and performance score of Project X

Dimensions / Criteria	Local weight (based on global weights)	Global weights (based on fuzzy DANP)	Performance Scale	Project Performance
LG	***0.199***			
JS	0.281	0.056	H	0.04
TS	0.176	0.035	M	0.02
IN	0.241	0.048	L	0.01
TT	0.302	0.06	L	0.02
U	***0.269***			
PTS	0.253	0.068	M	0.03
PMPT	0.234	0.063	L	0.02
PCPT	0.238	0.064	L	0.02
PCS	0.275	0.074	L	0.02
			Total Performance	**0,50**

The results show that Project X has no success on purchasing process however this finding doesn’t affect Project X’s performance score much by reason of this criteria’s low weight. On the other hand this project is good at “internal business processes” perspective and this finding shows that our proposed method is reliable because Project X works on generating a “Radar System” and it is normal to have high scores at radar systems, rf systems and sensor systems criteria. Moreover, Project X has the highest scores at “sensor systems” and “rf systems”. If the weights of perspectives are analysed, it is obvious that “uncertainty” perspective has the highest significance as this perspective exists in the nature of R&D projects and this perspective is followed by ”finance” perspective and it shows that for R&D activities it is essential to have a financial adequacy. In another point of view, “customer satisfaction” criteria has the highest impact on Project X’s performance score and it shows that customer satisfaction is also important for Institution A and Project X is good at customer satisfaction.

Moreover, we have asked the assessment team to determine some desired performance values for each criterion; so that we can find what performance interval is expected for Project X in terms of institution’s vision and strategies. The expected intervals of each criterion can be seen in Table 4.18.

Table 4.18 Expected performance intervals of each criterion

	Global weights (based on fuzzy DANP)	Upper Bound	Lower Bound	Total Performance of Upper Bound	Total Performance of Lower Bound
F					
GPPT	0.059	H	M	0.04	0.03
PC	0.059	M	L	0.03	0.01
CPCR	0.057	H	L	0.04	0.01
SPP	0.024	M	L	0.01	0.01
C					
CS	0.069	VH	H	0.07	0.05
SQ	0.045	VH	H	0.05	0.03
RS	0.035	VH	H	0.04	0.03
TL	0.034	VH	M	0.03	0.02
IBP					
IP	0.036	H	M	0.03	0.02
SS	0.038	VH	H	0.04	0.03
RAS	0.039	VH	H	0.04	0.03
RFS	0.037	VH	H	0.04	0.03
LG					
JS	0.056	H	M	0.04	0.03
TS	0.035	H	M	0.03	0.02
IN	0.048	H	L	0.04	0.01
TT	0.06	H	L	0.05	0.02
U					
PTS	0.068	H	M	0.05	0.03
PMPT	0.063	M	VL	0.03	0.00
PCPT	0.064	H	L	0.05	0.02
PCS	0.074	M	L	0.04	0.02
				0.77	**0.44**

It is seen that performance score of Project X (0.50) is within the expected scores 0.77-0.44. However, the performance score is too close to the lower bound, it means that Project X has no big performance problem but some precautions should be taken in order to increase the performance score. Otherwise, Project X might experience some big performance problems. In order to increase Project X's performance score, project management should improve the success of purchasing process, the expected value for "success of purchasing process" criterion is not very high (0.50-0.25) because institution A has some big problems with purchasing process, however Project X's success rate is below the expected value of this criterion (Very Low). Hence, project management should take some actions immediately for improving the success of purchasing process. On the other hand, performance score of "service and quality" criterion has a score below the lower bound. Hence, some corrective actions should also be taken in order to enhance the score of this criterion. These two criterions (SPP and SQ) has priority for improving performance score but other criterions that have performance score of lower bound (IN, TT, PCPT, etc.) are also important for Project X.

The proposed method shows the vulnerable points of projects and so that it helps the managers to focus on these points for improving the project performance. They can have some precautions or corrective actions to complete their projects within the planned time, cost and scope.

4.3 Comparison – Crisp & Fuzzy Results

Gündüz & Büyüközkan (2014) used DEMATEL and DANP techniques with crisp sets in order to assess the project performance. The assessed project and performance criteria are same in both study, so that it makes two studies comparable. The results of Gündüz & Büyüközkan (2014)'s study and comparison table of two studies can be seen in Table 4.19a – Table 4.19b and Table 4.20.

Table 4.19a Performance results of project X (Crisp Set)

Performance criteria	Global weights	Scale value	Performance Score
GPPT	0.06	0.5	0.03
PC	0.05	0.25	0.01
CPCR	0.04	0.5	0.02
SPP	0.05	0	0
CS	0.05	0.75	0.04
SQ	0.04	0.5	0.02
RS	0.04	0.75	0.03
TL	0.04	0.75	0.03

Table 4.19b Performance results of project X (Crisp Set)

Performance criteria	Global weights	Scale value	Performance Score
IP	0.05	0.75	0.04
SS	0.05	1	0.05
RAS	0.06	0.75	0.05
RFS	0.05	1	0.05
JS	0.06	0.75	0.05
TS	0.05	0.5	0.03
IN	0.05	0.25	0.01
TT	0.04	0.25	0.01
PTS	0.07	0.5	0.04
PMPT	0.05	0.25	0.01
PCPT	0.05	0.25	0.01
PCS	0.05	0.25	0.01
Total performance of Project X			**53%**

Table 4.20 The comparison table of two studies

Performance criteria	Global weights of crisp set	Global weights of fuzzy set
GPPT	0.063 (2)	0.059 (8)
PC	0.045 (15)	0.060 (7)
CPCR	0.044 (17)	0.057 (9)
SPP	0.050 (10)	0.025 (20)
CS	0.055 (5)	0.069 (2)
SQ	0.039 (20)	0.046 (12)
RS	0.043 (18)	0.036 (17)
TL	0.041 (19)	0.034 (19)
IP	0.053 (8)	0.037 (16)
SS	0.046 (14)	0.038 (14)
RAS	0.056 (4)	0.039 (13)
RFS	0.050 (11)	0.037 (15)
JS	0.056 (3)	0.056 (10)
TS	0.054 (7)	0.035 (18)
IN	0.048 (13)	0.048 (11)
TT	0.045 (16)	0.060 (6)
PTS	0.067 (1)	0.068 (3)
PMPT	0.055 (6)	0.063 (5)
PCPT	0.051 (9)	0.064 (4)
PCS	0.049 (12)	0.075 (1)

As we can see in Table 4.19, the total performance of Project X was calculated as % 53 with crisp sets. This result is very close to our result (% 50). But there are some significant differences in the global weights of criteria. The order of the criteria with crisp set is as PTS > GPPT > JS > RAS > CS > PMPT > TS > IP > PCPT > SPP > RFS > PCS > IN > SS > PC > TT > CPCR > RS > TL > SQ, while the order with fuzzy set is as PCS > CS > PTS > PCPT > PMPT > TT > PC > GPPT > CPCR > JS > IN > SQ > RAS > SS > RFS > IP > RS > TS > TL > SPP. Especially, differences (over .015 point) in the global weights of SPP, IP, RAS, TS, TT and PCS are important. For instance, SPP was calculated as the tenth most important criteria with crisp set, while fuzzy set says it is the least important of all criteria. SPP (Success of purchasing process) is an important criteria for R&D type projects, however according to assessment team SPP is a relatively insignificant criteria and it should take place in lower positions. Hence, the result of fuzzy set better reflects the opinion of assessment team and it seems more satisfying for the team. Moreover, crisp set says "RAS (Radar systems) is the most important performance indicator within the IBP perspective's criteria", but all IBP criteria have the same importance for Institution A. Hence, it is expected that they have very close importances. On the other hand, CS (Customer satisfaction refers to the customer's satisfaction rate) is an important criteria for Institution A, because satisfaction has an significant role in achieving customers' loyalty and it is seen that fuzzy set gives a higher importance to CS than crisp set. Furthermore, PCS (Probability of commercial success refers to the chance of making profit on project) is one of the vital criteria for Institution A in order to continue its activities and fuzzy set's result better reflects PCS's significance than crisp set. So that, the results of fuzzy set are more effective under uncertainty.

All these findings show that fuzzy sets are more appropriate for assessing the project performance, especially in environments where there is insufficient data. Companies, conduct performance assessment with experts opinion, should use fuzzy set in order to deal with the vagueness of experts' opinions and expressions.

5 Conclusion

This study aimed to determine the performance level of Project X on the basis of Institution A's vision and strategies, by integrating a BSC that can be used by managers to monitor the execution of duties by the staff within their responsibility and to monitor the results arising from these actions, with the fuzzy DEMATEL that builds an INRM for identifying dependences between criteria and the fuzzy DANP that is used to find the global weights of criteria. Our proposed model has shown that different measurement units related with the performance criteria under BSC approach and performance criteria of different structures can be consolidated with fuzzy DEMATEL and fuzzy DANP techniques. Besides, the proposed model has enabled the determination of the project performance on the basis of Institution A's vision and the strategies pursued to achieve this vision. In this way, it is possible to evaluate project performance from a strategic perspective according to not only past results but also leading criteria.

Moreover, the case study shows that our proposed method is good at assessing R&D projects' performance score and we evaluated a score of 50% for the case project. As a proposal, Project X should put an emphasis on "success of purchasing process", "project costs" and "innovation" criteria in order to increase its success level. Furthermore, the project should aware of the PCS and CS criteria's importance. It can be hard to make improvement in the area of innovation but Project X must immediately take an action of improving "success of purchasing process" and "project costs" areas. It can be considered as a future work to implement more innovative projects to serve better to Institution A's vision and strategies.

It is also seen that fuzzy extensions of DEMATEL and DANP techniques are more appropriate for performance assessment of R&D projects, because of the R&D projects' vague nature and because of the vagueness in experts opnions. When viewed from this angle, it does not seem logical to use the crisp set for structuring an R&D project performance system. Since crisp set gives good results with certain and data, while its results are not very good in an environment with high vaguness.

The limitation of this study, the proposed method is applied to a specific institution with institution specified criteria. Hence, the model can be made more generic by determining generic criteria and by using basic BSC perspectives. On the other hand, the model proposed in the scope of this study was related with an R&D institution; however, it can also be adapted to different businesses (such as; manufacturing and service). Modifications may be required on the proposed system due to a reason: the components constituting the analytical structure of the proposed model – namely, strategies, BSC perspectives and performance criteria – may vary depending on the business vision. Modifications and adaptations to be made due to this reason will enable the use of this model in other companies.

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BIOGRAPHICAL SKETCH

Ömer GÜNDÜZ is born in 1986 in HATAY. He received his high school education in Bornova Çimentaş high school. He graduated from Balıkesir University in 2009 in Industrial Engineering. After the university education, he did his military service in 2010. He had been working in Ziraat Bankası for 4 months in 2011. He is now a M.Sc. candidate in the Industrial Engineering Department at Galatasaray University and he works in TÜBİTAK as a researcher. Recently, He wrote a paper (Gündüz & Büyüközkan, 2014) for "The 10th International Strategic Management Conference" and the paper was about performance assessment of R&D projects.