

**T. C.**  
**MARMARA UNIVERSITY**  
**INSTITUTE FOR GRADUATE STUDIES IN**  
**PURE AND APPLIED SCIENCES**

**A DECISION MAKING MODEL for the EVALUATION**  
**of SUPPLY CHAIN EXECUTION and MANAGEMENT**  
**SYSTEMS**

**Sinan APAK**

**THESIS**  
**FOR THE DEGREE OF DOCTOR OF PHILOSOPHY**  
**IN**  
**ENGINEERING MANAGEMENT**

**SUPERVISOR**  
**Assoc. Prof. Dr. Özalp VAYVAY**

**İSTANBUL 2010**

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## **ÖZET**

### **TEDARİK ZİNCİRİ YÜRÜTME ve YÖNETME SİSTEMLERİNİN DEĞERLENDİRMESİNE YÖNELİK BİR KARAR VERME MODELİ**

Tedarik Zinciri Yürütme ve Yönetme sistemleri işletme uygulamaları olup gerekli bütün tedarik zinciri fonksiyonlarını tek bir sistemde toplar. Şirketlerin başarılı bir şekilde tedarik zinciri süreçlerini yürütme ve yönetmeleri için uygun sistemi değerlendirmeleri gerekmektedir. Bu sebepten ötürü bu çalışma, Tedarik Zinciri Yürütme ve Yönetme sistemlerinin seçimine yönelik uygun ve çok kapsamlı değerlendirme modeline odaklanmıştır. Ancak, Tedarik Zinciri Yürütme ve Yönetme sistemlerinin değerlendirilmesi, çok nitelikli karar verme problemi olup, belirsizlik ve karmaşıklık içerir. Bu belirsizlik ve karmaşıklık durumu ise birden fazla alternatifin çok kriterli olarak değerlendirmesini gerektirmektedir. Bu çalışmada, belirsizlik ve kesinsizlik ile başa çıkmak için bulanık mantık yaklaşımı kullanılmıştır. Değerlendirme sürecini gerçekleştirmek için Bulanık Analitik Ağ süreci modeli önerilmiş ve modelin üstünlüğünü göstermek amacıyla Bulanık Analitik Hiyerarşi süreci - Bulanık TOPSIS bütünleşik modeli ile karşılaştırılmıştır. Önerilen modelin etkinliğini göstermek için de gerçek bir uygulama yapılmıştır.

**April, 2010**

**Sinan APAK**

## **ABSTRACT**

### **A DECISION MAKING MODEL FOR THE EVALUATION OF SUPPLY CHAIN EXECUTION AND MANAGEMENT SYSTEMS**

A Supply Chain Execution and Management system is an enterprise application that integrates all necessary supply chain functions into a single system. In order to execute and manage supply chain processes successfully in an organization, it is necessary to evaluate a suitable system. For this reason, this study focuses on the evaluation model of the proper and comprehensive remedy for the Supply Chain Execution and Management system. However, Supply Chain Execution and Management system evaluation is a kind of multiple attribute decision-making problem associated with uncertainty and complexity, which requires considering a large number of complex factors as multiple evaluation criteria. To cope with this ambiguity and vagueness, a fuzzy logic approach is adopted. To achieve evaluation process a Fuzzy Analytic Network Process model proposed and compared with a Fuzzy Analytic Hierarchy Process - Fuzzy Technique for Order Preference by Similarity to Ideal Solution integrated model to demonstrate supremacy of the model. A real life example is given to demonstrate the application of the proposed method.

**April, 2010**

**Sinan APAK**

# **CLAIM OF ORIGINALITY**

## **A DECISION MAKING MODEL FOR THE EVALUATION OF SUPPLY CHAIN EXECUTION AND MANAGEMENT SYSTEMS**

Multi criteria decision making is one of the well-known research area in literature. However, our proposed fuzzy analytic approaches were not used in evaluating Supply Chain Execution and Management systems, specifically.

The study considers supply chain modules as criteria while evaluating Supply Chain Execution and Management systems. The criteria, which were conducted in this study is derived from literature review and industrial analysis. There has not found any study that uses supply chain modules as evaluation criteria in literature.

Therefore, we hereby declare that this thesis is original, and makes a humble contribution to science and technology.

**May, 2010**

**Assoc. Prof. Dr. Özalp VAYVAY**

**Sinan APAK**

## SYMBOLS

$\mu_A(x)$	: The grade of membership of the elements $x$
$\tilde{a}$	: Fuzzy comparison value
$\tilde{A}$	: Fuzzy set
$d_i^*$	: Fuzzy positive ideal solution
$d_i^-$	: Fuzzy negative ideal solution
$l$	: Lower limit of triangular fuzzy number
$lw_i$	: Lower values of the fuzzy weight of the $i$ th criterion
$m$	: Middle limit of triangular fuzzy number
$mw_i$	: Middle values of the fuzzy weight of the $i$ th criterion
$\tilde{r}_i$	: Geometric mean of fuzzy comparison value of criterion $i$
$u$	: Upper limit of triangular fuzzy number
$uw_i$	: Upper values of the fuzzy weight of the $i$ th criterion
$w$	: Eigen value
$\tilde{w}_i$	: The fuzzy weight of the $i$ th criterion
$\tilde{x}_{ij}^k$	: Rating of alternatives
$\lambda_{\max}$	: Largest eigen value

## ABBREVIATIONS

<b>Ab</b>	: Absolutely important
<b>AHP</b>	: Analytic Hierarchy Process
<b>ANP</b>	: Analytic Network Process
<b>APS</b>	: Advanced Planning Systems
<b>ATP</b>	: Available to promise
<b>BOM</b>	: Bill of Materials
<b>CI</b>	: Consistency Index
<b>COA</b>	: Center of Area
<b>DM</b>	: Demand Management
<b>ECO</b>	: Engineering Change Orders
<b>EDI</b>	: Electronic Data Interchange
<b>ERP</b>	: Enterprise Resource Planning
<b>Es</b>	: Essentially important
<b>ES</b>	: Enterprise Systems
<b>Eq</b>	: Equally important
<b>F</b>	: Fair
<b>F-AHP</b>	: Fuzzy Analytic Hierarchy Process
<b>F-ANP</b>	: Fuzzy Analytic Network Process
<b>FPIS</b>	: Fuzzy Positive Ideal Solution
<b>FNIS</b>	: Fuzzy Negative Ideal Solution
<b>FST</b>	: Fuzzy Set Theory
<b>G</b>	: Good
<b>GIS</b>	: Geographical Information System
<b>IS</b>	: Information System
<b>IT</b>	: Information Technology
<b>ITL</b>	: International Trade Logistics

<b>L</b>	: Less
<b>MADM</b>	: Multi Attribute Decision Making
<b>MCDM</b>	: Multi Criteria Decision Making
<b>MODM</b>	: Multi Objective Decision Making
<b>MRP II</b>	: Manufacturing Resource Planning
<b>OM</b>	: Order Management
<b>P</b>	: Poor
<b>PSP</b>	: Production and Supply Planning
<b>RFI</b>	: Requests for Information
<b>RI</b>	: Random Index
<b>QFD</b>	: Quality Function Deployment
<b>S&amp;OP</b>	: Sales and Operations Planning
<b>SC</b>	: Supply Chain
<b>SCE</b>	: Supply Chain Event Management
<b>SCEM</b>	: Supply Chain Execution and Management Systems
<b>SCEx</b>	: Supply Chain Execution
<b>SCM</b>	: Supply Chain Management
<b>SCO</b>	: Supply Chain Optimization
<b>SPP</b>	: Service Parts Planning
<b>SRM</b>	: Supplier Relationship Management
<b>TFN</b>	: Triangular Fuzzy Number
<b>TMS</b>	: Transportation Management System
<b>TOPSIS</b>	: Technique for Order Preference by Similarity to Ideal Solution
<b>VG</b>	: Very Good
<b>VP</b>	: Very Poor
<b>Vs</b>	: Very strongly important
<b>Wk</b>	: Weakly important
<b>WMS</b>	: Warehouse Management System

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# **CHAPTER I**

## **INTRODUCTION AND AIM**

### **I.1. INTRODUCTION**

Supply Chain Execution and Management (SCEM) systems are analytical management tools that identify how, where and when the demand could be satisfied through the process initiated with the customer. SCEM systems consist of many modules such as inventory planning, supply chain network design, production planning, and demand planning. All modules are integrated and each has a consequence for the supply chain planning to increase efficiency. The basic reason to use SCEM system is to support all planning and execution functions required for the supply chain. The implementation of those systems is a very complicated and costly task, and their inappropriate use may lead the firm to bankruptcy. Consequently, selection of those management systems consist of a complex decision process, and detailed analysis supported with analytical methods is needed. Hence, firms should evaluate their SCEM system with appropriate criteria and implement it properly to increase performance and efficiency.

Today's businesses are continuously expanding to include markets and business partners from all over the world. As companies grow and business becomes more sophisticated, the need to connect and optimize integrated systems and information increases inside and outside the organization. SCEM systems help to prepare companies to take advantage of opportunities and challenges with fast and effective integration and communications. These systems offer flexibility in managing supply chain. Most of companies have implemented software solutions to help automate their supply chain processes over the last decades. These systems have had a massive impact on how companies operate, both internally and with their suppliers and customers. SCEM solutions allow companies to maximize existing investment while also helping to implement new systems and technologies faster and more effectively. Managers are required to choose the appropriate level of

integration for particular relationships in the supply chain and the appropriate degree of information sharing (Lancioni *et al.*, 2003). The application of these systems has no boundaries, with hundreds of companies around the world using them to deliver seamless solutions to specific business problems. Aerospace, construction, electronics and high tech components, manufacturing, mining and quarrying, motor vehicles, publishing and media, transportation, warehousing, wholesale and retail trade are some of the industry that SCQM systems are used widely.

The supply chain software market has risen to the challenge of complexity in the supply chain by making its supply chain management solutions more and more complex, often to the detriment of the very efficiency and cost-effectiveness that supply chain users need. The price and total cost of ownership for mainstream supply chain system is legendary: multi-year implementations averaging many millions of dollars are common. Companies have trouble finding the return on investment for these massive supply chain projects. The evaluation of those systems is a very complicated and time-consuming task. In addition, with new standards, processes, and a continuously developing technology, the evaluation process becomes more elaborate and dynamic (Sarkis and Talluri, 2004).

Regardless of whether relationships and arrangements among the organization are formally established, these organizations may evaluate SCQM systems in an effort to gain a local benefit or to improve the supply chain as a whole. The benefits of evaluation SCQM systems in a supply chain reported in literature include reduced inventory levels, reduced logistics costs, and streamlined payments. These are Supply Chain Management (SCM) benefits - improvements to help produce macroeconomic benefits such as more stable economic output and higher productivity growth. With SCQM systems, we can achieve better information engineering.

Benefits of SCQM systems are can be classified as; increase top-line profit growth through supplies collaboration, increase customer service and decrease stock-outs, reduce inventory carrying costs, optimize value chain for cost reduction and profit management, reduce operating costs, increase competitiveness, create visibility among supply chain and trading partners, and adapt quick responses in supply chain. Therefore, SCM is coming under survey in trying to achieve this competitive advantage as it provides many opportunities for reducing operating costs and

improving customer service and satisfaction (Williamson *et al.*, 2004). Although, selecting wrong SCEM system application can affect the whole business poorly in quality, from sourcing and assembly to distribution. Within business with multiple departments, facilities, or partners, SCEM system can lead to irresolvable bottlenecks. In addition, a SCEM system, which is not sufficiently integrated with the rest of business system applications, can lead to serious disruption in supply chain operations. These systems also provide platforms for fast and reliable operations between trading partners, regardless of physical barriers.

SCEM system evaluation is important for to understand how different applications will improve supply chain process, select vendors that support appropriate transportation management, review warehouse management features and logic for pick, put-away and replenishment functionality, and evaluate collaboration environments and relationship terms. As well as details for partners within supply chain, ensure the modules are appropriate for business environment, and integrates across multiple operations.

The biggest question most managers have about all these changes though is “Are they worth it?” The answer is absolutely. An effective, realistic, and flexible SCEM system can have significant benefits for any business. First, it can make it easier to manage all of the different factors that contribute to the purchasing and production cycle. Additionally, the SCEM system reduces the chances of human error. Efficient SCEM systems also lead to greater productivity, lower costs, and reduced inventory. Additionally, a fine-tuned SCM system delivers better communication, shorter planning times, and more reliable forecasting. The amalgamation of all of these benefits is a balance between keeping costs reasonable and maintaining production levels. This is definitely worth the effort and delivers value to businesses.

Because of the associated with the benefits and risk of evaluation process, organizations in a supply chain may have difficulty in deciding whether they should accept or reject what types of modules are selected. It is very helpful for them to have systematic approaches that aid their decisions concerning to evaluation process. These approaches should allow the organizations to analyze relevant factors, especially the benefits and risks of SEM systems, and evaluate which types of modules that are the most beneficial to use. The approaches should also be applicable

to all cooperative arrangements in a supply chain so that SCEM system decisions are supported in both individual and group settings.

SCEM system consists of many modules such as inventory planning, supply chain network design, production planning, demand planning, etc. All of these modules should work in an integrated manner since each of them has a high potential to increase the efficiency of the supply chain planning. This study considers SCEM system operation modules as key evaluation criteria with sub-modules. SCEM system selection problem is not considered in a module base in multi attribute decision-making framework in literature until now. Several studies have been applied to such managerial systems evaluation including software selection. Mulebeke and Zheng (2008) used analytic network process as a multi attribute strategic decision making approach while in selection suitable software for product development process. Sen *et al.* (2009) applied fuzzy multi criteria decision making (F-MCDM) procedure for electronic company's Enterprise Resource Planning (ERP) software selection project. Wei and Wang (2004) proposed a hierarchical attribute structure to evaluate ERP projects systematically. Wei *et al.* (2005) presented a comprehensive framework for selecting a suitable ERP system. Lai *et al.* (2002), employed group decision making technique for selecting multi media authorizing system as software. Yazgan *et al.* (2009) applied multi attribute decision making (MADM) method for ERP software selection. Buyukozkan (2004, 2005, 2008) presented evaluation models based F-MCDM for software development projects.

The scope of the various SCEM systems differs considerably. Some vendors are highly specialized, while others attempt to cover a more broad range. The system, that most supports the required functionalities should be selected. Therefore, this study proposes a comprehensive SCEM system evaluation framework with an integrated approach based on fuzzy logic to make more rational selection decisions considering SCEM system operations modules. The problem on evaluation SCEM system is the selection of software solutions among many products for the proper system. Hence, MADM evaluation framework is adopted to manage this issue.

This study provides such approaches for organizations in a supply chain so that they can make decisions on types of systems with their modules. The approaches developed in this research are based on the multi criteria decision making (MCDM) techniques of the Analytic Hierarchy Process (AHP) with Technique for Order

Preference by Similarity to Ideal Solution (TOPSIS) and Analytic Network Process (ANP) including fuzzy logic.

## **I.2. PROBLEM STATEMENT**

SCEM systems provide a large number of features that are customizable and can be tailored to meet the specific needs of the organizations. Improper selection of a system may result in wrong strategic decisions with subsequent economic loss to the organization. For example, there are a number of solutions in an ERP market and every solution has different features. As ERP packages cost hundreds of thousands and even millions of dollars, purchasing a system solution is a high expenditure activity that consumes a significant portion of companies capital budgets (Verville and Hallington, 2002). Selecting the right solution is an exhausting process for companies. Therefore, selecting a system that meets the requirements needs a full examination of many conflicting factors and it is a difficult task. This has led researchers to investigate better ways of evaluating and selecting those systems.

One of the most important objectives of the business to achieve high competitiveness in the market is the selection of competitive priorities. The selection of different competitive priorities is a very critical MADM problem. Different conflicting selection decisions make the task more complicated and risky. Supply chain is a field that structural changes occur frequently. Uncertainty arises and continuous planning is required due to those changes in the processes of the supply chain. Hence, dynamic and integrated management systems are necessary for adaptation. In this sense, right decisions would be taken with the right management systems. Based on their organizational structure and business diversity, firms use management systems to not only identify right investments and reduce costs, but also increase their efficiency as well. This study attempts to identify which evaluation criteria are important for the decision making procedure and what are their effects on the final decision for the companies planning to implement supply chain execution and management systems. The implications of the study would not only be generic, but also depend to some specific points such as the size of the firm or the industry it operates.

The basic reason to use SCEM system is to support all planning and execution functions required for the supply chain (Hong and Kim, 2002; Sarkis and Sundarraj,

2000; Wei *et al.*, 2005). SCEM system evaluation is an important decision making problem of organization and affects directly the performance. Those systems selection is tiresome and time consuming in terms of complexity of business environment, resource shortages. Configuring these large generic systems to the needs of specific organizations, industry sectors, and countries is necessary and requires large investments of money, time, and expertise (Davenport, 1998; Klaus *et al.* 2000). Most of the large organizations worldwide have already adopted their system and small and medium-sized enterprises are increasingly following the suit (Bernroider and Koch, 2001; Everdingen *et al.* 2000; Klaus *et al.* 2000). All most all software packages can be customized to the specific needs of a particular organization. This, however, is very expensive and may lead to problems such as the incompatibility of product patches and new versions with the customized information system software (Butler, 1999; Summer, 2000). Consequently, some organizations choose to adapt themselves to suit the software being acquired instead of customizing the software to suit the organization (Davenport, 1998). Although, as some organizations do not want to modify themselves or furthermore, have critical needs that can not be met by standard functionality provide by the packaged systems. It is in these organizations' best interest to select the information systems software that best fits their needs with the least amount of customization so that both further maintenance problems and organizational misfits are avoided (Davison, 2002; Everdingen *et al.*, 2000; Light, 2001; Soh *et al.*, 2000).

With the parallel of globalization, international firms experience integration requirements seriously. Fundamentally, integration process could be available with the sharing of information and reaching it easily. Supply chain is a critical factor for firms to manage and compete effectively. If the organizations that cannot able to use SCEM system sufficiently, they become too incapable of operational capabilities. Either that kind of firms are to invest their management systems or they will lose their position on the market. SCEM system evaluation with the right criteria able to firms reduces unproductiveness and increase supply chain performance and competitive power. However, looking at the literature a supply chain execution and management system evaluation effort in the Turkish industry is not documented. The literature usually displays enterprise resource planning systems formation; in addition to those studies, this study will reflect a decision making model for the

evaluation of supply chain execution and management systems and will guidance to appropriate systems selection.

Questions such as whether an organization should evaluate own system, or it is time-consuming work in order to reap the most benefits for the organization itself, the partner, and the supply chain may be difficult for an organizational unit in a supply chain to answer. The difficulty of this decision arises from the following:

1. structural complexity of the decision process;
2. needs a deep knowledge and expertise on those system;
3. execution system evaluation decision involve various factors or criteria, such as the supply chain structure, the partner relationships, and information system and technology;
4. these criteria are often qualitative and difficult to quantify;
5. qualitative data often depends on experience and knowledge to weigh and prioritize;
6. the best decisions from each partner.

However, SCEM system evaluation in a supply chain is a complex process, potentially involving serious risks and uncertainties because it includes supply chain partners, customers, and competitors with behaviors that are difficult to anticipate and control. Moreover, the result of evaluation significantly influences not only the participating organization but also the partner organization and supply chain as a whole.

### **I.3. AIM OF THE STUDY**

The main objective of this study is to propose a systematic evaluation model to help the participants in supply chain for the selection of an optimal SCEM system among a set of available alternatives. SCEM system selection problem is both a MCDM problem where many criteria should be considered in decision-making, and a problem containing subjectivity, uncertainty and ambiguity in assessment process. Therefore, this study utilizes MCDM methods to determine the importance weights of evaluation criteria, and fuzzy logic to obtain the performance ratings of the feasible alternatives in linguistic values parameterized with triangular fuzzy numbers.

The problem of competitive priorities selection of SCEM system is formulated using various literatures and expert opinions. This study considers the important decision modules in SCEM systems while proposing appropriate evaluation model. The different decision criteria may vary depending on the need of the manufacturer, its preferences about different criteria and management strategy. It may not be easy to convert its needs into useful criteria because needs are often expressed as general qualitative concepts while criteria should be quantitatively evaluated.

SCEM systems and other software evaluations are to identify the best alternative for company requirements. Different company surveys may result differently, because key operations and functions or way of doing works may differ. In supply chain business, there are many vendors dealing with optimization of supply chain. Their products are different because of their customers, and industries they work.

As this study suggests; any methodology have been developed for solving an evaluation SCEM system (in module base) decision problem. Thus, a guideline methodology needed to develop for helping individuals or the group of decision makers to evaluate SCEM system decision. To meet this need, this research proposes:

1. To develop methodologies for helping an organizational unit in supply chain to make SCEM system evaluation in a group decisions. These methodologies provide multiple alternative approaches, allowing the unit to select the approach that is the most suitable for its situation;
2. These methodologies aim to resolve decision conflicts that might occur between these units and suggest a compromise solution that is agreeable to both.
3. Evaluation process enables us to identify importance of each criterion (module) according to its hierarchical and network position.

In addition, this study is important to the areas of supply chain and decision making for two reasons. First, it combines and applies existing MCDM tools to solve the particular problem of SCEM system in a supply chain. Second, it develops a process for integrating the assessment of two partners who may have conflicting preferences of the decision choices. The process resolves these preferences and

balances the needs of organization between the supply chain departments resulting in win-win solution.

Benefit of the study could be categorized for software role takers as:

Information technology (IT) project managers could save time and avoid errors in the creation of high quality requirements for a software acquisition. Uses the reports help develop all requests for information (RFI) and software tender documents.

IT Consultants could use comprehensive criteria to determine build vs. buy analysis and perform gap analysis for legacy systems against the latest software functionality included in the reports. They have access to the most comprehensive vendor data available.

Software manufacturers and vendors could compare their system against the combined feature set of the leaders in their category to help prioritize future development.

In general, this study provides a proposal selecting SCCEM system for supply chain applications. For many, this can be a difficult process due to the number of available solutions and the numerous and confusing claims made by software vendors. Selecting SCCEM system for SCM support requires an in-depth knowledge of business and IT applications. To obtain the best fit at the lowest price in the minimum time requires knowledge of the latest software packages, plus the application of smart buying practices. At that point, this study presents an analytic thinking while evaluating such SCCEM systems. Our evaluation process can help as:

1. Bring objectivity and transparency to the selection process.
2. Reduce the risk, and duration of the selection system.
3. Choose the solution that best satisfies the specific business requirements.

#### **I.4. OUTLINE OF THE STUDY**

This study models two different MCDM methods for SCCEM system evaluation. One of the methods is F-AHP \_ F-TOPSIS and the other one is F-ANP as a decision-making approach. The results from two different methods enable us to compare alternatives and present simple and selective approach. A fuzzy logic adopted due to subjective considerations of human judgments. In the first part, a

multistage MADM methods used; F-AHP to determine the relative weights of evaluation criteria, and F-TOPSIS to rank the alternatives. In the second part, F-ANP proposed to consider dependencies between secondary criteria and alternatives and compared with first model.

The problem statement, the research objective and aim have been presented in this chapter. Then, study is structured as follows: Chapter II presents a general background of enterprise and supply chain systems. In Chapter III, describes the proposed models for SCEM system evaluation and presented the stages of the proposed approaches are explained in detail. How the proposed model is used on a real word example is explained and compared results in Chapter IV. In the last Chapter V, conclusions and suggestions are discussed.

# **CHAPTER II**

## **GENERAL BACKGROUND**

### **II.1. GENERAL OVERVIEW**

SCEM system is the specific management system for an organization due to organization's business. There have been such ERP, SCM main systems, are used to define business solutions. Early studies show us selection processes of these systems are studied many times considering different methodologies and criteria. SCEM systems are relatively related with ERP and SCM systems. Hence, we have to review those systems evaluation approaches and criteria to better understand the differences that are done on this study. A number of methods have been applied to ERP, SCM or other information system selection including scoring, ranking, mathematical optimization, and multi-criteria decision analysis. However, sophisticated mathematic models often weaken the applicability of these methods or limited attributes to carry out in a real-world information system selection decision, especially when some attributes are not readily quantifiable, as well as not too easy for managers to understand. Moreover, these methodologies focus too much on quantifiable calculations and look down upon the comprehensive selection framework of information system and the strategic considerations of a company.

Enterprise systems can integrate a firm's internal information from a financial perspective, allowing finance, accounting, purchasing and other departments to acquire information in a timely manner. ERP emphasizes integration of the flow of information relating to the major functions of the firm. The broader and more complex the organization is, the more it requires integrating this information flow. When applying SCM, orders can be forecasted efficiently and correctly, stock costs for supply chain partners can be reduced, and a manufacturing schedule can be set to optimize manufacturing and supply time. SCM emphasizes close collaboration between supply chain partners and the building of a strong alliance in their joint strategic business focus.

This chapter overviews relevant literature which concern SCEM systems in supply chain management, supply chain theories and applications of decision making techniques that facilitate to fulfill the research objectives. The reviewed literature consists of two major sections. The first section reviews the backgrounds of the supply chain systems and its applications and considered criteria as well as benefits and risks among supply chain. The second section deals with the literature review of multi attribute decision-making approaches that are used in evaluation phase of those systems.

## **II.2. REVIEW OF SUPPLY CHAIN SYSTEMS**

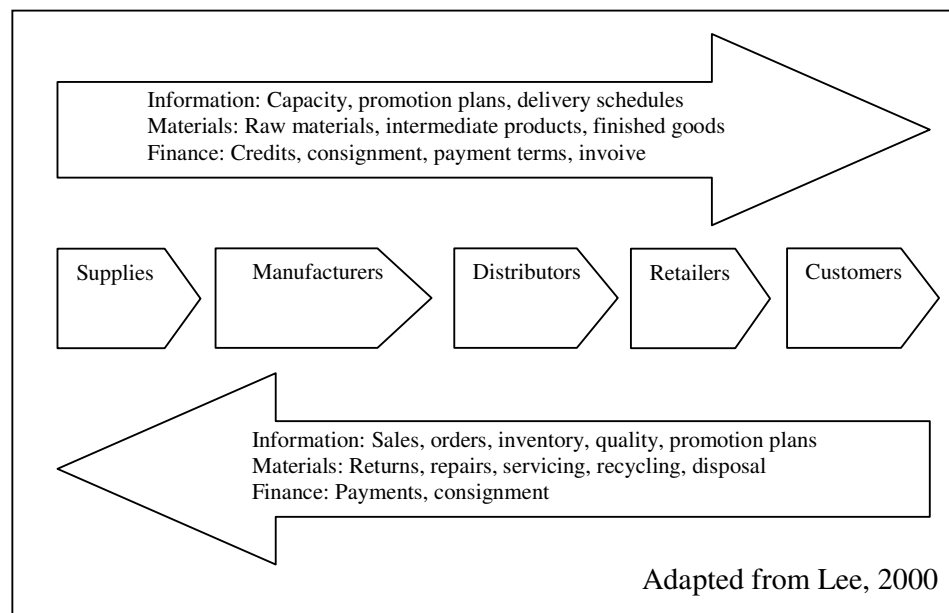
In this emerging competitive environment, the ultimate success of a single business will depend on management's ability to integrate the company's intricate network of business relations (Lambart and Cooper, 2000), which leads to the motivation of continuous evaluation of the supply chain. The major aims of SCM are to reduce supply chain risk, reduce production costs, maximize revenue, improve customer service, optimize inventory levels, business processes, and cycle times, and resulting in increased competitiveness, customer satisfaction and profitability (Chou and Chang, 2008; Ha and Krishnan, 2008; Heizer and Render, 2004; Stevenson, 2005).

Many researchers and practitioners have used different definitions of supply chain according to their points of view of concepts and usages. Christopher (1998) defines a supply chain as "A network of connected and interdependent organizations mutually and co-operatively working together to control, manage and improve the flow of materials and information from suppliers to end users". While Mentzer *et al.* (2001) gives a definition of supply chain as "a set of three or more entities (organizations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and information from a source to a customer". The Council of Supply Chain Management Professionals has developed the definition of SCM as follows (<http://cscmp.org/digital/glossary/glossary.asp>):

"Supply Chain Management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes

coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers. In essence, supply chain management integrates supply and demand management within and across companies. Supply Chain Management is an integrating function with primary responsibility for linking major business functions and business processes within and across companies into a cohesive and high-performing business model. It includes all of the logistics management activities noted above, as well as manufacturing operations, and it drives coordination of processes and activities with and across marketing, sales, product design, finance, and information technology.”

A supply chain is generally comprised of their forward and backward flows: material, information and financial. These flows move through a network consisting of customer, suppliers, manufactures, and distributor as shown in Figure II.1. Effectively managing these elements in an integrated system results an optimal performance for a supply chain.



**Figure II.1** Supply Chain Flows

Executive information systems are information systems that combine many of the features of management information systems and decision support systems. Goal of executive information systems was to provide top executives with the immediate and easy access to information about a firm's critical success factors, that is, key factors that are critical to accomplishing an organization's strategic objectives.

Organizations that are linked together in a supply chain are linked by various kinds of relationships, which depend on types of the organizations in the chain. The coordination of flows along the supply chain can be executed efficiently by utilizing the latest developments in information and communication technology. These allow processes formerly executed manually to be automated. Supply Chain Management can also refer to supply chain management software, which are tools or modules used in executing supply chain transactions, managing supplier relationships and controlling associated business processes. Traditional ERP systems and Electronic Data Interchange (EDI) interfaces are not equipped for supply chain management across networked organizations. ERP systems focus on the integral management of processes within a company (Van Lierop and Vanmaele, 1996). Moreover, the procedural ERP software cannot easily support the coupling and decoupling of organizations to the dynamic network. ERP systems have intelligence for coordination, but miss the flexibility needed for networked organizations. Traditional company systems could mutually be linked through EDI. The systems and interfaces can resemble the network structure, but do not provide additional functions for logistics control across organizations. A system like ERP, Transportation Management System (TMS) and Warehouse Management System (WMS) has its strength in the consistent management of elementary business data, such as customers and sales orders, items and prices, warehouses and bins, resources and work orders, suppliers and purchase orders. Each of the systems has its own database in which these data are stored. The software programs in an ERP system, WMS or TMS provide functions for the transformation of the stored data during the course of the business process. The users can access the programs they need for their tasks through a user interface (Verwijmeren, 2004).

The ERP and SCM focus on co-ordination of the processes within the organization. Their databases store the internal data, the programs provide intelligence for internal co-ordination and the user interfaces give access to internal

users. Therefore, these traditional systems are fit for internal logistics management, but they miss the co-ordination capabilities required for the management of dynamic supply chains. The software components in the architecture are called Supply Chain Execution and Management Systems, to express the power they provide for supply chain management as an extension to the local ERP, SCM, WMS and TMS and such systems.

ERP is a integrated, consulate enterprise wide information system that combines all necessary business functions like production planning, purchase, inventory control, sales, finance, human resource. ERP software automates and integrates business processes and allows information sharing in different business functions. In addition, that ERP software supports the finance, human resources, operations and logistic, sale and market in functions by through more effected and productive business process. At the same time, it improves the performance of organization's functions by controlling those (Hallikainen, 2006). Therefore, ERP selection is an important decision making problem of organization and affects directly the performance. The ERP selection is tiresome and time consuming in terms of complexity of business environment, resource shortages as well as SCEM systems. Yazgan *et al.* (2009) mentioned the importance ERP systems and proposed a group decision model using ANP and artificial neural network (ANN) to select ERP system. As a selection criteria they proposed five main criteria such as financial analyzes, general characterizes, system control and software design, production planning, data and knowledge properties with seventeen sub criteria. Wei *et al.* (2005) contributed a study using AHP-based approach to ERP selection; they considered total costs, implementation time, functionality, user-friendliness, flexibility, reliability as selection criteria with their sub criteria. Wu *et al.* (2007) presented an ERP selection methodology with their approach; organizations can more easily and systematically determine the locations of possible misfit and their degree of importance, thereby understanding the risk in their implementing an ERP. Hakim and Hakim (2010) offered a decision-making model to help companies make the right decisions on their approach to the implementation of ERP in Iranian automotive industry considering three perspectives, strategic, technical, and executive. Kumar *et al.* (2003) investigated critical management issues in ERP implementation projects such as selection of ERP vendor, project manager, and

implementation partners; constitution of project team; project planning, training, infrastructure development, on-going project management; quality assurance and stabilization of ERP. In their research that identified a number of critical management challenges in the ERP, implementation activities, such as training, upgrading infrastructure, project management and stabilizing ERP systems. Organizational strategies in testing and quality assurance, meeting incompatibilities between organizational needs and the ERP systems, increasing user acceptance, and resolving challenges in shakedown are also documented. Cebeci (2009) presents an approach to select a suitable ERP system for textile industry, the fuzzy analytic hierarchy process, a fuzzy extension of the multi-criteria decision-making technique AHP, was used to compare these ERP system solutions, and balanced scorecard is based on four key perspectives, which are financial, customer, internal processes, and learning and growth. Verville and Hallington (2003) presented a model of the ERP software acquisition process that includes six distinctive processes such as planning, information search, selection, evaluation, choice, and negotiation. Grapski and Leech (2007) found that groups of complementary controls need to be employed in the implementation of ERP systems to achieve a successful implementation and applied economic theory and examined implementation controls and subsequent perceived success of ERP systems. In addition, their study demonstrated that managers must control all of the five factors that are project management, change management, alignment of the business and the new information system, internal audit activities, consultant and planning activities if they desire to have a successful ERP implementation. Liao *et al.* (2007) presented a model, which is based on linguistic information processing, for dealing with ERP system selection, in their model function and technology, strategic fitness, vendor's ability, and vendor's reputation criteria were used to evaluate ERP system alternatives. Karsak and Ozogul (2009) develops a novel decision framework for ERP software selection based on quality function deployment (QFD), fuzzy linear regression and zero-one goal programming. Their proposed framework enables both company demands and ERP system characteristics to be considered, and provides the means for incorporating not only the relationships between company demands and ERP system characteristics but also the interactions between ERP system characteristics through adopting the QFD principles. Yang *et al.* (2007) proposed a model of selection of system suppliers and

contract negotiation during the ERP implementation of a local construction company. They discussed seven issues: coding system, working process reengineering, priority of ERP functionality implementation, customization, participant roles, and consultant role and performance level of subcontractor, which also affected the implementation. Genoulaz *et al.* (2005) and Motwani *et al.* (2005) surveyed ERP literature based on a classification according to six categories: implementation of ERP; optimization of ERP; management through ERP; the ERP software; ERP for supply chain management to demonstrate the importance of ERP systems.

An important role of ERP is to serve as a platform for other applications, such as SCM. In spite of the latest developments of ERP software that provide a unified platform for managing and integrating core business processes within a firm, including SCM the decision-making between marketing and production planning on the whole supply chain still remains rather disjoint. Liu *et al.* (2002) address the system integration of an APS system with ERP. The authors propose an integration model structure and illustrated it by the system integration mechanism taking into account the required frequency of data integration and different approaches of data transfer. Chen and Chen (2005) developed a tactical-level decision model that solves the production-scheduling problem, as analogous to the sales and operations planning, the authors proposed a scheme that can be used as a coordination centre of the APS system within a generic ERP framework, which integrates and coordinates distinct functions within a firm. Verwijmeren (2004) presented a software-component architecture for supply chain management across dynamic organizational networks. The author proposes a local management in the architecture, which is done by existing ERP, WMS, and TMS systems, while the whole management is executed by supply chain engines. Gayialis and Tatsiopoulos (2004) utilise advanced IT systems to effectively support the planning and management of distribution operations, and particularly, the transportation processes. The combination of a SCM application with a geographical information system (GIS) integrated with an ERP software resulted to their decision-support tool. Akkermans *et al.* (2003) studied the future impact of ERP systems on supply chain management. One of their main findings is that the panel experts saw only a modest role for ERP in improving future supply chain effectiveness and a clear risk of ERP actually limiting progress in SCM: ERP was seen as offering a positive contribution to only four of the top 12 future

supply chain issues. Moreover, they identified key limitations of current ERP systems in providing effective SCM support. It is mainly because the first generation of ERP products has been designed to integrate the various operations of an individual firm, whereas in modern SCM, the unit of analysis has become a network of organizations, making these ERP products inadequate in the new economy. Kelle and Akbulut (2005) argue that even if ERP software provides different tools that can support supply chain integration, at the same time it has several features that prevent the integration with business partners. They based their analysis on the inventory management aspects of supply chain coordination and their results can be used in enterprise software to measure the potential monetary value of policy coordination, to promote cooperation, and minimize the total supply chain system cost. Su and Yang (2010a) provided further insights into the adoption of ERP systems and the impacts on firm competence in SCM and proposed a model featuring ERP benefits to firm competences in supply chain management. They demonstrated that there exist close interrelations among the benefits of implementing ERP systems and firm competences in SCM. That evidence confirms that operational benefits, business process and management benefits, and strategic IT planning benefits of ERP in turn enhance firm competences of SCM in operational process integration, customer and relationship integration, and planning and control process integration.

The primary benefit of SCM systems is better operational and business planning. The MRP II and ERP systems of the nineties usually included only rough-cut capacity planning logic, with basic finite-capacity planning functionality limited to key work centers (Vollmann *et al.*, 2005). SCM systems use finite-capacity planning algorithms that do not require iterative adjustments to the master schedule, and real-time planning capabilities allow firms to react quickly to supply and demand changes. Increased revenue, increased productivity, operational cost savings, lower inventory, and reduced order-to-fulfillment cycle time are some of the benefits from SCM system implementations. Su and Yang (2010b) proposed a conceptual framework featuring the ERP benefits and SCM competencies, and examined the impacts of the former on the latter. Authors' results confirmed the operational, managerial, and strategic benefits of ERP for the SCM competencies, but not the IT infrastructure and organizational benefits as significant predictors of them. In their study, more than 80% of respondents think it necessary to first adopt an ERP system

as the backbone of company operations before deploying other enterprise systems (ES), such as the SCM system (Su and Yang, 2010b). A variety of soft computing techniques including fuzzy logic and genetic algorithms has been employed to improve effectiveness and efficiency in various aspects of supply chain management (Ko *et al.*, 2010). Also, Ko *et al.* (2010) presented a review of soft computing applications in supply chain management and their findings were both genetic algorithms and fuzzy logic approach are the most popular techniques adopted to solve supply chain management problems. Particularly in the manufacturing management and order fulfillment issues, and the numerous and complex data sources are always needed to solve most of the problems in supply chain management. Soft computing tools seem promising and useful to analyze this data and to support manager's decision making in a complex environment.

Supply chain information sharing among departments refers to the extent to which critical and proprietary information is communicated to one's supply chain department (Monczka *et al.*, 1998). Shared information varies from strategic to tactical in nature and from information about logistics activities to general market and customer information (Mentzer *et al.*, 2000). That kind of information can be linked with IT. IT is an important enabler for effective supply chain management. As supply chain, management and cycle time compression emerge as central strategies of logistics management, effective IT becomes increasingly necessary to support logistics process (Sanders and Premus, 2002). Much of the current interest in supply chain management is motivated by the possibilities that are introduced by the abundance of data and the savings inherent in sophisticated analysis of these data. Dewett and Jones (2001) defined IT as a linkage between information systems and information technologies. Information systems include many different varieties of software platforms and database. Information technologies encompass a broad array of communication media and devices linking information systems and people. Tam *et al.* (2002) pointed out that there is a demand for the integration of SCM and ERP. They also compared the differences between ERP and SCM systems, and emphasized that extended ERP systems compel firms to provide a communication and information flow among supply chain agents, thus overcoming natural boundaries. SCCEM system integrates both information systems and information technologies in supply chain operations and management. It is well known that the

strength of transactional ERP systems is not in the area of planning. Hence, SCEM systems have been developed to fill this gap.

SCEM systems have become important tools for synchronizing information among the customers and suppliers of a supply chain. However, recent innovations in flexible business technologies have led to a confusing variety of SCEM system alternatives. Predicting which SCEM system will best fit an organization's strategies is complicated by a lack of a theory for understanding how the various capabilities of SCEM systems should be aligned with an organization's strategies. SCEM system capabilities and can help organizations minimize risks by ensuring their chosen systems fit their competitive strategy and supply chain environment.

In summary, SCEM system is not a management paradigm as such. Instead, it represents a new focus on how to link organizational units to the best serve customer needs and to improve the competitiveness of a supply chain as a whole. In this endeavor, SCEM system has drawn knowledge and approaches from a number of disciplines like computer science, logistics, marketing, operations research, organizational theory and many more. To extract, adapt and combine those approaches which best suit a specific supply chain is the challenge of managing a supply chain successfully (Simchi-Levi *et al.*, 2003).

### **II.2.1. SCEM System Industry**

The IS market has been and continues to be one of the fastest growing segments of the IT industry. In recent years, many companies around the world have implemented information systems and the number of companies that plan to implement those systems is growing rapidly.

There are two ways for acquiring SCEM system. One of them is to purchase pre-package SCEM software from a business software solution vendor. Another one is to have a tailor made one especially designed for the organization.

Most of company does not consider tailor made SCEM system because of the process takes long time to integrate those systems. Implementation of those systems requires deep analysis of entire work. Generally tailor made systems are used for specific departments to handle departmental works not for general linkage for whole organization.

SCEM system vendors provide industry leading functionality and visibility to enable supply chain executives to optimize production, minimize costs and inventory, react to unplanned disruptions and maintain high customer service levels. SCM technologies are well positioned to address the economic realities facing worldwide markets where costs are increasing while competition and customer demands are intensifying. At that point, supply chain systems are perfect business solutions for the current economic constraints facing global enterprises. Revenues at the supply chain vendors increased 17.6 percent from 2006 to 2007, from \$5.1 billion to \$6 billion (Wailgum, 2008). That shows us there is greater need for vendor services to help support, improve or tune applications to meet business needs, environments and processes. According to Gartner, which is the world’s leading information technology research and advisory company, demand for SCM vendor services from companies such as SAP, Oracle, JDA Software, Ariba and Manhattan Associates, is also on the increase (www.gartner.com). These five software vendors own the top five spots in the SCM market.

**Table II.1** The Top Five Supply Chain Management Vendors in 2007

<b>The Top 5</b>	<b>SCM Revenue / Market Share</b>
SAP	\$1.3 billion / 22.4%
Oracle	\$955 million / 16%
JDA Software	\$230 million / 3.9%
Ariba	\$160 million / 2.7%
Manhattan Assoc.	\$152 million / 2.6%

(Note: 2007 Gartner estimates)  
(www.gartner.com/ it/analysts)

SAP held the top spot with 22.4 percent of SCM software revenue in 2007, and Oracle was the only other vendor to have double-digital market share.

Pre-packaged systems support many industries. These industries can include diverse industries such as automotive, construction, chemical, energy, professional services, utilities, and distribution. Generally, pre-packaged systems must provide some customized software modules to facilitate these different types of industries (Karnopp, 2006).

As we look at the new numbers about supply chain software revenues for 2009 according to specific systems, there is \$4.442 billion total revenue for vendors in a year in Table II.2.

**Table II.2** Top 20 supply chain management software suppliers for 2009

Rank	Vendor	2008 Revenue	SCP	WMS	MES	TMS
1	SAP	\$942 million	*	*	*	*
2	Oracle	\$715 million	*	*	*	*
3	JDA Software	\$390 million	*			*
4	Manhattan Associates	\$337 million	*	*		*
5	Red Prairie	\$293 million		*	*	*
6	i2 Technologies	\$255 million	*			*
7	Infor	\$177 million	*	*	*	*
8	ILOG	\$175 million	*			
9	IBS	\$171 million	*	*	*	*
10	Epicor	\$138 million	*	*		*
11	Swisslog	\$122 million	*	*		*
12	Sterling Commerce	\$115 million		*		*
13	Aldata	\$108 million	*	*		*
14	Microsoft	\$92 million	*		*	
15	High Jump	\$85 million		*	*	*
16	Applied Materials	\$70 million			*	
17	CDC Software	\$66 million	*	*	*	*
18	Click Commerce	\$65 million		*		
19	QAD	\$57 million	*	*	*	*
20	IFS	\$49 million	*		*	

- Revenues based on company reports or industry estimates

**SCP:** Supply Chain Planning, **WMS:** Warehouse Management System, **MES:** Manufacturing Execution System, **TMS:** Transportation Management System

Source: <http://www.mmh.com/article/356221009>

The leaders in 2008 look much the same as in 2007. Once again, No. 1 SAP with \$942 million and No. 2 Oracle with \$715 million top the list. In a tough year, both posted significant percentage gains, with SAP up nearly 12% and Oracle growing by nearly 9%. JDA Software with \$390 million, Manhattan Associates with \$337 million and Red Prairie with \$293 million rounded out the top five.

All of the SCM categories showed few mergers and acquisitions of note and few technological breakthroughs. Those categories include supply chain planning (SCP) and network design applications as well as supply chain execution solutions like ERP, WMS, Manufacturing Execution systems (MES) and TMS.

The market for supply chain management software applications and services, or SCM, topped \$6.68 billion in 2008, a 4% increase over 2007, according to the most current estimates from AMR Research (Wailgum, 2008). AMR is predicting a

6% decline in 2009, while last year AMR expected the market to top \$8 billion by 2010.

**Table II.3** Top 5 supply chain execution software suppliers for 2009

<b>Rank</b>	<b>Vendor</b>	<b>2008 SCEX Revenues</b>
1	Manhattan Associates	\$337 million
2	Red Prairie	\$293 million
3	SAP	\$137 million
4	Oracle	\$132 million
5	Aldata	\$108 million

- Revenues based on company reports or industry estimates

**SCEX:** Supply Chain Execution

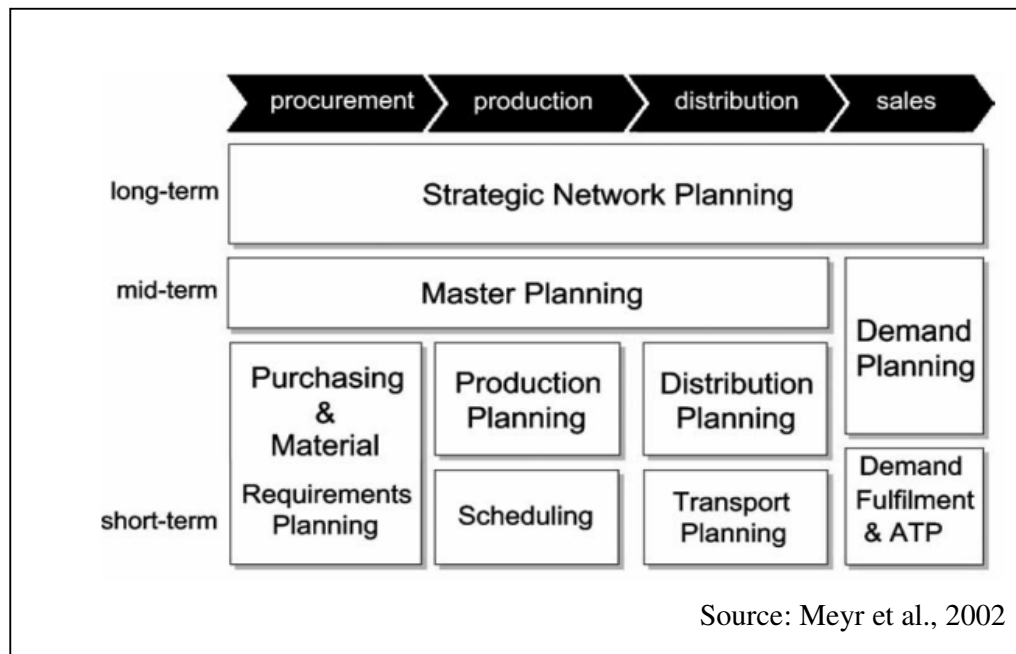
Source: <http://www.mmh.com/article/356221009>

Table II.3 based on only SCEX systems revenue in 2009 with \$1.007 billion total revenue with five vendors.

### **II.2.2. SCXM system Modules**

Supply chain execution and management system is a boundary-spanning field of study of supply chain networks, which organizations use to acquire, produce, and deliver goods and services all over the supply chain. Those systems integrates source (strategic procurement and supply management), make (manufacturing and service operations), deliver (demand fulfillment), and return (reverse logistics, recycle, and remanufacture) processes, along with information systems as the critical enabler of supply chain efficiencies and responsiveness. These core processes span traditional functional boundaries and encompass important activities such as information management; purchasing; inventory flow scheduling and control; logistics-production coordination; transportation systems operation and infrastructure; and customer service, order fulfillment, and distribution facilities management. Supply chain execution and management systems play an increasingly critical role in the ability of firms to reduce costs and increase the responsiveness of their supply chain.

Although developed independently by different software vendors SCXM system exhibit a common architecture based on the principles of hierarchical planning. The focus is on supporting the material flow across a supply chain and related business functions: procurement, production, transport and distribution as well as sales (see Figure II.2).



**Figure II.2** Software modules covering the supply chain planning matrix

A critical aspect of supply chain management is the selection of an appropriate type of supply chain information system to achieve optimal performance. Supply chain execution and management system applications provide real time analytical decisions that manage the flow of information throughout the supply chain network of trading partners and customers in both directions (Sahay and Gupta, 2003). Investment on information systems are important, especially in the current business environment, because of the large sums of money spent on information technologies (Gunasekaran *et al.* 2006). The concept of evaluation of information system such as execution and management system has fallen within the scope of internal enterprise decision making. With the growth of supply chain projects and technologies, the evaluation process takes on more characteristics that are complex. Many corporations, large and small, have taken an interest in this growing supply chain information system market that makes decision phase important.

When we reviewed literature, we saw that most of literature concerned about information system evaluation with different aspects. There are less study of supply chain executive and management system evaluation considering all modules that are used in information systems. Some literature focused on independent variables such

as financial and non-financial subjects, vendor, functionality, and technical criteria on evaluating a system for supply chain but not more about modules of supply chain execution and management systems. Ketikidis *et al.* (2008) found that companies and government in south east Europe do not seem to be ready for playing a significant and demanding role in global supply chains with the usage of effective information systems for logistics and supply chain management. Baki and Cakar (2005) mentioned same difficulties for Turkish manufacturing companies. With the regional differences, evaluation phase differs with the small to medium sized and large organizations concerning information system requirements and evaluation process (Bernroider and Koch, 2001). In addition, supplier relationships and the need of managing inter organizational responsibilities are becoming more visible with the development of supply chain execution and management systems. Also, there is no single integration that addresses all supply chain information system problems. Multiple permutations of technologies need to be used to solve integration problems in information systems (Themistocleous *et al.*, 2004). Complexity of the supply chain makes systems evaluation, selection, and justification more complex (Clemons and Kleindorfer, 1992; Levinson, 1994). Supply chain decision support systems are not simple but are a cluster of various emerging software and hardware technologies (Sahay and Gupta, 2003).

While evaluation process is complex and difficult many companies face with failure to have strategic value because information technology becomes more sophisticated over time. Evaluation phase divided into different aspects, Gunasekaran *et al.* (2006) determined commonly employed criteria for information systems evaluation which can be grouped as follows: i) strategic impact, ii) tactical considerations, iii) operational performance, iv) financial measures, v) non-financial indicators, vi) tangibles, and vii) intangibles, based on a wide literature survey. However, we noticed that supply chain modules evaluation article was not found among those literatures. The reason shall be the evaluation criteria are more technical than those independent approaches.

The decision making process has grown more difficult in recent years with the increased complexity of business operation about by the rapid growth of supply chain management. The complexities of this dynamic business environment should be taken into account supply chain system evaluation. A review of the current

literature on supply chain execution and management system is conducted. As we mentioned before most of articles focus on different types of measures such as strategic, tactical, and operational, tangibles, intangibles, financial and non-financial. Some articles focus on the techniques and tools used in evaluating information system projects and investments. Here are the articles that mention the modules that are used in supply chain management. In addition, literature presented applications with supply chain management modules. It is important that to define such modules, would take place while evaluating SCEM systems.

Stadtler (2004) covered in his article supply chain matrix modules that covering the supply chain planning matrix and focuses on software for advanced planning. He discussed such modules; demand planning, master planning, production planning and detailed scheduling, purchasing and material requirements planning, demand fulfillment and available to promise (ATP), event based planning, uncertainty, decentralization and collaboration. Whitehair and Berg (2002) mentioned that there is a greater need to link advanced planning system with accounting standards.

Meyr *et al.* (2002) covered on supply chain planning module with; strategic network planning, master planning, demand planning, purchasing & material requirement planning, production planning, scheduling, distribution planning, transportation planning, demand fulfillment and ATP. Downs (2002) and Fleischmann and Meyr (2003) reported a successful implementation of a linear programming model for order promising in the demand fulfillment and ATP module. Master planning has to coordinate activities and processes along a SC and thus has to capture decisions in procurement, transport, production and distribution adequately. The integration of transport and production decisions within SC has been the concern of several papers (Simpson and Erenguc, 2001; Lanzenuer and Pilz-Glombik, 2000).

Arbib and Marinelli (2005), Fischer (2001), Kilger and Schneeweiss (2002), Persson and Gothe-Lundgren (2005) specified that modules should be added such as; master planning, order promising, shortage planning to supply chain structure scheduling and shipment planning module.

Berkelaar *et al.* (2002), Drexl and Kimms (1997), Dudek and Stadtler (2005), Eppen *et al.* (1989), Escudero *et al.* (1999), and Santoso *et al.* (2003), Spitter *et al.*

(2005), Wagner (2002), and Wolsey (2002) studied on uncertainty module for lot sizing optimization and presented an approach for modeling lead times and lot sizing sub modules within master planning module and scheduling module.

Nielsen and Larsen (2005) and Minner (2000) indicated that an inventory control policy could be attributed to a central purchasing function and for inventory management module. Boyson *et al.* (2003) mentioned importance of bar-coding and material handling technologies in inventory management systems.

Dellaert and Jeunet (2005) and Vollman *et al.* (1997) demonstrated importance of materials requirement planning module with its sub-modules of an ERP system including various forms of discount options in purchasing.

Simpson and Erenguc (2001), and Haehling von Lanzenuer and Pilz-Glombik (2000) studied on procurement, transport, production and distribution modules how to make more efficient. Maravelias and Grossmann (2003), Rom *et al.*, (2002), Azevedo and Sousa (2000), and Suerie and Stadler (2002); studied on optimizing event-based planning module. Graves (2003) indicated processing time module should be included in uncertainty module in supply chain management system.

Kjenstad (1998) and Fox *et al.* (2000) cited functional agents, which are responsible for order acquisition, logistics, transport, or scheduling modules with their importance. Lummus and Vokurka (1999) indicated supply chain management involves planning and management of material, information and financial flows in a network consisting of manufacturers, distributors, vendors, and customers optimization modules. Caputo *et al.* (2003) proposed hardware and software architecture for support to logistics planning phase including geographical information system technology, warehouse location, and choice of vehicle routing. They characterized transportation parameters such as fleet size, vehicle type, fleet cost, service demand, number of depots, cost items, kind of operation, number of routes per vehicles in the planning period, travel time, road network, times and distances, and objectives. Karkkainen *et al.* (2007) stated transaction processing, supply chain planning and collaboration, and order tracking and delivery coordination drivers represent differ in inter-firm information system uses in supply chain management. Lancaster *et al.* (2006) evaluated functionality of marketing and company information, catalog and product information, inventory information for supply chain partners, logistics information for supply chain partners, customer

personalization, and order tracking categories for effective e-SCM. Sahay and Gupta (2003) studied on a supply chain package, which generally includes such components; Supply chain design/configuration, supply chain planning, advanced planning and scheduling, demand management, inventory management, work center execution system, warehouse management system, transportation management, distribution network management, customer order management, and component and supplier management, supply chain collaboration.

Helo and Szekely (2005) reviewed the development of software applications and presented some functions such as inventory management, order flow, optimize delivery routes for retailers, operational transport control, transportation business control, route planning, real time information, integrated material handling, human resources and finance control, multi-site, multi-language, multi-user system, integration of data store, advanced reporting features, supply chain inventory and lot size optimization, order decoupling, material flow analysis, internet based real time transactions, supply chain level reporting.

Songini (2005) commented that the contract management module is a key piece of the release (John Webb, vice president of supply chain application product strategy at Oracle). Harreld (2001) stated the transportation execution suite has been designed to handle domestic and international transportation needs for enterprise users. Waltner (2000) focused on the benefits gained from factory planner module and mentioned the importance of factory planner module. Sykes (1997) stated that Oracle adds modules to software lines, which are human resources, manufacturing, sales and marketing, and workflow applications. Disney *et al.* (2004) mentioned supply chain management across companies is supported by information technology based tools such as advanced planning and scheduling systems, collaborative planning, forecasting, and replenishment, efficient consumer response, vendor-managed inventories, and improvements in mathematical optimization of supply chains. Bartsch and Bickenbach (2002) gave examples for advanced planning system with functions such as demand planner, supply network planner, supply chain cockpit, and global availability check. Lee *et al.* (2002) presented special modules in their editorial study such as supply chain planning, supply chain execution, supply chain modeling and simulation, E-business and SCM, advanced planning and scheduling, integrated production, distribution planning, purchasing, procurement,

multi-plant chain planning, integrated inventory management, order processing and customer relationship management, vendor relations model.

Silver *et al.* (1998) and Huchzermeier *et al.* (2002) mentioned the importance of demand planning module and that should be included to supply chain management systems. Demand planning enables accurate demand forecasts are an important input to decision models used in SCEM systems. Forecast errors are directly related to required safety stocks, while frequent adjustments of demand forecasts can lead to dramatic changes in plans. Hence, great emphasis has to be put on choosing correct forecasting models. So far, sophisticated models are very rare in demand planning (Huchzermeier *et al.* 2002). Demand management forecasts how much product to move through the supply chain, how much product to produce, and how much product will need to be produced in the future, based on historical data. Supply chain analytics enables supply chain managers to create work-around if problems within the supply chain occur. Supply chain analytics is comprised of supply chain optimization, supply chain event management, and production and supply planning. Order management enables suppliers (or manufacturers) to take an order, search within their inventory to see if the item is available, and ship the item to its final destination.

Production planning and detailed scheduling enables especially production planning and detailed scheduling have to be adapted to the specific needs and conditions arising at the shop floor. Here, it does not seem wise to find an overall tool adequate for any possible type of production. Warehouse management system enables firms to optimize methods of storing and moving inventory through the warehouse. Transportation management system enables transportation firms to manage and optimize any mode of transportation. International trade logistics helps organizations with the logistics of importing and exporting, the finances related to these activities, and collaboration between firms across multiple locations. Supplier relationship management (SRM) manages the relationships between suppliers, distributors, and manufacturing firms. SRM is one of the key features that enable manufacturing firms to source products quickly.

As we stated before SCM systems are used to coordinate the movement of products and services from suppliers to customers (including manufacturers, wholesalers, and retailers). These systems are used to manage demand, warehouses,

trade logistics, transportation, and other issues concerning facilities, and movement and transformation of materials on their way to customers. To support that linkage among organizations those modules should be included to supply chain software.

According listed references, widely industry analysis, and inspecting existent supply chain execution and management systems, we combined most important and mostly used modules and sub-modules and presented in next chapter. Decision maker team would determine the most needed modules and sub models for evaluation phase.

# CHAPTER III

## METHODOLOGY OF THE RESEARCH

### III.1. MULTIPLE CRITERIA DECISION MAKING

Multiple criteria decision-making (MCDM) refers to making decisions in the presence of multiple, usually conflicting criteria. The problems of MCDM can be broadly classified into two categories: multiple attribute decision making (MADM) and multiple objective decision-making (MODM), depending on whether the problem is a selection problem or a design problem. MODM methods have decision variable values that are determined in a continuous or integer domain, with either an infinitive or a large number of choices, the best of which should satisfy the decision maker's constraints and preference priorities. MADM is a methodology that helps decision-makers makes preference decisions selection regarding a finite set of available alternatives courses of action characterized by multiple potentially conflicting attributes (Chang *et al.*, 2007). MADM methods, on the other hand, are generally discrete, with a limited number of predetermined alternatives. MADM is an approach employed to solve problems involving selection from among a finite number of alternatives. An MADM method specifies how attribute information is to be processed in order to arrive at a choice.

Each decision matrix in MADM methods has four main parts, namely: (a) alternatives, (b) attributes, (c) weight or relative importance of each attribute, and (d) measures of performance of alternatives with respect to the attributes. The decision table shows alternatives,  $A_i$  (for  $i = 1, 2, \dots, N$ ), attributes,  $B_j$  (for  $j = 1, 2, \dots, M$ ) weights of attributes,  $w_j$  (for  $j = 1, 2, \dots, M$ ) and the measures of performance of alternatives,  $m_{ij}$  (for  $i = 1, 2, \dots, N; j = 1, 2, \dots, M$ ). Given the decision table information and decision making method, the task of the decision maker is to find the best alternative and to rank the entire set of alternatives. It may be added here that all the elements in the decision table must be normalized to the same units, so that all possible attributes in the decision problem can be considered.

The typical multi attribute evaluation problem focuses on a set of feasible alternatives and considers more than one criterion to determine a priority ranking for alternative implementation. A decision maker needs to select or rank alternatives that are associated with non-commensurate and conflicting attributes (Chen and Hwang, 1992). MADM involves three phases; firstly, it needs collecting the information about attribute weights and attribute values; secondly, it involves weighted aggregation of the attribute values across all attributes for each alternative to obtain an overall value; thirdly, it orders the overall values to obtain the best alternatives (Xu, 2004).

**Table III.1** Decision table in MADM methods

Alternatives	Attributes					
	B <sub>1</sub> (w <sub>1</sub> )	B <sub>2</sub> (w <sub>2</sub> )	B <sub>3</sub> (w <sub>3</sub> )	- (-)	- (-)	B <sub>M</sub> (w <sub>M</sub> )
A <sub>1</sub>	m <sub>11</sub>	m <sub>12</sub>	m <sub>13</sub>	-	-	m <sub>1M</sub>
A <sub>2</sub>	m <sub>21</sub>	m <sub>12</sub>	m <sub>13</sub>	-	-	m <sub>2M</sub>
A <sub>3</sub>	m <sub>31</sub>	m <sub>12</sub>	m <sub>13</sub>	-	-	m <sub>3M</sub>
-						
-						
A <sub>N</sub>	m <sub>N1</sub>	m <sub>N2</sub>	m <sub>N3</sub>	-	-	m <sub>NM</sub>

Methodology based on fuzzy hierarchy within two different approaches. In MCDM each criterion needs to be compared with other criteria in terms of their relative importance for achieving the overall objective of the problem (Yeh and Chang, 2009). However, in many cases, the preference model of the human decision maker is uncertain, and it is relatively difficult to provide exact numerical values for the comparison ratios. To cope with uncertain judgments expressions were the ratios as fuzzy sets, which incorporate the vagueness of human thinking. Linguistic variables are very useful in dealing with uncertain and inaccurate factors involved in complex group decision situations (Lu *et al.*, 2008). Firstly, fuzzy logic is presented then MADM approaches are detailed.

### III.2. FUZZY MULTI ATTRIBUTE DECISION MAKING

It is such an ordinary action to make decision, which contains alternatives and criteria. Many organizational decisions are made through evaluating a set of potential alternatives and then ranking them or selecting a satisfactory one from them based on the available information at hand and the perspectives of decision makers. Decision makers have to select, classify the alternatives or develop new alternatives according to the predefined criteria. In fuzzy decision-making, alternatives are evaluated by using quantitative and qualitative variables, because fuzzy models use both of them, which are more flexible than other decision-making models. Fuzzy set theory uses also linguistic variables to represent imprecise information and vagueness of human language. That makes fuzzy models more superior than others do.

Zimmermann (1987) first presented introducing practically Zadeh's fuzzy set theory (Zadeh, 1965) into conventional decision-making models. Following this, a lot of research has been conducted in the area of group decision-making under the application of fuzzy set theory. Some of them have also applied the concept of linguistic variables proposed by Zadeh (1975) to handle linguistic terms and approximate reasoning in a group decision-making problem. Some researches (Carlsson and Fuller 1996; Chang and Chen 1994; Dubois *et al.*, 2001; Herrera and Verdegay 1994; Hsu and Chen 1996; Kacprzyk *et al.*, 1992; Lu *et al.*, 2008; Marimin *et al.* 1998; Nishizaki and Seo 1994; Wang and Lin 2003; Zhang and Lu 2003) have been carried out in describing the uncertainty of individual preferences for alternatives and aggregating these fuzzy individual preferences into a group decision.

Bezdek *et al.* (1978), Blin (1974), Nurmi (1981), Tanino (1988), Montero and Tejada (1986) interpret group decision-making as follows: Suppose you have a set of options,  $S = (s_1, s_2, \dots, s_n)$ , and  $m$  individuals. Each individual  $k$ ,  $k = 1, \dots, m$ , provides his or her preferences over  $S$ . As these preferences may be not clear-cut, their representation by individual fuzzy preference relations is strongly advocated (Kahraman *et al.*, 2003).

Lee (1996) builded a group decision-making structure model of risk in software development and proposed two algorithms to tackle the rate of aggregative risk in a fuzzy environment by fuzzy sets theory during any phase of the life cycle. Herrera *et al.* (1996) presented a consensus model in-group decision-making under linguistic assessments; also, Herrera *et al.* (1997) presented several group decision-

making processes by a direct approach. These processes are designed using the linguistic ordered weighted averaging operator. Li (1999) studied on decision making with multiple judge, multiple criteria in a fuzzy environment, where the performance of alternatives and importance of criteria are imprecisely defined and represented by fuzzy sets. Chen (2001) presented an algorithm to evaluate the rate of aggregative risk in software development using fuzzy set theory under the group decision-making environment. Bozdag *et al.* (2003) applied fuzzy group decision making for computer integrated manufacturing systems selection, Cochran and Chen (2005) used fuzzy multi criteria selection approach for object oriented simulation software for production system analysis, Lee *et al.* (2004) used fuzzy multi criteria for software selection and Lin *et al.* (2006) for warehouse system selection. This technique is used when performance rating and weights can not be given precisely. In such cases, the fuzzy set theory is used to model the uncertainty.

### **III.2.1. The Fuzzy Logic, Fuzzy Set Theory and Fuzzy Numbers**

In bivalent logic, truth is bivalent, implying every proposition, is either true or false, with no degrees of truth allowed. In multivalent logic, truth is a matter of degree. However, fuzzy logic is not in conflict with bivalent logic, it is a generalization of bivalent logic in which everything is, or is allowed to be, a matter of degree. Fuzzy logic provides a foundation for the methodology of computing with words and perceptions (Zadeh, 2004).

Fuzzy set theory (FST) is a mathematical theory introduced by Zadeh (1965, 1975) to model uncertainty attributed to the vagueness and imprecision in real systems, particularly that of the human cognitive processes. The underlying logic of linguistic approach is that the truth-values are fuzzy sets and the rules of inference are approximate rather than exact (Gupta *et al.*, 1977). Fuzzy logic allows us to make rational decisions in an environment of uncertainty, fuzziness and imprecision without losing the richness of verbal judgment (Klir and Yuan, 1995). FST resembles human reasoning in its use of approximate information and uncertainty to generate decisions. Fuzzy terms are a linguistic variable, which play a central role in fuzzy logic, and underlies most of its applications (Zadeh, 2004). A linguistic variable is a variable whose values are words or sentences in a natural or synthetic

language (Zadeh, 1973). Fuzzy set theory has been widely developed and various generalizations have applied.

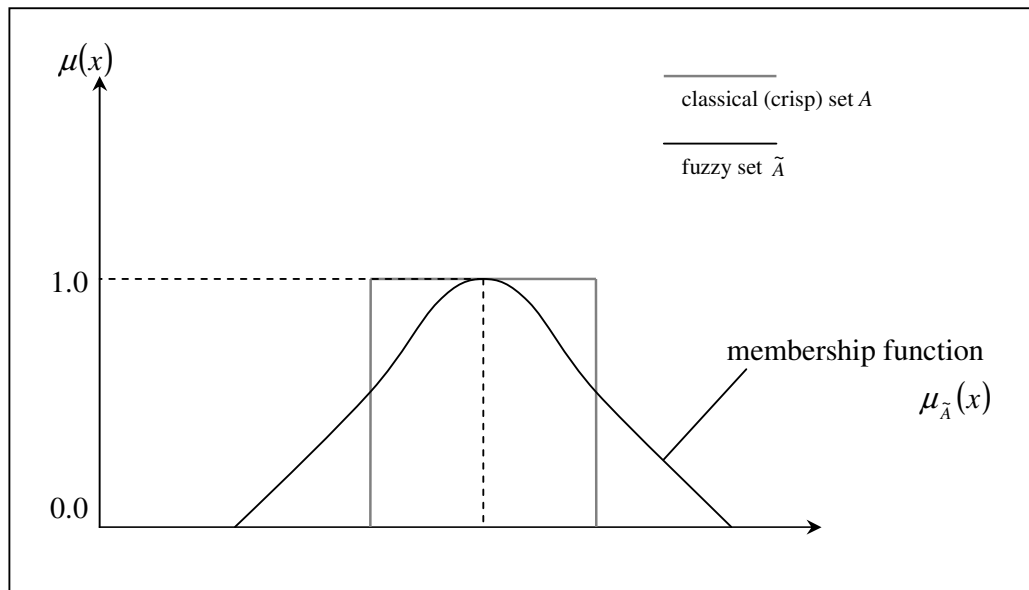
By contrast, fuzzy set theory permits the gradual assessment of the membership of elements in relation to a set; this is described with the aid of a membership function valued in the real unit interval  $[0, 1]$ . Fuzzy sets are an extension of classical set theory since, for a certain universe, a membership function may act as an indicator function, mapping all elements to either 1 or 0, as in the classical notion.

Specifically, a fuzzy set is any set that allows its members to have different grades of membership (membership function) in the interval  $[0, 1]$ . A fuzzy set on a classical set  $X$  is defined as follows:

$$\mu_A : X \rightarrow [0,1] \tag{III.1}$$

$$\tilde{A} = \{(x, \mu_{\tilde{A}}(x)) \mid x \in X\} \tag{III.2}$$

The membership function  $\mu_A(x)$  quantifies the grade of membership of the elements  $x$  to the fundamental set  $X$ . An element mapping to the value 0 means that the member is not included in the given set, 1 describes a fully included member. Values strictly between 0 and 1 characterize the fuzzy members.



**Figure III.1** Fuzzy membership function

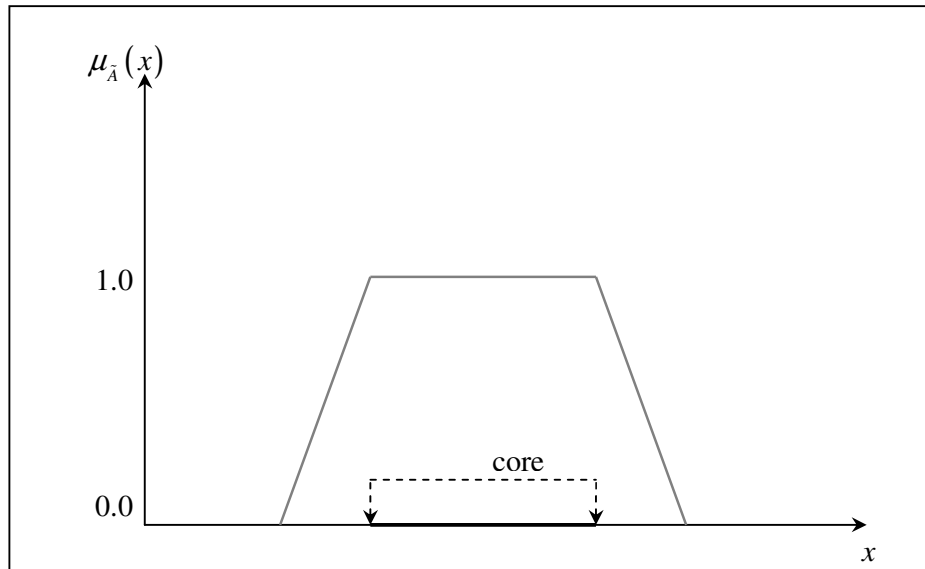
A fuzzy model is the idea of a fuzzy set. A fuzzy set differs from conventional (crisp) sets in its semi permeable boundary membrane. Instead of a characteristic function, that has two states: inclusion and exclusion, the fuzzy set has a function that admits a degree of membership in the set from complete exclusion “0” to absolute inclusion “1”. The value “0” is used to symbolize complete non-membership, the value “1” is used to symbolize complete membership, and values in between are used to symbolize intermediate degrees of membership (Fayad and Webb, 1999).

The core of a fuzzy set is the area where the elements have maximum degree of membership.

$$core (A) = \{ x \in X \mid \mu_A(x) = 1 \} \quad (III.3)$$

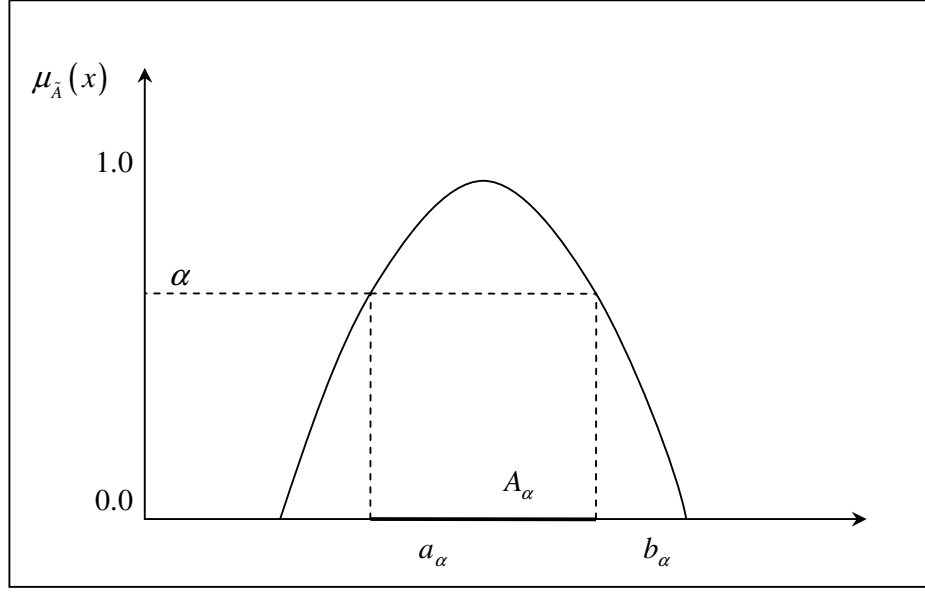
The  $\alpha$ -cut is a set or crisp interval of fuzzy set  $A$  for a particular degree of membership at height  $\alpha$ .

$$\alpha\text{-cut } (A) = \{ x \in X \mid \mu_A(x) \geq \alpha \} , A_\alpha = [a_\alpha, b_\alpha] \quad (III.4)$$



**Figure III.2** Core of a fuzzy set (Vanegas and Labib, 2001)

A fuzzy set is called as normal fuzzy set if it has at least one element with a membership degree of 1 ( $\mu_A(x) = 1$ ), otherwise it is non-normal.



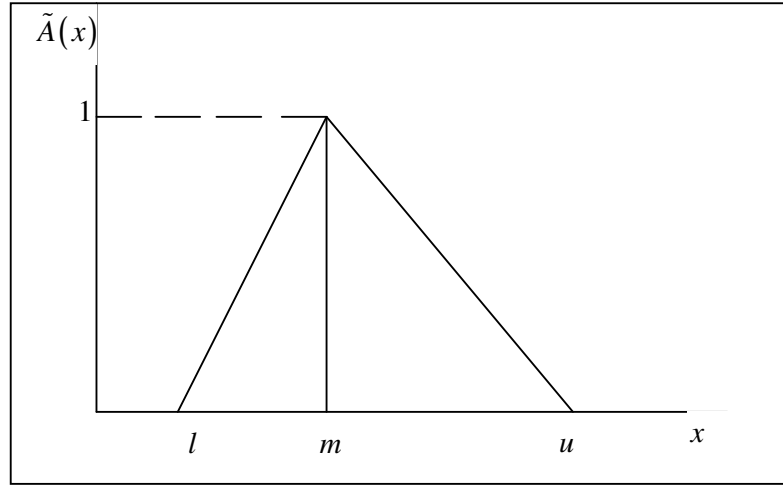
**Figure III.3**  $\alpha$ -cut of a fuzzy set (Vanegas and Labib, 2001)

A fuzzy number is a special case of a fuzzy set, and it can be described as a subset of real numbers whose membership function  $\mu_A$  is a continuous mapping from  $\mathbf{R}$  (real line) to a closed interval  $[0,1]$  (Liang and Wang, 1994). Triangular, trapezoidal and Gaussian are some types of fuzzy numbers, however triangular and trapezoidal are most common types of fuzzy numbers. We consider triangular type of fuzzy number as a well-known application.

The membership functions for a triangular fuzzy numbers (TFN) are triangular shape and can be presented by a triplet  $(l, m, u)$ , indicating the lower limit of support, the mode (core) and the upper limit of support (Chen, 1996). They are most common fuzzy numbers, and main reason for using them is that decision makers find them intuitively easy to use (Liang and Wang, 1994). TFN's membership function is defined as:

$$\mu_{\tilde{A}}(x) = \begin{cases} \frac{x-l}{m-l}, & l \leq x \leq m \\ \frac{u-x}{u-m}, & m \leq x \leq u \\ 0, & \text{otherwise} \end{cases} \quad (\text{III.5})$$

where  $l \leq m \leq u$ ;  $l$  and  $u$  stand for the lower and upper value of the support of  $A$ , respectively;  $m$  is the most possible value of fuzzy number  $A$ . When  $l = m = u$ , it is a non-fuzzy number by convention (Büyüközkan, 2004).



**Figure III.4** Triangular Fuzzy Numbers  $(l, m, u)$

with  $-\infty < l \leq m \leq u < \infty$  and the operational laws of two TFNs  $\tilde{A}_1 = (l_1, m_1, u_1)$  and  $\tilde{A}_2 = (l_2, m_2, u_2)$  as shown (Kaufmann and Gupta, 1991):

Fuzzy number addition and subtraction:

$$\tilde{A}_1 \mp \tilde{A}_2 = (l_1, m_1, u_1) \mp (l_2, m_2, u_2) = (l_1 \mp l_2, m_1 \mp m_2, u_1 \mp u_2) \quad (\text{III.6})$$

Fuzzy number multiplication:

$$\tilde{A}_1 \otimes \tilde{A}_2 = (l_1, m_1, u_1) \otimes (l_2, m_2, u_2) = (l_1 \times l_2, m_1 \times m_2, u_1 \times u_2) \quad (\text{III.7})$$

Fuzzy number inverse:

$$\tilde{A}^{-1} = (l, m, u)^{-1} \cong \left( \frac{1}{u}, \frac{1}{m}, \frac{1}{l} \right) \text{ for } l, m, u > 0 \quad (\text{III.8})$$

Buckley (1985) showed how to derive the priorities from a set of fuzzy comparisons described by trapezoidal membership functions and in practical applications, the triangular form of the membership function is used most often for

representing fuzzy numbers that characterize linguistic information (Yeh and Deng, 2004). The popular use of TFN is mainly attributed to their simplicity in both concept and computation. Theoretically, the merits of using TFN in fuzzy modeling have been well justified (Pedrycz, 1994). With the simplest form of the membership function, triangular fuzzy numbers constitute an immediate solution to the optimization problems in fuzzy modeling (Yeh and Chang, 2009).

The most possible value, the lower bound, and the upper bound of the fuzzy group weight of the criterion are given by the geometric mean, the smallest value, and the largest value. Also, the mean value of the individual weights, respectively. As a measure of central tendency, the geometric mean is well suited to represent the most possible value of a triangular fuzzy number. In addition to its merits for synthesizing ratio judgments as used in equation 1, the geometric mean is a meaningful way of dealing with situations where a consensus cannot be obtained and the group is not willing to compromise on a judgment (Dyer and Forman, 1992, Aull-Hyde *et al.*, 2006).

When we through the operations of fuzzy set to get the fuzzy interval, next we will convert the fuzzy value into the crisp value. This is something that is normally done after a fuzzy decision has been made and the fuzzy result must be used in the real world.

Fuzzy systems generally incorporate as last step a defuzzification process that output the core of the fuzzy system into a crisp value (Leekwijck, 1999). This is known as defuzzification and probably the best-known defuzzification operator is the center of area (COA). To utilize the COA method to find out the non-fuzzy number is a simple and practical method, and there is no need to bring in the preferences of any evaluators, so it is used in this study. The non fuzzy value (NFV) of the fuzzy number  $\tilde{R}_i$  can be found by the following equation:

$$NFV_i = \left[ (uR_i - lR_i) + (mR_i - lR_i) \right] / 3 + lR_i \quad \forall i. \quad (III.9)$$

According to the value of the derived NFV for each criterion's and alternative's crisp value can then proceed.

### **III.2.2. Fuzzy Rating and Ranking**

A decision maker who wants to order fuzzy quantities extracts a specific feature from fuzzy sets and ranks these fuzzy sets according to the feature extracted. Therefore, decision maker can reach different ranking orders if he uses different ranking methods (Prodanovic, 2001).

Fuzzy decision, which is a model for decision making in a fuzzy environment, the object function and constraints, are characterized as their membership functions, the intersection of fuzzy constraints and fuzzy objection function. Fuzzy decision-making method consists of three main steps:

1. Representation of the decision problem: the method consists of three activities. (a) Identifying the decision goal and a set of the decision alternatives. (b) Identifying a set of the decision criteria. (c) Building a hierarchical structure of the decision problem under consideration.
2. Fuzzy set evaluation of decision alternatives: the steps consist of three activities. (a) Choosing sets of the preference ratings for the importance weights of the decision preference ratings include linguistic variable and triangular fuzzy number. (b) Evaluating the importance weights of the criteria and the degrees of appropriateness of the decision alternatives. (c) Aggregating the weights of the decision criteria.
3. Selection of the optimal alternative: this step includes two activities. (a) Prioritization of the decision alternatives using the aggregated assessments. (b) Choice of the decision alternative with highest priority as the optimal.

In general, fuzzy logic is much more general than traditional logical systems; it provides a foundation for the methodology of computing words and perceptions. Overall SCEM system evaluation procedure contains subjective judgments including vague and imprecise information. These kinds of processes make fuzzy logic necessary for SCEM system evaluation. Fuzzy MADM methods are used in this study to compute ratings for vendors. To achieve evaluation process two different models are presented and compared each other of evaluation processes, which are, F-AHP with F-TOPSIS, and F-ANP respectively.

We considered F-AHP – F-TOPSIS and F-ANP methodologies to find out best proposal for MADM in SCEM systems evaluation.

### III.3. F-AHP with F-TOPSIS APPROACH

The significance of the F-AHP with F-TOPSIS is that it allows a decision maker to express his/her judgment of the importance of criteria and decision alternatives in linguistic forms. This kind of judgment can improve the efficiency of human judgment compare to the traditional scale of the AHP. A framework of F-AHP with F-TOPSIS includes two major phases outlined in Figure III .5.

The F-AHP phase applies the fuzzy set theory (Zadeh, 1965) to construct the pair-wise comparisons of the AHP by transforming linguistic judgments into fuzzy numbers and uses extent analysis (Chang, 1992) to calculate and integrate the weights of the criteria and alternatives. These weights are then used to rank the alternatives in F-TOPSIS phase.

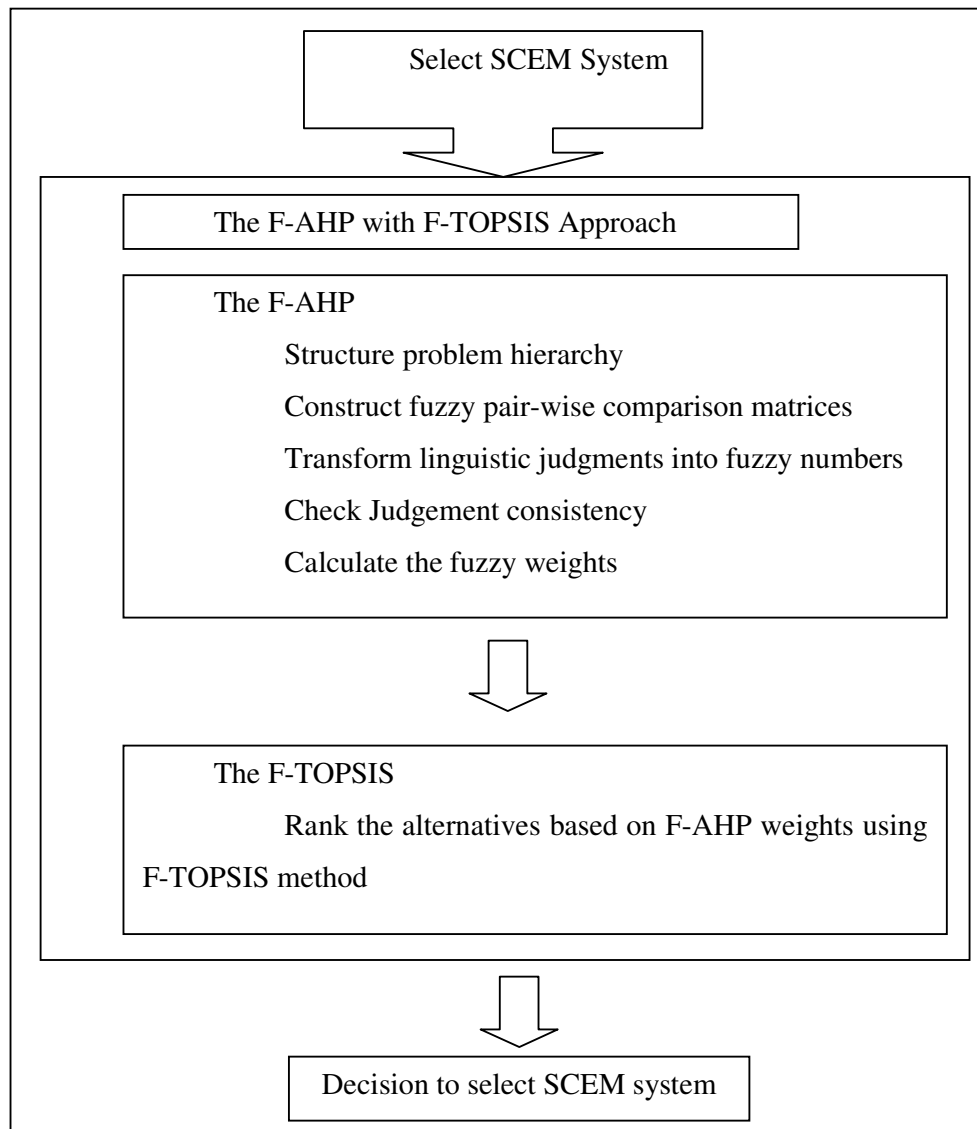


Figure III.5 Framework of F-AHP with F-TOPSIS

AHP and TOPSIS integrated models have been applied to various decision-making problems. While, Lin *et al.* (2008) used AHP and TOPSIS approaches to identify customer requirements and design characteristics, and help achieve an effective evaluation of the final design solution for assist designers, Secme *et al.* (2009), and Ertugrul and Karakasoglu (2009) used that approaches to evaluate performances of banks and firms' financial ratios, respectively. Buyukozkan *et al.* (2008) proposed that approach to evaluate e-logistics-based strategic alliance partners. There have been done numerous studies on AHP and TOPSIS integrated model but there is non-study about evaluation of SCEM systems. Here, some recent studies are presented for to support methodology's usability.

### **III.3.1. F-AHP Phase**

The F-AHP phase obtains judgments about the importance of criteria and decision alternatives from the decision-makers and calculates total weights, which will be used in F-TOPSIS model.

The analytic hierarchy process has been widely used for evaluation of software packages (Jadhav, 2009), which, was first introduced by Saaty (1980), also is one of the most used multi-criteria decision making methods. It is used to derive relative priorities on absolute scales from both discrete and continuous paired comparisons in multilevel hierarchic structures (Satty, 1988). AHP is also a measurement theory that prioritizes the hierarchy and consistency of judgmental data provided by a group of decision makers. AHP incorporates the evaluations of all decision makers into a final decision, without having to elicit their utility functions on subjective and objective criteria, by pair-wise comparisons of the alternatives (Saaty, 1990).

In conventional AHP, the pair-wise comparison is established using a nine-point scale, which converts the human preferences between available alternatives as equally, moderately, strongly, very strongly or extremely preferred. Even though the discrete scale of AHP has the advantages of simplicity and ease of use, it is not sufficient to take into account the uncertainty associated with the mapping of one's perception to a number. Therefore, fuzzy logic is introduced into the pair-wise comparison to deal with the deficiency in the traditional AHP. This is referred to as fuzzy AHP. Laarhoven and Pedrycz (1983) extended AHP into fuzzy AHP (F-AHP), bringing the triangular fuzzy number of the fuzzy set theory directly into the pair-

wise comparison matrix of the AHP. In F-AHP method, the decision maker can specify preferences in the form of natural language or numerical value about the importance of each performance attribute. To give interval judgments than fixed value judgments is more confident for decision makers. So, triangular fuzzy numbers are used to decide the priority of one decision variable over other in F-AHP (Chan and Kumar, 2005).

F-AHP is an efficient tool to handle the fuzziness of the data involved in deciding the preferences of different decision variables. The comparisons produced by the expert are represented in the form of triangular fuzzy numbers to construct fuzzy pair-wise comparison matrices (Ghodsypour and O'Brien, 1998). By the help of F-AHP, we can efficiently handle the fuzziness of the data involved in the decision of selecting best supplier. It is easier to understand and it can effectively handle both qualitative and quantitative data in the multi-attribute decision making problems. In this approach, triangular fuzzy numbers are used for the preferences of one criterion over another.

This study bases on Buckley (1985), and Hus and Yang (2000) to analyze data and reach consensus among experts. Consensus is an important technique for incorporating the judgment of several decision makers. The process of obtaining consensus ensures that everyone's interest are considered; thus consensus enhances confidence in the priority values by using several judges to bring the results in line with majority preferences (Saaty, 1980). In making group decisions using AHP, consensus is obtained to (1) construct hierarchy structures, (2) judge the importance of criteria or alternatives in pairwise comparisons (3) make a final decision. This technique is attractive for two reasons (Dyer and Forman, 1992). First, the discussion is beneficial to help ensure that relevant information possessed by any of the group members, either objective or subjective, is made available to the entire group. Second, consensus is desirable so that the group members feel they are owners of the decision, thereby obtaining their best efforts to reach a successful implementation.

The F-AHP phase includes steps as follows:

Step 1 Structure problem hierarchy

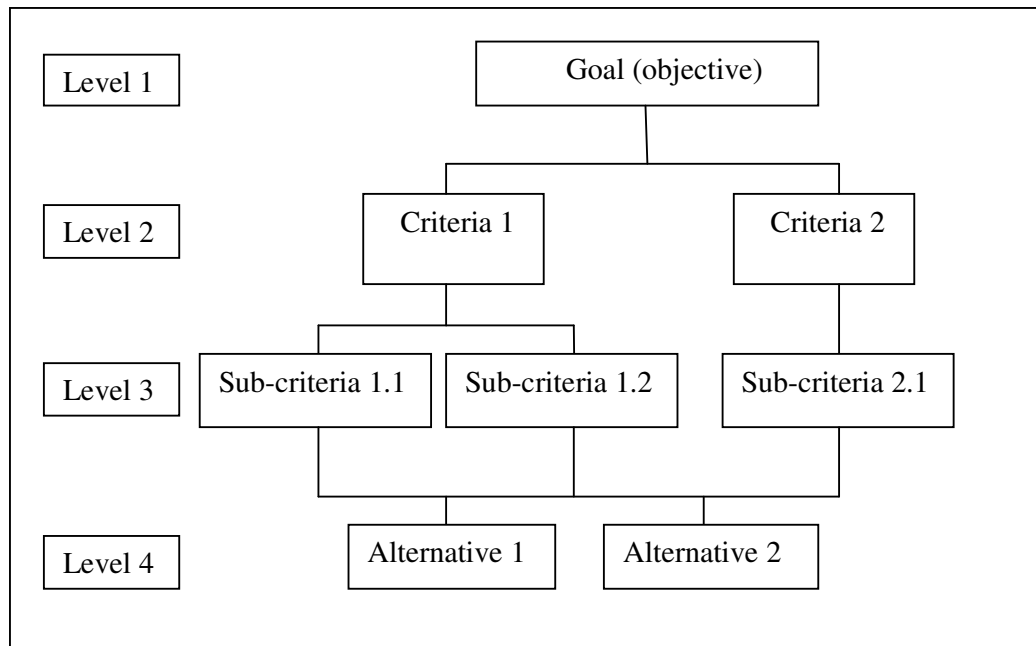
The first step of the approach is to construct a problem into a hierarchy, including a goal, set of criteria, and set of alternatives. The general hierarchy

structure of the F-AHP is shown as Figure III.6. The highest level of the hierarchy (level 1) consist of only one element, an object or a goal, that decision maker wants to reach. The lower levels (level 2) of the hierarchy contain criteria (attributes), which contribute to the goal. The process may continue down to criteria that are more detailed at level 3. The last level of hierarchy, level 4, includes decision alternatives, which are to be evaluated in terms of the criteria in the upper level.

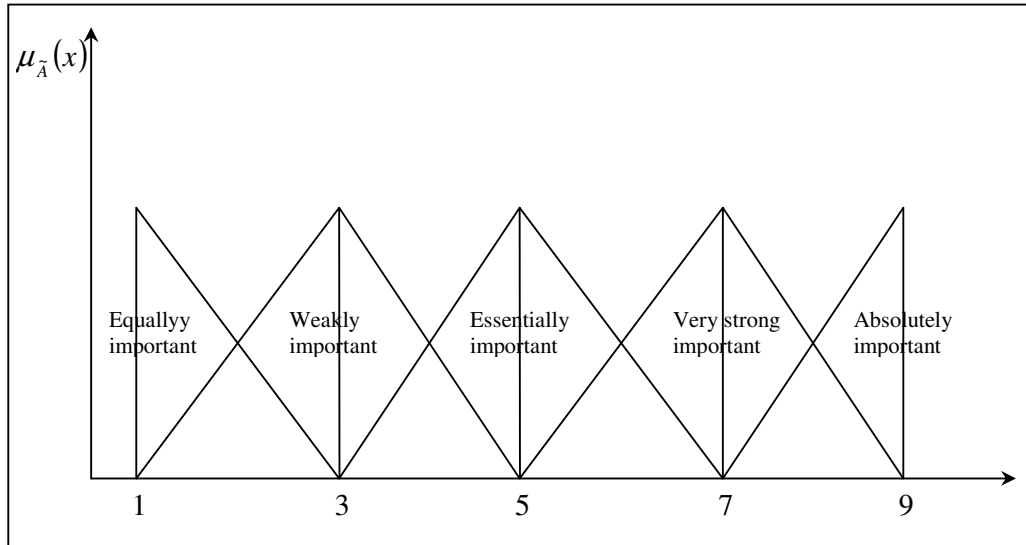
Structuring the problem hierarchy is the most creative step that has a significant effect on the result of the decision (Saaty, 1994).

Step 2 Construct fuzzy pair-wise comparison

According to Zadeh (1973), it is very difficult for conventional quantification to express reasonably those situations that are overtly complex or hard to define; so the notion of a linguistic variable is necessary in such situation. A linguistic variable is a variable whose values are words or sentences in a natural or artificial language. Here, we use this kind of expression to compare two building SCEM system evaluation criteria by five basic linguistic terms, as “absolutely important,” “very strongly important,” “essentially important,” “weakly important” and “equally important” with respect to a fuzzy five level scale (see Fig. III.7) (Chiou, 2001).



**Figure III.6** Construct fuzzy pair-wise comparison Matrices



**Figure III.7** Membership function of linguistics variables for comparing two criteria

### Step 3 Transform Linguistic Judgments into Fuzzy Numbers

After decision makers finish assigning linguistic judgment in the pairwise comparison matrix in step 2, the linguistic judgment is transformed into a fuzzy number. In this paper, the computational technique is based on the following fuzzy numbers defined by Mon *et al.* (1994) in Table III.2. Here each membership function (scale of fuzzy number) is defined by three parameters of the symmetric triangular fuzzy number, the left point, middle point and right point of the range over which the function is defined.

**Table III.2** Membership function of linguistic scale

Fuzzy number	Linguistic scales	Scale of fuzzy number
$\tilde{1}$	Equally important (Eq)	(1, 1, 3)
$\tilde{2}$	Weakly important (Wk)	(1, 3, 5)
$\tilde{3}$	Essentially important (Es)	(3, 5, 7)
$\tilde{4}$	Very strongly important (Vs)	(5, 7, 9)
$\tilde{5}$	Absolutely important (Ab)	(7, 9, 9)

*Note.* This table is synthesized the linguistic scales defined by Chiou and Tzeng (2001) and fuzzy number scale used in Mon *et al.* (1994).

Assign linguistic terms to the pairwise comparisons by asking which is the more important of each two criteria, such as

$$\begin{aligned}
A &= \begin{bmatrix} 1 & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \tilde{a}_{21} & 1 & \cdots & \tilde{a}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & 1 \end{bmatrix} \\
&= \begin{bmatrix} 1 & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ 1/\tilde{a}_{12} & 1 & \cdots & \tilde{a}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ 1/\tilde{a}_{1n} & 1/\tilde{a}_{2n} & \cdots & 1 \end{bmatrix} \tag{III.10}
\end{aligned}$$

where criterion  $i$  is relative less importance to criterion  $j$ .

$$\tilde{a}_{ij} = \begin{cases} \tilde{1}, \tilde{3}, \tilde{5}, \tilde{7}, \tilde{9} & \text{criterion } i \text{ is relative importance to criterion } j, \\ 1 & i = j, \\ \tilde{1}^{-1}, \tilde{3}^{-1}, \tilde{5}^{-1}, \tilde{7}^{-1}, \tilde{9}^{-1} & \text{criterion } i \text{ is relative less importance to criterion } j \end{cases}$$

The set of linguistic terms presented in Table III.2. Using Table III.2, the decision-maker transforms the linguistic judgment to the corresponding triangular fuzzy scale. For example, a decision maker consider that criterion  $i$  very strongly importance as compared with  $j$  under certain criteria. This linguistic judgment is very strongly importance and is transformed to triangular fuzzy scale as (5, 7, 9). This is entered in cell  $a_{ij}$  of the pair-wise comparison matrix. On the other hand, cell  $\tilde{a}_{ij}$ , is defined as  $(\tilde{a}_{ij})^{-1}$ , so the decision maker enters the fuzzy scale as (1/9, 1/7, 1/5).

Implying that triangular fuzzy numbers are substituted into the pair-wise comparison matrix to deal with criteria measurement and determine the fuzzy consensus problem in judgment (Bozbura *et al.*, 2007, Chang *et al.*, 2008).

Geometric means is used for aggregating the judgments of each group member found in pairwise comparisons matrices. This approach is used when individuals are willing to relinquish their own preferences for the good of the organization (Forman and Peniwati, 1998). The results of this approach are then a group judgment, which is called single composite decision maker (Honest and Lootsma, 1996).

Chang *et al.* (2009) describes geometric mean which represents the consensus of decision makers, is used as the model for triangular fuzzy numbers that is the

mean of membership =  $l$ . Where  $l$  denotes the minimum numerical value,  $u$  denotes maximum numerical value, and  $m$  is the geometric mean, which represents the consensus of most decision makers. However, we prefer to use Lee's (2009) calculations for control criteria for attaining the goal. From each decision maker's questionnaire results, establish fuzzy weights for control criteria according to the membership functions, we denote  $l, m, u$  are the geometric mean of decision makers consensus in this study and the TFNs  $\tilde{a}_{ij}$  are established as follows

$$\tilde{a}_{ij} = (l_{ij}, m_{ij}, u_{ij}), \quad (\text{III.11})$$

$$l_{ij} \leq m_{ij} \leq u_{ij} \text{ and } l_{ij}, m_{ij}, u_{ij} \in [1/9, 1] \cup [1, 9]$$

$$l_{ij} = \left( \prod_{k=1}^n B_{ijk} \right)^{1/n}, \quad (\text{III.12})$$

$$m_{ij} = \left( \prod_{k=1}^n B_{ijk} \right)^{1/n}, \quad (\text{III.13})$$

$$u_{ij} = \left( \prod_{k=1}^n B_{ijk} \right)^{1/n}. \quad (\text{III.14})$$

where  $B_{ijk}$  represents a judgment of decision maker  $k$  for the relative importance of two criteria i-j.

The most possible value, the lower bound, and the upper bound of the fuzzy group performance rating of the criterion are given by the geometric mean. The rationale for using triangular fuzzy number and the geometric mean is in line with that for obtaining the group criteria weights.

#### Step 4 Check the Consistency

It may be difficult for decision-makers to reach consistency in the process of evaluating the pair-wise comparisons. Consistency means that the decision is exhibiting coherent judgment in specifying the pair-wise comparison of the criteria or alternative. Consistency ratio is computed, according to the consistency index and

random index (Saaty, 1980). The consistency index (CI) of a matrix of comparisons is given by,

The priority of the elements can be compared by the computation of eigen values and eigen vectors:

$$R.w = \lambda_{\max} .w$$

where  $w$  is the eigenvector, the weight vector, of matrix  $R$  and  $\lambda_{\max}$  is the largest eigen values of  $R$ . The consistency property of the matrix is then checked to ensure the consistency of judgments in the pairwise comparison. The consistency index and consistency ratio (CR) are defined as (Saaty, 1980):

**Tablo III.3 Random Index (RI)**

N	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59

$$CI = \frac{\lambda_{\max} - n}{n - 1} \tag{III.16}$$

$$CR = \frac{CI}{RI} \tag{III.17}$$

where  $n$  is the number of items being compared in the matrix, and RI is random index, the average consistency index of randomly generated pairwise comparison matrix of similar size, as shown in Table III.3. As suggested by Saaty (1994), the upper threshold CR values are 0.05 for a 3x3 matrix, 0.08 for a 4x4 matrix, and 0.10 for larger matrices. If the consistency test is not passed, the decision maker must revise the original values in the pairwise comparison matrix.

However, consistency ratios of pairwise comparison matrices consisting of fuzzy numbers cannot be calculated by using the method described above. Different methods for computing this ratio can be found in the literature and in this study, the algorithm proposed by Mikhailov (2004) is used. According to algorithm, if the  $\lambda$  value computed for pairwise comparison matrices consisting of fuzzy numbers is between 0 and 1, the matrix is assumed to be consistent and  $\lambda$  is less than 0 the

matrix is assumed to be inconsistent. Consistencies of pairwise comparison matrices are analyzed and  $\lambda$  values are calculated with this algorithm.

The optimal value  $\lambda$  is a natural indicator for measuring the consistency of decision maker's judgments, so it is called a consistency index Mikhailov (1999). A value of the consistency index  $\lambda \geq 1$  indicates a consistent interval case, where all solution ratios completely satisfy the interval case, where all solution ratios completely satisfy the initial judgment, i.e.  $l_{ij} \leq \frac{w_i}{w_j} \leq u_{ij}$ . For weakly inconsistent judgments, when the extended interval bounds, the consistency index  $\lambda^*$  takes a value between one and zero, which depends on the degree of inconsistency and the values of the tolerance parameters. A negative value  $\lambda < 0$  shows that the interval judgments are strongly inconsistent and the solutions ratios are outside the extended intervals. Consistencies of pairwise comparison matrices are analyzed and  $\lambda$  values are calculated with this algorithm (Mikhailov, 2004).

Another validity of the model would be tested in a final step by investigating whether or not the same results are found by different decision-making approaches (Whitaker, 2007). The application presented in this study includes those two-validity tests.

#### Step 5 Calculate the Fuzzy Weighted Vectors

This step describes how to calculate the weight vectors for the criteria and alternatives. There are various methodologies presented in the literature that can be used for calculating fuzzy weight vector, such as Van Laarhoven and Pedrycz (1983), Buckley (1985), and Chang (1996).

This study uses the methodology of Buckley (1985) as a framework for calculating the fuzzy weight vector, because it is rather simple. Barzilai (1994) and Lootsma (1993) discuss reasons for using geometric mean instead Saaty's procedure.

To use geometric mean technique to define the fuzzy geometric mean and fuzzy weights of each criterion by Buckley (1985) as follows:

$$\tilde{r}_i = (\tilde{a}_{i1} \otimes \tilde{a}_{i2} \otimes \dots \otimes \tilde{a}_{in})^{1/n}, \quad (\text{III.17})$$

$$\tilde{w}_i = \tilde{r}_i \otimes (\tilde{r}_1 \oplus \dots \oplus \tilde{r}_n)^{-1}, \quad (\text{III.18})$$

Where  $\tilde{a}_{in}$  is fuzzy comparison value of criterion  $i$  to criterion  $n$ , thus,  $\tilde{r}_i$  is geometric mean of fuzzy comparison value of criterion  $i$  to each criterion,  $\tilde{w}_i$  is the fuzzy weight of the  $i$ th criterion, can be indicated by a TFN,  $\tilde{w}_i = (lw_i, mw_i, uw_i)$ . Here  $lw_i$ ,  $mw_i$  and  $uw_i$  stand for the lower, middle and upper values of the fuzzy weight of the  $i$ th criterion.

Calculations are done for each criterion (for main and secondary-criteria) then the global weights are found by multiplying main criterion fuzzy weight to each secondary-criterion weight that connected to main criterion fuzzy weight.

Jadhav and Sonar (2009), and Kettunen and Laanti (2005) reported a systematic review of papers published in journals and conference proceedings, which AHP is used to evaluate software systems. According to the study AHP methodology was used by Colombo and Francalanci (2004) to select CRM packages, Davis and Williams (1994) to evaluate and select simulation software, Kim and Moon (1997) to select workflow management system, Kim and Yoon (1992) to select expert system shell for instructional purposes, Kontio *et al.* (1996) to define reusable component evaluation, Kontio (1996) to select COTS, Lai *et al.* (1999) to select multimedia authoring system, Mohanty and Venkataraman (1993) to select automated manufacturing systems, Morera (2002) to evaluate COTS, Ngai and Chan (2005) to evaluate knowledge management tools, Ossadnik and Lange (1999) to evaluate AHP software, Phillips-Wren *et al.* (2004) to evaluate decision support system, Sarkis and Talluri (2004) to select e-commerce software and communication systems, Shtub *et al.* (1998) to select operations management software, Teltumbde (2000) to evaluate ERP projects, Toshtzar (1988) to evaluate computer software, Wei *et al.* (2005) to select ERP system, Zahedi (1998) to evaluate and select database management system, and Zahedi (1990) to evaluate expert systems.

Also, many researchers have studied on software evaluation applications of fuzzy AHP (Jadhav and Sonar, 2009) and several models are constructed in relation with the evaluation of supply chain systems. Sarkis (2004) studied the justification and evaluation of e-commerce technology media and software for whole supply chain. F-AHP has been used to help experts to evaluate knowledge portal (Kreng and Wu, 2007), to evaluate IT departments (Lee *et al.*, 2008), to select a suitable ERP system for textile industry (Cebeci, 2009), to classify inventories (Cakir and

Canpolat, 2008), to estimate the relative importance strategic factors involved in the decision making process of adopting third party e-markets (Fu *et al.*, 2008) and also to develop radio frequency identification technology development in the logistics and supply chain management (Lin, 2009),

The fuzzy weights of alternatives derived from F-AHP process will be used as parameters for goal constraints in the F-TOPSIS.

### **III.3.2. F-TOPSIS PHASE**

The basic principle of this approach is that the chosen alternative should have shortest distance from the ideal solution and forest distance from the negative ideal solution (Opricovic and Tzeng, 2004).

Technique for preference by similarity to ideal solution (TOPSIS) is used to obtain the collective preference scoring and ordering SCEM system alternatives. TOPSIS views a multi-attribute decision making problem with  $t$  alternatives as a geometric system with  $t$  points in the  $n$ -dimensional space (Kahraman, 2007). The implementation of TOPSIS that is used in this study is adopted from Hwang and Yoon (1981) and is based on the concept that the chosen SCEM system alternatives should be the shortest distance from the ideal solution and the farthest from the negative ideal solution. TOPSIS defines an index called similarity to the positive-ideal solution and the remoteness from the negative-ideal solution. Then the method chooses an alternative with the maximum similarity to ideal solutions (Yoon and Hwang, 1995).

The advantages of using F-TOPSIS concept have been highlighted by (a) its intuitively appealing logic, (b) its simplicity and comprehensibility, (c) its computational efficiency, (d) its ability to measure the relative performance of the alternatives with respect to individual or all evaluation criteria in a simple mathematical form, and (e) its applicability in solving various practical MCDM problems (Deng *et al.*, 2000; Yeh *et al.*, 2000).

As it is mentioned before, under many conditions, crisp data are inadequate to model real-life situations. A more realistic approach may be to use linguistic assessments instead of crisp values, that is, to suppose that the ratings and weights of the criteria in the problem are assessed by means of linguistic variables (Chu, 2002).

Yang and Hung (2007) described this methodology as:

Step 1 Determine the weighting of evaluation criteria; the overall weights of various criteria have been considered with F-AHP method to conduct F-TOPSIS phase.

Step 2 Choose the appropriate linguistic variables for the alternatives with respect to criteria. The linguistic variables are described by TFNs, such as  $\tilde{x}_{ij} = (a_{ij}, b_{ij}, c_{ij})$  in Table III.4.

**Table III.4** Linguistic Variables for the preference rating of alternatives

Linguistic variable	Corresponding triangular fuzzy numbers
Very poor (VP)	(0.0, 0.0, 0.2)
Poor (P)	(0.0, 0.2, 0.4)
Fair (F)	(0.3, 0.5, 0.7)
Good (G)	(0.6, 0.8, 1.0)
Very Good (VG)	(0.8, 1.0, 1.0)

Then, the fuzzy calculations done in a fuzzy decision matrix as follows;

$$\tilde{D} = \begin{matrix} & C_1 & C_2 & \dots & C_n \\ \begin{matrix} A_1 \\ A_2 \\ \vdots \\ A_m \end{matrix} & \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \dots & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{22} & \dots & \tilde{x}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \dots & \tilde{x}_{mn} \end{bmatrix} \end{matrix}, \quad i = 1, 2, \dots, m; \quad j = 1, 2, \dots, n \quad (\text{III.19})$$

$$\tilde{x}_{ij} = \frac{1}{k} \left( \tilde{x}_{ij}^1 + \tilde{x}_{ij}^2 + \dots + \tilde{x}_{ij}^k \right) \quad (\text{III.20})$$

where  $\tilde{x}_{ij}^k$  is the rating of alternative  $A_i$  with respect to criteria  $C_j$  evaluated by decision makers, and  $\tilde{x}_{ij}^k = (a_{ij}^k, b_{ij}^k, c_{ij}^k)$ .

Step 3 Construct the fuzzy decision matrix and the normalized fuzzy decision matrix To avoid the complicated normalization formula used here to transform the various criteria scales into a comparable scale. Therefore, we can obtain the normalized fuzzy decision matrix denoted by  $\tilde{R}$ :

$$\tilde{R} = \left[ \tilde{r}_{ij} \right]_{m \times n} \quad i = 1, 2, \dots, m; j = 1, 2, \dots, n. \quad (\text{III.21})$$

Then the normalization process can be performed by following formula:

$$\text{where } \tilde{r}_{ij} = \left( \frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*} \right), \quad (\text{III.22})$$

$$c_j^* = \max_i c_{ij}. \quad (\text{III.23})$$

The normalized  $\tilde{r}_{ij}$  are still triangular fuzzy numbers.

Step 4 Construct the weighted normalized fuzzy decision matrix.

The normalization method mentioned above is used to preserve the property that the ranges of normalized TFNs belong  $[0,1]$ . Considering the different importance of each criterion, we can construct the weighted normalized fuzzy decision matrix as

$$\tilde{V} = \left[ \tilde{v}_{ij} \right]_{m \times n}, \quad i = 1, 2, \dots, m; j = 1, 2, \dots, n. \quad (\text{III.24})$$

and

$$\tilde{v}_{ij} = \tilde{r}_{ij} \times \tilde{w}_j \quad (\text{III.25})$$

and  $\tilde{w}_j$  global TFN weights as defined in (III.24) that are calculated in F-AHP phase.

Step 5 Determine the fuzzy positive-ideal solution (FPIS) and fuzzy negative-ideal solution (FNIS).

According to the weighted normalized fuzzy decision matrix, we know that the elements  $\tilde{v}_{ij}$  are normalized positive TFNs and their ranges belong to the closed interval  $[0,1]$ . Then, we can define the FPIS  $A^*$  and  $A^-$  as following formula:

$$A^* = \left( \tilde{v}_1^*, \tilde{v}_2^*, \dots, \tilde{v}_n^* \right) \quad (\text{III.26})$$

and

$$A^- = ( \tilde{v}_1^-, \tilde{v}_2^-, \dots, \tilde{v}_n^- ) \quad (\text{III.27})$$

$$\text{where } \tilde{v}_j^* = w_j \times (1,1,1) \text{ and } \tilde{v}_j^- = w_j \times (0,0,0) \text{ for all } j = 1, 2, \dots, n. \quad (\text{III.28})$$

Step 6 Calculate the distance of each alternative from FPIS and FNIS.

The distances ( $d_i^*$  and  $d_i^-$ ) of each alternative from  $A^*$  and  $A^-$  can be currently calculated by the vertex method (Chen, 2000), which is calculated as:

Let  $\tilde{a} = (a_1, a_2, a_3)$  and  $\tilde{b} = (b_1, b_2, b_3)$  be two triangular fuzzy numbers,

$$d(\tilde{a}, \tilde{b}) = \sqrt{\frac{1}{3} \left[ (a_1 - b_1)^2 + (a_2 - b_2)^2 + (a_3 - b_3)^2 \right]} \quad (\text{III.29})$$

then,

$$d_i^* = \sum_{j=1}^n d(\tilde{v}_{ij}, \tilde{v}_j^*), i = 1, 2, \dots, m \quad (\text{III.30})$$

and

$$d_i^- = \sum_{j=1}^n d(\tilde{v}_{ij}, \tilde{v}_j^-), i = 1, 2, \dots, m \quad (\text{III.31})$$

where  $d(\cdot, \cdot)$  is the distance measurement between two fuzzy numbers.

Step 7 Calculate the closeness coefficient (CC) of each alternative

A CC is defined to determine the ranking order of all alternatives once the  $d_i^*$  and  $d_i^-$  of each alternative  $A_i$  ( $i = 1, 2, \dots, m$ ) has been calculated. The CC of each alternative is calculated as

$$CC = \frac{d_i^-}{d_i^* + d_i^-}, i = 1, 2, \dots, m. \quad (\text{III.32})$$

Step 8 According to the CC, the ranking order of alternatives can be determined.

Obviously, an alternative  $A_i$  is closer to the FPIS ( $A^*$ ) and farther from ( $A^-$ ) as  $CC_i$  approaches 1. Therefore, according to the closeness coefficient, we can

determine the ranking order of all alternatives and select the best one from among a set of feasible alternatives.

From the next part, we propose another fuzzy analytic evaluation methodology to compare results and findings with F-AHP and F-TOPSIS method, which is F-ANP method.

#### **III.4. F-ANP APPROACH**

F-ANP is the alternative evaluation methodology selected in this study. ANP, a general form of the AHP, is also widely used MADM method that incorporates feedback and interdependent relationships among criteria and decision alternatives. A significant difference between AHP and ANP is that the former employs a unidirectional hierarchical relationship among decision levels via a system with feedback approach (Buyukozkan *et al.*, 2004). Hence, ANP can be used as an effective tool in the cases where the interactions among the elements of a system from a network structure (Karsak, *et al.*, 2002).

The Analytic Network Process (ANP) is also a multi-criteria theory of measurement used to derive relative priority scales of absolute numbers from individual judgments (or from actual measurements normalized to a relative form) that also belong to a fundamental scale of absolute numbers. These judgments represent the relative influence, of one of two elements over the second on a third element in the system, in a pairwise comparison process with respect to an underlying criterion (Saaty, 2004). Through its supermatrix whose entries are themselves matrices of column priorities, the ANP synthesizes the outcome of dependence and feedback within and between clusters of elements.

The Analytic Hierarchy Process (AHP) with its independence assumptions on upper levels from lower levels and the independence of the elements within a level is a special case of the ANP. Systemic thinking is essential in decision making to represent decisions in the framework of a network. The ANP is a way to implement this type of thinking. One had to overcome the limitation of linear hierarchic structures and the requirement that scales can be added and multiplied to deal with dependence and feedback using judgments about importance and preference along with, for example, measurements in the form of likelihood as probability (Saaty, 2004).

The F-ANP methodology is a robust MADM technique for analyzing the major issues facing uncertainty in decision-making processes. ANP captures the interdependence of decision criteria and improves the limitation of AHP. F-ANP is an efficient tool to handle the fuzziness of the data involved in deciding the preferences of different decision variables. The linguistic level of comparisons produced by the professionals and experts for each comparison are tapped in the form of triangular fuzzy numbers to construct fuzzy pair-wise comparison matrices.

The proposed F-ANP uses the triangular fuzzy numbers like in F-AHP and F-TOPSIS as a pair wise comparison scale for deriving the priorities of different selection criteria and attributes.

The main objective in the process is to determine the overall influence of all the elements in conjunction with each other (Saaty, 1999).

The problem should be stated clearly and decomposed into rational system like a network. The structure can be obtained by the opinion of decision makers through brainstorming or other appropriate methods like in F-AHP and F-TOPSIS phases. Chang *et al.* (2007) processed F-ANP as follows:

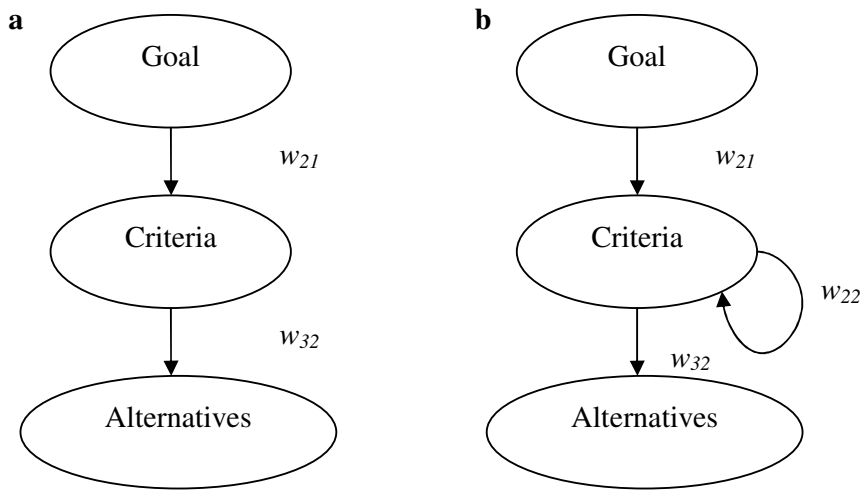
Saaty (1980) contended that the geometric mean accurately represents the consensus of expert opinion and is the most widely used as the model for triangular fuzzy numbers. As it mention in chapter III.2.1 the triangular fuzzy numbers were established as formula III.11 to III.14.

#### Supermatrix formation

The supermatrix concept is similar to the Markov chain process (Saaty 1996). To obtain global priorities in a system with interdependent influences, the local priority vectors are entered in the appropriate columns of a matrix, known as a supermatrix. As a result, a supermatrix is actually a partitioned matrix, where each matrix segment represents a relationship between two nodes (components or clusters) in a system (Meade and Sarkis 1999). Let the components of a decision system be  $C_k$ ,  $k = 1, 2, \dots, N$ , which has  $n_k$  elements denoted as  $e_{k1}, e_{k2}, \dots, e_{kn_k}$ . The local priority vectors obtained in like F-AHP are grouped and located in appropriate positions in a supermatrix based on the flow of influence from a component to another component, or from a component to itself as in the loop. A standard form of a supermatrix is as in formula III.32 (Saaty, 1996):



there usually is interdependence among clusters in a network, the columns of a supermatrix usually sum to more than one. The supermatrix must be transformed first to make it stochastic; that is, each column of the matrix sums to unity. A recommended approach by Saaty (1996) is to determine the relative importance of the clusters in the supermatrix with the column cluster (see Figure III.8) block as the controlling component (Meade and Sarkis 1999). That is, the row components with nonzero entries for their blocks in that column block are compared according to their impact on the component of that column block (Saaty 1996).



**Figure III.8** Hierarchy and network (a) hierarchy; (b) network

With pair-wise comparison matrix of the row components with respect to the column component, an eigenvector can be obtained. This process gives rise to an eigenvector for each column block. For each column block, the first entry of the respective eigenvector is multiplied by all the elements in the first block of that column, the second by all the elements in the second block of that column, and so on. In this way, the block in each column of the supermatrix is weighted, and the result is known as the weighted supermatrix, which is stochastic.

Raising a matrix to powers gives the long-term relative influences of the elements on each other. To achieve a convergence on the importance weights, the weighted supermatrix is raised to the power of  $2k + 1$ , where  $k$  is an arbitrarily large number, and this new matrix is called the limit supermatrix (Saaty 1996). The limit

supermatrix has the same form as the weighted supermatrix, but all the columns of the limit supermatrix are the same. By normalizing each block of this supermatrix, the final priorities of all the elements in the matrix can be obtained.

When the supermatrix formed, the priority weights of the alternatives can be found in the column of alternatives in the normalized supermatrix. On the other hand, if a supermatrix only comprises clusters that are interrelated, additional calculations must be made to obtain the overall priorities of the alternatives. The alternative with the largest overall priority should be selected, as it is the best alternative as determined by the calculations made using matrix operations.

F-ANP methodology is also used in researches in software selection problems modeling. Yazgan *et al.* (2009) compared two different MADM approach, which are artificial neural network (ANN) and ANP for an ERP software selection process. In their study they suggested some solutions to reduce a form a group decision to a single one. Wei *et al.*, (2005) studied on analytic process based ERP selection. Their proposed procedure allows a company to identify the elements of ERP system selection and formulate the fundamental-objective hierarchy and means objective network. The approach is flexible enough to incorporate extra attributes or decision makers in the evaluation. Notably, the proposed framework can accelerate the reaching of consensus among multiple decision makers. Ravi *et al.*, (2005) developed ANP model for end of life computers selection problem. Their paper could provide to the decision maker a more realistic and accurate representation of the problem for conducting reverse logistics operations for end of life computers. They also mentioned the ability of ANP to consider interdependencies among and between levels of decision attributes makes it an attractive multi-criteria decision-making tool. Ayag and Ozdemir (2007) adopted fuzzy ANP to evaluating conceptual design alternatives in a new product development and mentioned pros and cons of applying F-ANP model. The advantage of the ANP method is to capture interdependencies across and along the decision hierarchies, the disadvantage of the model is the relationships among determinants, dimensions and attribute-enablers required very long and exhaustive effort. Those recent given example studies are related with evaluation process with ANP approach and there have been numerous study on ANP applications on literature.

# CHAPTER IV

## APPLICATION OF THE METHODOLOGIES

In this section, we investigated our methodologies in a real word application. This application realized in a both manufacturing and distributor company. This company produces heavy construction equipment and distributor of the global brands and has an important domestic market share. This application has realized for SCCEM system for this company. For this SCCEM system, management team is planning to buy a new SCCEM system. However, when investigating for SCCEM systems, they are not sure about the most proper one. To evaluate the alternatives, we proposed a methodology in previous chapter.

As an initial step to our methodology, we asked to group related personnel to this evaluation process. This group is named as the “decision makers” with four members. Four decision maker were composed of the two industrial engineer, one supply chain executer, and a supply chain consultant. Those decision makers are capable to take decisions on SCCEM systems due to their work experience and expertise on such systems.

First two activities of the decision makers are to identify SCCEM system alternatives and the decision criteria. From the SCCEM system alternatives in the market, the decision makers filter system alternatives for vendor selection by examining vendors’ capabilities to evaluate seven alternatives ( $S_1, \dots, S_7$ ) with their experiences which were preferred according to their market share, the background of the system and the conditional capabilities to utilize company needs. Additionally, evaluation process decision criteria are determined with decision makers. In the decision criteria determination phase, decision makers’ experiences and related literature, which is mentioned in chapter II, are utilized.

#### **IV.1. DEFINING ALTERNATIVES and CRITERIA**

The evaluation of alternatives (vendors) is a quite complex process involved in many factors or attributions. Cost, quality, and lead-time could be regarded as key factors in previous research works. Nevertheless, companies should also pay attention to imprecise, vague and such as supply chain modules, potential and other attributions of vendors. As a result, those seven alternative systems could be detailed. As a company consideration, names of those systems are not given due to respect of vendors although some critical specialties of systems are given in below:

*System 1 ( $S_1$ ):* Vendor is the world's leading provider of business software, offering applications and services for companies of all sizes and in more than 25 industries. Solution employs over 48,500 people in more than 50 countries. Today, more than 89,000 companies in over 120 countries run vendor software. The one solution platform offers packaged application capabilities that grow with organization, support business requirements, and transform traditional supply chains into adaptive supply chain networks. System responds to demand through a responsive supply network in which distribution, transportation, and logistics are integrated into real-time planning processes.

*System 2 ( $S_2$ ):* Vendor provides software and service solutions to 4,000 customers in manufacturing, distribution, maintenance, and service sector industries across 40 countries. Solution of the company is designed to increase visibility and improve material flow through the supply chain by managing planning, scheduling, procurement and fulfillment for optimum service levels and maximum profitability. Solution copes as easily with the configuration of increasingly complex supply chains as it does with high volumes of simple transactions, using flexible tools to help with strategic decision-making and operational control. In addition, solution encompasses sophisticated planning and optimization tools, highly configurable warehouse execution functions, advanced procurement applications, and comprehensive fulfillment and scheduling options. It brings the sophisticated functionality normally associated with costly best-of-breed solutions within easy reach of medium-sized enterprises. System is simple to use, fully integrated, and with an extremely low cost of ownership.

*System 3 ( $S_3$ ):* This corporation supplies software for information management. With annual revenues of more than \$10.9 billion (USD), the company offers its

database, tools, and application products, along with related consulting, education, and support services, in more than 145 countries around the world. Vendor's solution supply management comprises fully integrated planning/forecasting and fulfillment applications. Working together, Solution's supply chain products deliver enhanced productivity and efficiency for product-driven industries. In addition, the integration between Advanced Planning and Fulfillment software such as Order Management, Procurement, Warehouse Management and Transportation Management enables instantaneous response to events that influence a company's supply chain.

*System 4 (S<sub>4</sub>):* Vendor's solution enables networks of trading partners including suppliers, manufacturers, distributors and retailers to collaborate, integrate and synchronize their planning, production and logistics operations. Solution has a complete set of supply chain management solutions in one Internet-based collaborative framework, including global supply chain visibility; demand, inventory and replenishment planning; supply and sourcing optimization; transportation planning and execution; and warehouse management. Specifically, solution increases shipping and inventory accuracy by optimizing the flow of materials and information through distribution centers; and helps cut operational costs and improves productivity, order fill rates, space utilization and customer service. It also incorporates advanced workflow technology, industry-specific practices, and RFID technology.

*System 5 (S<sub>5</sub>):* Vendor solutions at approximately 6,000 licensed sites in more than 90 countries around the world, in 27 languages. Applications support shared services, cross-border trade, multi-site manufacturing and multi-entity accounting. The solutions are built on a deep, foundational understanding of manufacturing. Designed to streamline the management of manufacturing operations, supply chains, financials, customers, technology, and business performance, vendor solutions provide manufacturers easy access to the time-sensitive information they need to plan as they continue to meet daily manufacturing targets.

*System 6 (S<sub>6</sub>):* Vendor is one of the largest providers of business software in the world. The company has over 70,000 customers, and has implementation and support capabilities in over 100 countries in the Americas, Europe, the Middle East, Africa, and Asia. Solution is an automotive, web-enabled supply chain management

solution. It enables inter enterprise communication and systems integration and combines information from disparate systems.

*System 7 (S<sub>7</sub>):* Vendor is an e-business solution and service provider for the global retail industry. Vendor solutions help retailers, manufacturers, and their trading partners streamline and automate sourcing and supply chain processes. With a hosted platform, customer support, and retail experience, Solution focuses on simplifying the implementation process. Suite supports collaborative work processes at the points along the supply chain where retail-trading partners interact. The product is intended to support areas where communication, information visibility, and joint goal setting are requirements for both parties.

After the alternative systems are decided, decision makers decide on criteria that are used in evaluation phase. As a result after investigation the related literature, SCEM systems, data provided by software enterprises and research relative references, we gathered ten main criteria with sixty secondary criteria which main criteria are Demand Management (DM), Supply Chain Optimization (SCO), Warehouse Management System (WMS), Production and Supply Planning (PSP), Service Parts Planning (SPP), Transportation Management System (TMS), International Trade Logistics (ITL), Order Management, Supply Chain Event Management (SCE), Supplier Relationship Management (SRM) and sixty secondary criteria which is given in Table IV.1, related to SCEM systems. We refer SCEM system module and sub-module as criterion and secondary criterion, respectively.

According listed references, widely industry analysis, and inspecting existent supply chain execution and management systems, we gathered most important and mostly used criteria and secondary criteria together. One of the most valuable part of this study is to identify and collect those criteria in a base.

Dimensions of SCEM system criteria can be defined as follows:

#### ***Demand Management (DM)***

Demand management systems today have moved beyond the narrow concept of statistical forecasting to encompass both global and cross enterprise trading partner processes. In addition, the real-time nature of today's business requires that rapid feedback from markets and adjustments to demand assumptions are propagated through the supply chain to improve delivery and cost performance.

**Table IV.1** SCEM system evaluation criteria

<b>Code</b>	<b>Criteria and secondary criteria</b>
<b>DM</b>	<b>Demand Management</b>
DM1	Promotion Planning
DM2	Forecasting
DM3	Life Cycle Planning
DM4	Consensus and Collaborative Planning
DM5	Event Planning
<b>SCO</b>	<b>Supply Chain Optimization</b>
SCO1	Network Optimization
SCO2	Route and Territory Design
SCO3	Fleet Planning, Routing and Scheduling
SCO4	Inventory Optimization for Supply Network
<b>WMS</b>	<b>Warehouse Management System (WMS)</b>
WMS1	Warehouse and Bin Configuration
WMS2	Inventory Control for Warehouses
WMS3	Receiving and Quality Control
WMS4	Put-away, Picking
WMS5	Cycle Count
WMS6	Packing and Shipping
<b>PSP</b>	<b>Production and Supply Planning</b>
PSP1	Long-term Sales, Operations and Capacity Planning
PSP2	Operational Planning
PSP3	Procurement Collaboration
PSP4	BOM, Design and Building
PSP5	Routing Design and Optimization
PSP6	Cycle Time Analysis and Optimization
<b>SPP</b>	<b>Service Parts Planning</b>
SPP1	Parts and Service Planning
SPP2	Service Delivery and Execution
SPP3	Workforce Optimization
SPP4	Transportation Planning
SPP5	Reverse Logistics
<b>TMS</b>	<b>Transportation Management System (TMS)</b>
TMS1	System Definition and Implementation
TMS2	Required Features and Functions
TMS3	System Analysis and Reporting for Transportation
<b>ITL</b>	<b>International Trade Logistics (ITL)</b>
ITL1	Advanced Collaboration
ITL2	Product Description
ITL3	Compliance Model
ITL4	Logistics
ITL5	Commerce

**Table IV.1 SCEM system evaluation criteria (cont.)**

<b>Code</b>	<b>Criteria and secondary criteria</b>
<b>OM</b>	<b>Order Management</b>
<b>OM1</b>	Order Promising
<b>OM2</b>	Inventory Analysis for Order
<b>OM3</b>	Sourcing Management
<b>OM4</b>	(Manufacturing) Order Tracking
<b>OM5</b>	Inbound and Assembly Coordination or Multi-site Staging
<b>OM6</b>	Shipment Tracking
<b>SCE</b>	<b>Supply Chain Event Management</b>
<b>SCE1</b>	Metrics and Formula Library for Data
<b>SCE2</b>	Rules and Alerts Hierarchy Setup for Events
<b>SCE3</b>	Data Drilling, Aggregating, and Exploding for Data mining
<b>SCE4</b>	Price Deviation Analysis
<b>SCE5</b>	Engineering Change Order Tracking
<b>SCE6</b>	Inventory Shortage Analysis for Supply
<b>SCE7</b>	Quality Data Analysis
<b>SCE8</b>	Equipment, Breakdown Analysis
<b>SCE9</b>	Demand Volatility Analysis
<b>SCE10</b>	Analysis of Logistics inefficiencies
<b>SCE11</b>	Risk Management
<b>SRM</b>	<b>Supplier Relationship Management (SRM)</b>
<b>SRM1</b>	Collaboration in Design and Requirements Identification
<b>SRM2</b>	Commodity Management
<b>SRM3</b>	Supplier Management
<b>SRM4</b>	RFx (Request For x) and Contract Management
<b>SRM5</b>	Catalog Management for Product
<b>SRM6</b>	MRP or Requisition-Driven Procurement
<b>SRM7</b>	Price, Discounts, Cost Management
<b>SRM8</b>	Return Management
<b>SRM9</b>	Quality and Engineering Change Order Management

Demand management means identifying and creating demand (marketing, merchandising, and promoting), modeling (forecasting, pricing, and life cycle planning), and collaborating (communicate, simulate, and create consensus) with the network of trading partners. It also means evaluating results and creating learning cycles where the market, including geographic, demographic, and economic assumptions are evaluated and improved upon to constantly improve the performance of the chain.

### *Promotion planning (DM1)*

Promotion management systems allow organizations to plan promotions with their trading collaborate, including simulating, executing, and evaluating the promotion performance. Some performance planning issues to be aware of are that frequently promotion plans are not integrated into the demand streams; or promotions are launched without the requisite tracking of real-time events to monitor and modify the promotions in action, during the promotion cycle.

### *Forecasting (DM2)*

Reliable forecasts represent not only algorithms, which are appropriate to the business setting, but also are based on an inclusive, highly integrative process that gathers all data that can impact the ultimate demand placed upon the supply chain. Data granularity is critical to ensure that the right product at the item level is produced or distributed. Superior forecast processes require the evaluation of historical data as well as the current demand activity, and the ability to adjust forecasts on the most current data and assumptions.

### *Life Cycle Planning (DM3)*

Life cycle planning is becoming a more popular capability. Demand characteristics change over the life of a product and require close attention to demand patterns to ensure that markets are not starved during ramp-up nor supplied with excess in later stages. In addition, firms are frequently left with excess inventory during engineer change orders (ECOs) or other product changes as well as end-of-life, due to poor planning and visibility to demand cycles and communication of product phase-outs. Life cycle planning provides the ability to view sell-in and sell-through point of sale (POS) data and will recommend alternate curves based on early actual sales information.

### *Consensus and Collaborative Planning (DM4)*

Consensus planning is a method to create a "one number" forecast for the enterprise. Within complex organizational structures, many professionals are responsible for planning in different areas, such as product marketing for product and product families; sales for territory sales plans; channel and alliance management for channel forecasts; finance for revenue and corporate strategic plans; and manufacturing for shipment or off-the-dock plans. The wide range of professionals involved often creates confusion, poor coordination, and missed business

opportunities when sales are missed or excess inventories mount. Ultimately, a process must produce a forecast, one number, upon which the supply chain will act.

Collaboration among trading partners has become standard practice in many industries as more supply chain activities are being outsourced. Within the demand management module, collaborative forecasting must comply with process and data standards that have been validated by the VICS Council, Rosetta Net, and other industry bodies that have modeled these processes for their industries. In addition, a collaborative software system must allow the ability for joint sharing and modeling of demand supply gaps between trading partners. It must allow trading partners to view, drive alternative solutions and simulations, and resolve issues around price and unit availability, which include flexibility and target replenishment levels (re-order points).

#### *Event Planning (DM5)*

Event planning for various marketing events became more complex as firms started using a rich set of trading collaborates, which include media, channel partners, and retailers. Product launches, special media and advertising, promotional events, or new store openings need fine planning to be successful. Today, systems must move from PowerPoint to strong profit analytics for ensuring market success and return-on-investment.

#### *Supply Chain Optimization (SCO)*

Network optimization or the supply chain designer is the highest-level optimization solver. Its purpose is to design an optimal physical supply chain network and solve long-term strategic problems. Network optimization is usually done yearly or whenever major shifts in the supply chain occur. Though these simulations are done infrequently, the changes made in a strategic design in the business have large impacts on the supply chain's daily performance. For example, what is the optimal location of warehouses to ensure high levels of customer satisfaction while being close enough to supply sources, transportation lanes, and ensure both a high performance and cost effective fulfillment capability. What is the optimal location for manufacturing plants? What capacity footprint should these plants have in order to meet long-term demand requirements for the markets served? Those systems take inputs from many sources of data both operational as well as

long-term forecast horizons to design the optimally performing supply chain network.

*Network Optimization (SCO1)*

Network optimization or the supply chain designer is the highest-level optimization solver. Its purpose is to design an optimal physical supply chain network and solve long-term strategic problems. Network optimization is usually done yearly or whenever major shifts in the supply chain occur. Though these simulations are done infrequently, the changes made in a strategic design in the business have large impacts on the supply chain's daily performance. For example, what is the optimal location of warehouses to ensure high levels of customer satisfaction while being close enough to supply sources, transportation lanes, and ensure both a high performance and cost effective fulfillment capability. What is the optimal location for manufacturing plants? What capacity footprint should these plants have in order to meet long-term demand requirements for the markets served? Some systems take inputs from many sources of data both operational as well as long-term forecast horizons to design the optimally performing supply chain network.

*Route and Territory Design (SCO2)*

These systems take both master data from an optimized network, then define the best methods and routes and blend these with current orders to create near term routes. Frequently a third-party carrier will execute this component on behalf of the customer. Nevertheless, users should consider these modules, since unique product requirements that are placed upon carriers need to be understood within the supply chain, both for customers, as well as for the shipper and carrier. These solutions will allow the user to determine if she is getting the most expeditious service. Territory design defines, optimal of regional and geographic logistics strategies to support local markets.

*Fleet Planning, Routing and Scheduling (SCO3)*

This capability can be used both strategically--for inputs to purchasing decisions and balancing national or territory capacity or tactically to determine fleet requirements for a specific timeframe (weeks or days for example). Transportation routing and scheduling optimization can be purchased in a transportation planning and optimization system or as part of a transportation execution system. These

systems take both master data from an optimized network, then define the best methods and routes and blend these with current orders to create near term routes. Frequently a third-party carrier will execute this component on behalf of the customer. Nevertheless, users should consider these modules, since unique product requirements that are placed upon carriers need to be understood within the supply chain, both for customers, as well as for the shipper and carrier. These solutions will allow the user to determine if she is getting the most expeditious service.

#### *Inventory Optimization (SCO4)*

Inventory planning and optimization systems allow the organization to create an inventory supply network from multi-tier or n-tier suppliers through to multi-channel to customers. ERP systems not only do not have such modeling and graphic capability, but they do not have the ability to integrate data from many sources through the supply chain to create these kinds of models. Inventory management strategies need to be thought through both at the strategic and tactical levels. What are the right approaches to inventory stocking both at the raw, component, or WIP levels, as well as for finished goods? What are the right hedging strategies as a product moves through its lifecycle: from new product or market introduction, to seasonality's, to end-of-life? What are the right staging and pipeline levels? What is the right replenishment level by channel or customer to meet market share, revenue, profit targets, and customer service levels, while minimizing obsolescence? Planning inventory at the right stage raw, practical assembly, or finished goods has huge implications for a firm's responsiveness and profitability. Strategically, inventory planning and optimization systems work well in partnership with forecasting systems. Long-term forecasting, analyzing, and determining demand, lets the optimizer set a profitable supply plan for the market.

#### ***Warehouse Management System (WMS)***

A warehouse management system (WMS) should provide database and user-level tools in order for a company to optimize its storage facilities while at the same time providing user level task direction and activity support.

The combination of system-directed operations, supported by real-time, paperless, and interactive information systems will provide warehouse management and

personnel with the tools to direct, control, measure, and report on distribution operations.

The WMS should enable warehouse operators to optimize pick, put-away, and replenishment functions by employing powerful system logic to select the best locations and sequences. These are defined by rules that are based on industry best practices, while taking into account enterprise specific opportunities and constraints.

In order to facilitate ongoing activity tracking and performance reporting the WMS should include integration with bar code and wireless radio frequency data collection devices to enable accurate, efficient tracking of goods through the storage facility.

#### *Warehouse and Bin Configuration (WMS1)*

The WMS should have flexible system architecture and include multiple configuration options. Warehouse Management System is a powerful solution that will help automate inventory-handling process. In addition, it is the key to order fulfillment process. This add-on feature is design for a warehouse with multiple bin configurations. The Multi-Bin process can be either a one-step or a two-step process. The two-step process eliminates the burden of the office person having to know which bin the item is going to be received to or shipped from, which in many cases only the warehouse knows. The extra step of communication between the warehouse and the office slows down the multi-bin process and makes it more difficult.

#### *Inventory Control for Warehouses (WMS2)*

Inventory control module works as a standalone product or can be integrated with the other modules. The Inventory Control Module tracks product usage and costs, and maintains inventory at optimum levels. Complete information is available about the value of inventory, quantities on hand, quantities committed, and the flow of inventory items. Inventory Control handles multiple warehouses. Items can be transferred from one warehouse to another. Inventory can be tracked for each item in each warehouse. Tracks quantities sold, returned, and used up to 12 prior periods. Each warehouse for an item has it's own reorder level, stocking location, and historical statistics.

#### *Receiving and Quality Control (WMS3)*

The WMS should assist the operator in the receipt of inbound shipments by providing activity prompts through the appropriate user interface. The WMS should

support automated receipt of products through a combination of EDI or other data input to relate the initial receipt record, confirming this through radio frequency barcode readers. The WMS should enforce the quality control process through a series of system-directed prompts to ensure that product is handled correctly and that damaged or expired products are not received or stored in the storage location.

*Put-away and Picking (WMS4)*

The WMS should include system-directed put-away, making the association between product receipts and storage locations--this should be supported by a series of rules that are established as part of the system implementation process. The WMS should provide the user with a system-directed pick path, optimizing travel time between pick locations and based on the rules that are established at the time of system implementation.

*Cycle Count (WMS5)*

It is an inventory management procedure where a small subset of inventory is counted on any given day. Cycle counts contrast with traditional physical inventory in that physical inventory stops operation at a facility and all items are counted, audited, and recounted at one time. Cycle counts are less disruptive to daily operations, provide an ongoing measure of inventory accuracy and procedure execution, and can be tailored to focus on items with higher value or higher movement. Cycle counting by usage states that items more frequently accessed should be counted more often, irrespective of value. Every time an employee adds or removes an item, there is a risk of introducing inventory variance. Logical inventory zones can be set up to distinguish items depending on how frequently they are touched. Volume consumed, volume transacted, and volume moved is all ways of determining this.

*Packing and Shipping (WMS6)*

The WMS should include product level and item level data to make the association between an order and series of orders and required packing materials and documentation. The WMS should also make the association between the orders and the transportation plan, directing the user to the appropriate staging and shipping location in the facility once the order is picked complete.

### ***Production and Supply Planning (PSP)***

Today's supply chain planning systems have significant advantages over MRP II systems of the past. These systems incorporate up-to-date algorithms and philosophies on how supply chains work. In addition, they have a technology advantage over MRP II, in that they are memory resident, which allows the solutions to solve for simulation issues extremely quickly, with very large arrays (models). These large models solve for simultaneous, multi-level, and multi-node problems that MRP II systems cannot.

#### ***Long-term Sales, Operations and Capacity Planning (PSP1)***

Sales and operations planning (S&OP) is an important corporate process that brings together sales, marketing, and supply chain to create feasible business plans (strategic) and fulfillment plans (tactical supply plans). Today's real-time supply chain planning systems have the advantage here, since they allow simulation and scenario building, which can be created even in joint meeting sessions to test assumptions and then drive cross-functional communications.

#### ***Operational Planning (PSP2)***

Production planning in the new APS systems can aggregate or disaggregate multilevel plans, so the concept of a master production system (MPS) to material resource planning (MRP) to capacity resource planning (CRP) can fundamentally be abolished. These systems can solve to multi-level plans, sites, and simulated planning objectives.

#### ***Procurement Collaboration (PSP3)***

Ability to dynamical collaborates with the supplier to create demand, place orders, and get a systemic response from the supplier with commitments and changes.

#### ***BOM, Design and Building (PSP4)***

A bill of material can define products as they are designed (Engineering Bill of Material), as they are ordered (Sales BOM), as they are built (Manufacturing bill of material), or as they are maintained (Service BOM). BOMs are hierarchical in nature with the top level representing the sub-assembly or end-item. Planning systems have unique data requirements, frequently these needs to be developed within the context of the creation of the planning model. In addition, unique data may come from customers and suppliers who will need to be included.

### *Routing Design and Optimization (PSP5)*

Routing protocols provide the intelligence that takes a collection of physical links and transforms them into a network that enables packets to travel from one host to another. Though routing design is the single most important design task for large networks. System provide examples of the more unusual designs and examine their trade-offs.

### *Cycle Time Analysis and Optimization (PSP6)*

Cycle time is the total time from the beginning to the end of your process, as defined by you and your customer. Cycle time includes process time, during which a unit is acted upon to bring it closer to an output, and delay time, during which a unit of work is spent waiting to take the next action.

### ***Service Parts Planning (SPP)***

Considering some of the largest corporations in the world actually make not only their profit margins, but also form a two-to-ten year customer relationship from the service component of their business, the importance of service planning and management cannot be overlooked. As we know, customers may not buy from a firm again--regardless of the attractiveness of the product--if the service component of the relationship is not optimal. Service parts planning is a module designed to enable the creation of service centers, depots, and the positioning of the appropriate inventory and workforce capacity to meet outbound customer service requirements. This module can be a stand-alone software solution, a web-based network solution, or a module within a service and maintenance solution. It can integrate with service contract and maintenance agreement systems as well as maintenance systems--but it is not intended to play the role of those solutions. There is significant complexity on positioning service parts to support customers and meet service-level targets. The business benefits are significant both in cost management and in customer satisfaction.

### *Parts and Service Planning (SPPI)*

Service parts planning deals with the creation and replenishment of a supply network for service operations. This can include OEMs, service partners, as well as service logistics providers. Parts planning in service management can be quite complex. Inventory optimization needs to be thought about in terms of immediate

and long-term needs. Products may no longer be sold in the market place, but will need to be serviced even ten to twenty years in the future. In addition, service level requirements need to be considered--customer-by-customer.

*Service Delivery and Execution (SPP2)*

Service planning systems are not expected to be a call center solution, but they do need to integrate in order to handle the management of depot responsiveness.

*Workforce Optimization (SPP3)*

Workforce optimization is used for determining the right skill mix and location of personnel to support service demands. This can include on-site, co-managed personnel at the customer site.

*Transportation Planning (SPP4)*

Transportation planning and execution has a significant role to play in the service supply chain. As in traditional models, there is always a trade-off in the time and cost between fixed assets and delivery responsiveness in serving customers. Dynamic repair needs--emergency breakdowns in remote settings can exacerbate delivery problems.

*Reverse Logistics (SPP5)*

Reverse logistics issues, such as pickup of parts for delivery to third-party locations for repair, are included.

***Transportation Management System (TMS)***

Transportation involves many different parties within and outside a company who are required to routinely share information and ideas. A fully functional transportation management system should provide the basic components of a shared information system to support:

Content such as rates, routes, roles, and contracts at inter-enterprise generic levels, Commerce to support and create transaction sets, documents, and information exchanged to facilitate the booking, execution, and settlement of transportation movements on an "any-to-any" level,

Collaboration for real-time and interactive exchange between multiple parties, irrespective of roles.

The data model and data dictionary of the TMS should thus support a wide and diverse range of interactions. The system should also facilitate the exchange of

data with a series of external and internal applications, as well as provide user-level tools and utilities. The combination of these robust system infrastructures and collaborative applications should enable the user to perform all necessary functions involved in the planning, execution, and analysis of transportation movements.

*System Definition and Implementation (TMS1)*

The TMS should include tools and applications to enable the user to create profiles for all contracts, associated carriers, and trade lanes for inter-modal and multi-leg moves. This should support regional as well as international transportation movements. The key to the successful operation of the TMS is a robust foundation created during the system implementation.

*Required Features and Functions of Transportation (TMS2)*

Transportation management systems should enable users to perform all key functions when planning, executing and analyzing transportation movements.

*System Analysis and Reporting for Transportation (TMS3)*

Data gathered through the execution stages should be available for analysis and reporting, both real-time queries and ad hoc and structured reporting. Carrier performance is a key element of successful logistics. The TMS should enable the user to track carrier performance--ad hoc as well as through structured queries and reports. Data captured through the shipment lifecycle should be used to identify areas of poor performance as well as responsible parties for damage and claims. Lack of performance according to plan should also be available through event management and other TMS tools. Data should be available from the TMS to provide input to analysis and reporting tools, for example Excel, as well as more complex tools and applications.

***International Trade Logistics (ITL)***

Module provides an integrated transportation management and trade compliance solution that enables organizations to make faster, smarter trade decisions by streamlining, accelerating, and integrating complex import and export processes. It ensures timely delivery of goods and curtails customs delays at the border, reducing exposure to non-compliance fines, penalties, and seizures.

#### *Advanced Collaboration (ITL1)*

True collaboration across a global and disparate set of entities and information systems requires a neutral and secure environment. It is a key that this environment enables all players to engage in an electronic dialogue to collaborate in acquiring, transferring, transporting, and settling with regional and international trading partners. In addition, the data model should take into account the different roles of all participants and manage these through a set of rule-based processes. As such, the system implementation should include clear definitions in terms of buy-sell relationships, financial terms, service level agreements, as well as related contact details and user profiles for suppliers, customers, and related service providers.

#### *Product Description (ITL2)*

Item master includes a description of the product and defines all key characteristics of the any given product.

#### *Compliance Model (ITL3)*

Rules and regulations related to duties, tariffs, quotas, restricted parties, preferred nation status, and other compliance issues could vary depending on the combination of source of supply, product composition, relationship between buyer and seller, and destination for final delivery of products. This requires a data model that considers all these factors, maintaining the inter-relationship at the product, trading partner, and logistics level.

#### *Logistics (ITL4)*

The application should provide the user with a set of tools to establish rates, routes, and contracts for preferred transportation modes and providers. This should also include tools to create and exchange information and documents required in order to integrate transportation provider information and costs with product and trading partner data.

#### *Commerce (ITL5)*

Starting with the initial request for goods--whether this is an RFI, an RFQ or a formal purchase order, all information that is exchanged during the shipment life cycle should be facilitated by the ITL system. This requires a synchronized system and process, where the product and shipment requirements are integrated into an automated order fulfillment environment. The product item master and associated tables will determine the cost of the product as well as the relationship between the

product and any duties or tariffs that are applicable. Tables related to customs duties and tariffs as well as associated rates of exchange and transportation costs should be available as part of the system functions. This will enable the user to obtain an estimated total cost of goods sold as well as a final cost of goods sold, to highlight any variances or discrepancies. This implies a data model that includes an understanding of all the data exchanged and processed at the product and item level, between order management systems, as well as the data exchanged with warehouse management and transportation systems.

### ***Order Management (OM)***

A distributed order management system is a unique supply chain application. Generally, it cannot function as a stand-alone solution but depends on integration with other systems to perform its functions. It is as much a technology as an application. Why would a firm engage in the implementation of such a solution? Because, today's order execution and fulfillment requires integration across multiple enterprises. Thus, firms need to implement software that enables business processes and data integration in heterogeneous business and systems environments.

#### ***Order Promising (OM1)***

This system is not responsible for order administrative functions such as CRM, quoting, and other administrative functions.

#### ***Inventory Analysis for Order (OM2)***

This module helps you determine how much inventory you should hold, and when you should place inventory orders. The module attempts to keep your inventory level as efficient as possible, while maintaining adequate safety stock.

#### ***Sourcing Management (OM3)***

A primary attribute of a distributed order fulfillment system is the ability to do multi-stage sourcing and assembly. This requires a very open architecture to integrate seamlessly with various systems and supply chain nodes, in a real-time fashion.

#### ***Manufacturing Order Tracking (OM4)***

Order tracking allows online tracking of any product among all manufacturing process. Centralized purchasing avoids duplication and makes tracking of manufacturing orders. Compare prices from different vendors before placing a purchase order. You may track your shipment with an easy way.

### *Inbound and Assembly Coordination or Multi-site Staging (OM5)*

Many orders are sourced and built by a network of partners. Frequently, notification of cancellations does not occur. Keeping these orders synchronized is critical toward meeting schedules as well as avoiding over-building or building ahead of demand.

### *Shipment Tracking (OM6)*

Through this online tracking facility, you can get real time status information on your shipment.

### ***Supply Chain Event Management (SCE)***

Supply chain event management or supply chain network systems are a new class of solutions designed to monitor, notify, analyze, measure, and control business process and execution types of activities. These systems take advantage of new architectural principles brought about by several forces: high-availability, publish and subscribe architectures; tools like Java; the maturity of artificial intelligence rule-based programming capabilities; emerging agent technologies; as well as web architectures and standards (such as SOAP and XML). These solutions allow not only open, real-time views into global information, but also the ability to pinpoint and drill into key information, sensing deviations in business plans versus execution expectations (unplanned events).

The network solutions today are the beginning of a fundamental rethinking of how software is developed, deployed, and used. There is a reason that major ERP firms are grappling with these new architectures and developing on these technologies platforms. They provide more responsiveness and ultimately a lower cost of ownership. They have the ability to allow virtual business models to operate in highly visible modes. As these solutions have been developed and rolled-out in this early market, vendors have developed a level of functional expertise, which focuses on logistics, supplier relationship management, and production management. In addition, these solutions can be purely collaborative inter-enterprise solutions, linking trading partners to operate policy and process activities over the Internet.

Another alternative is an internal architecture, which must also support execution-level activities. Interestingly, these solutions can not only perform

execution-level support, but also perform next generation business intelligence application capabilities by providing real-time reporting and analytics.

*Metrics and Formula Library for Data (SCE1)*

Metrics used to measure the effects of process improvement are either developed new or selected from the library accordingly considering the organizational goals. If new metrics are developed, they are added into the library for reuse. Selection of metrics and data collection should begin as early as possible. In order to validate the effects of process improvement, it is necessary to measure not only the performance of improved processes but also that of current processes. Data required for calculating metrics should be continuously collected in parallel with process assessment and improvement. The collected data is aggregated into measures. Measures on current and improved process are compared in that module.

*Rules and Alerts Hierarchy Setup for Events (SCE2)*

A hierarchy set up lets you group content into a hierarchy that makes content easier to find. Easy to use hierarchy selector, it enables respondents to navigate to the correct hierarchy variable with ease.

*Data Drilling, Aggregating, and Exploding for Data Mining (SCE3)*

These systems can substitute or replace the traditional business intelligence (BI) system by providing real-time views of data, working off a dynamic database, rather than through the traditional OLAP approach.

*Price Deviation Analysis (SCE4)*

Price deviation analysis can be defined, reducing the risk for simple errors, like key-in errors in the purchase department or from suppliers that may reside in the system for a longer period, resulting in complicated cleanup tasks. Cost, price deviations are identified and presented real-time in the deviation monitor, giving the finance department a unique tool to act on.

*Engineering Change Order Tracking (SCE5)*

Efficiently manage design review and approval for multiple types of engineering change orders across the extended product team. You can define unlimited change order types, establish appropriate workflow routings for each, and grant external partners access to participate in this module. Provide early visibility to design impact across the extended enterprise through proactive alerts, notifications,

and collaborative change management tools. Decrease cycle time through workflow automation, change control board visibility, and accelerate time to market.

*Inventory Shortage Analysis for Supply (SCE6)*

Inventory shortage occurs any time the demand from online manufacturing for traffic or impressions exceeds the available supply. This module offers some inventory prediction and/or management capabilities.

*Quality Data Analysis (SCE7)*

A high degree of data quality is required for all organizations. For best served information this module take account every data significance in analyze period. Organizational databases are filled with unsatisfied data. In that way, this module enables to analyze those data accuracy.

*Equipment, Breakdown Analysis (SCE8)*

Equipment breakdown causes are completely user-defined. Module uses breakdown causes in down time analysis and reliability analysis. Break down causes may be associated with their preventive tasks. After doing so, the reliability analysis section of module may be used to guide you towards setting the correct tasks and task intervals as a way of circumventing these equipment breakdown causes.

*Demand Volatility Analysis (SCE9)*

Analyzing the demand volatility some steps is applied. First, determining initial demand at the start of a dispatch interval used to launch the demand forecast. Then, set the target demand, which is the demand at the end of a dispatch interval, and the demand that the forecasting process is aiming to predict. Improvements in this area are expected to result in better use sources to fill the gap between dispatch and demand.

*Analysis of Logistics Inefficiencies (SCE10)*

Analyzing out inefficiencies from logistics is a specialized endeavor that requires a clear overview of every link in the chain.

*Risk Management (SCE11)*

Risk management often focuses on matters of insurance. Risk management is attempting to identify and then manage threats that could severely influence or bring down the organization. Generally, this involves reviewing operations of the organization, identifying potential threats to the organization and the likelihood of their occurrence, and then taking appropriate actions to address the most likely

threats. However, there are several major considerations when assessing areas of risk in your business.

### ***Supplier Relationship Management (SRM)***

Supplier Relationship Management (SRM) is a relatively new way of categorizing software—born out of the concept that you have customer relationship management (CRM) systems for managing customer-facing processes, enterprise resource planning (ERP) systems for internal processes and SRM for both supplier-facing processes and managing the supply base. The heart of SRM is sourcing and procurement, which differ from their internally-focused ERP counterparts primarily in that the SRM modules have a much greater emphasis on integrating and connecting with the suppliers. SRM also includes interactions with the supply base throughout the full lifecycle of processes from design through to fulfillment, manufacturing, and settlement.

#### *Collaboration in Design and Requirements Identification (SRM1)*

Suppliers of strategic components and materials add value to the concept, requirement definition process by giving early feedback on what is feasible, and suggesting alternatives that may add value, reduce cost, and be easier to manufacture. SRM suites facilitate this by providing collaboration tools that allow suppliers to participate as a member of the team that sets requirements and targets (performance, cost, serviceability, etc.) for new products.

#### *Commodity Management (SRM2)*

Commodity management is the central sourcing function. Tools for analyzing global spend across many dimensions are needed to come up with optimum sourcing decisions. Tools to create and manage the supply plan give unambiguous direction to procurement.

#### *Supplier Management (SRM3)*

Supplier management enables finding and qualifying the best supplier, maintaining the list of approved suppliers, maintaining and accessing a database of supplier profile information, and critically measuring, monitoring, and analyzing the performance of suppliers.

#### *RFX and Contract Management (SRM4)*

Tools for creating and distributing a request for information, request for proposal, or request for quotation (we are using the term RFX to signify any of these) are critical in environments of high volumes of RFXs. These should allow a rich set of criteria to be considered and provide automated analysis and an interactive cycle with the supplier participants.

#### *Catalog Management for Products (SRM5)*

Catalog management tools need to import data from the supply base, which is generally stored in a vast variety of formats and using a variety of different semantics. The tools should help in the onerous task of cleansing and normalizing the catalog data. Normalization is more important in companies and departments where parametric searching of the catalog is required. Pre-populated and pre-normalized catalogs of products across one or more industry may also be included. Catalog syndication is required for larger organizations or distribution/e-marketplaces where you need to create multiple different views and subsets of a master catalog.

#### *MRP or Requisition-Driven Procurement (SRM6)*

MRP-driven procurement is often handled by the ERP system. Lacking an ERP system, SRM systems may provide this functionality, which consists of managing the POs or work orders generated by MRP systems. Requisition-driven procurement systems allow users to buy from catalogs, automatically route requisitions for approval, provide tracking of approval status, generate and send purchase orders, control maverick spending, integrate with RFX and contract management systems, and tie into settlement and reconciliation.

#### *Price, Discounts, Cost Management (SRM7)*

Prices and discounts management provides functions to monitor and analyze purchase price variance, which is the key to controlling costs.

#### *Return Management (SRM8)*

Returns management becomes important in SRM for situations where components are being returned to and repaired or replaced by suppliers.

#### *Quality and Engineering Change Order Management (SRM9)*

In the context of SRM systems, quality focuses primarily on supporting the certification process for components, as well as managing the corrective action process. In addition, reporting on defects in the field. ECO (engineering change orders) management systems should help analyze the impact of the change across the

organization (for example, manufacturing, sourcing, engineering, field support, etc.) and with your supply base. This includes both analysis tools (e.g. for analyzing and quantifying the cost impact) and the infrastructure to route the ECO around the organization for approval. A key part of this is obtaining commitments from suppliers. Once approved, the system should help in executing, recording, and auditing results of ECOs

During the competitive priorities selection, the knowledge and critical information are taken from the group of experts in the industry and according to the priorities of the firms; the corresponding importance of one criterion over another can be decided.

## **IV.2. ANALYTIC APPROACH APPLICATIONS**

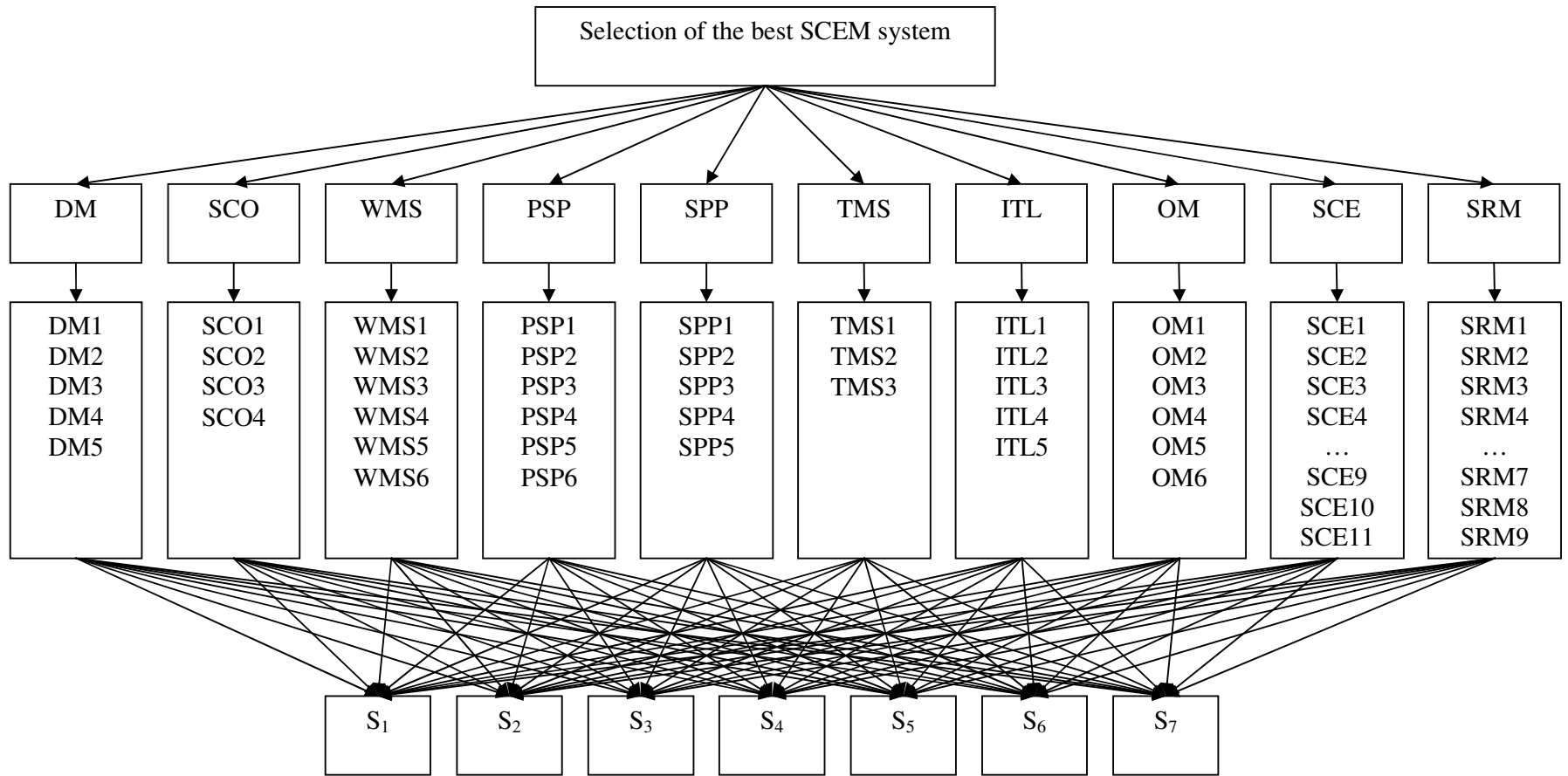
We have adopted both Excel and MATLAB as the development for fuzzy decision support system, because these calculations provide powerful numerical functions, optimization procedures, good visualization capabilities and programming interfaces. In addition, the MATLAB allows for an easy communication with Excel, as well as with other applications.

The model calculations of our approach process are composed of two main components equations of Excel worksheets and M-files of MATLAB. The initial configuration of the model, F-AHP weighting calculations, F-TOPSIS final priorities and F-ANP weighting calculations are done in the Excel workspace. MATLAB is used for the implementing the F-ANP phase as well as for some complex matrix operations, such as raising the supermatrix to powers.

Based on our methodology we applied two different fuzzy analytic approach to verify each other to select best probable SCEM system. In the first part F-AHP and F-TOPSIS integrated model is applied and then F-ANP model is done for comparison.

### **IV.2.1. Application of F-AHP and F-TOPSIS Integrated Model**

According to this model, we define criteria priority weights with F-AHP model and then alternatives ranked with F-TOPSIS model. Decision hierarchy structured with the determined alternative SCEM systems and criteria is provided in Fig. IV.1.



**Figure IV.1** The decision hierarchy of SCEM system

There are four level in decision hierarchy structured for SCEM system evaluation. The overall goal of the decision process determined as selection of the best SCEM system is in the first level of the hierarchy. Criteria and secondary-criteria are second and third level and the alternative systems are on the fourth level of the hierarchy.

After the approval of decision hierarchy, criteria used in SCEM system selection are assigned weights using F-AHP in the second stage. In this phase, pairwise comparison matrices are formed to determine the criteria weights. The decision makers make individual evaluations using the scale provided in Table III.2, to determine the values of the elements of pairwise comparison matrices. Computing the geometric mean of the values obtained from individual evaluations, a final pairwise comparison matrix on which there is a consensus is found. The weights of the criteria are calculated based on this final comparison matrix. In the last step of this phase, decision-making team approves calculated weights of the criteria.

As mentioned, the F-AHP methodology first necessitates the pairwise comparison of the criteria and secondary-criteria in order to determine their weights.

Weights were obtained by using F-AHP method, and then the weights of each decision maker and average weights were derived by geometric mean method suggested by Buckley (1985). The following sample demonstrates the computational procedure of the weights of main criterion DM for four decision makers:

According to the interviews with four decisions maker is a representative about the importance of evaluation dimensions, then the pairwise comparison matrices of criterion will be obtained as follow:

**Table IV.2** Linguistic Pairwise Comparison for Decision maker # 1

	DM	SCO	WMS	PSP	SPP	TMS	ITL	OM	SCE	SRM
DM	-	<i>LWk</i>	<i>LEs</i>	<i>LWk</i>	<i>LWk</i>	<i>LEs</i>	<i>LVs</i>	<i>LWk</i>	<i>LEs</i>	<i>Wk</i>
SCO		-	<i>LVs</i>	<i>Eq</i>	<i>LEs</i>	<i>LVs</i>	<i>Eq</i>	<i>LVs</i>	<i>Eq</i>	<i>LVs</i>
WMS			-	<i>Wk</i>	<i>LEs</i>	<i>Eq</i>	<i>Wk</i>	<i>Es</i>	<i>Wk</i>	<i>Es</i>
PSP				-	<i>LWk</i>	<i>LVs</i>	<i>Eq</i>	<i>LVs</i>	<i>Eq</i>	<i>LVs</i>
SPP					-	<i>Wk</i>	<i>Wk</i>	<i>W</i>	<i>Es</i>	<i>Wk</i>
TMS						-	<i>Wk</i>	<i>Eq</i>	<i>Wk</i>	<i>Eq</i>
ITL							-	<i>LVs</i>	<i>Eq</i>	<i>LWk</i>
OM								-	<i>Wk</i>	<i>Eq</i>
SCE									-	<i>LWk</i>
SRM										-

**Table IV.3** Linguistic Pairwise Comparison for Decision maker # 2

	DM	SCO	WMS	PSP	SPP	TMS	ITL	OM	SCE	SRM
DM	1	<i>Eq</i>	<i>LWk</i>	<i>LWk</i>	<i>LVs</i>	<i>LEs</i>	<i>Eq</i>	<i>Eq</i>	<i>LWk</i>	<i>LWk</i>
SCO		1	<i>Eq</i>	<i>Eq</i>	<i>LEs</i>	<i>LWk</i>	<i>Eq</i>	<i>Eq</i>	<i>Eq</i>	<i>LWk</i>
WMS			1	<i>Wk</i>	<i>Wk</i>	<i>Eq</i>	<i>Wk</i>	<i>Eq</i>	<i>Wk</i>	<i>Wk</i>
PSP				1	<i>LEs</i>	<i>LWk</i>	<i>Wk</i>	<i>LWk</i>	<i>Eq</i>	<i>Eq</i>
SPP					1	<i>Wk</i>	<i>Wk</i>	<i>LWk</i>	<i>LEs</i>	<i>Eq</i>
TMS						1	<i>Wk</i>	<i>Eq</i>	<i>Wk</i>	<i>Eq</i>
ITL							1	<i>LWk</i>	<i>Wk</i>	<i>Eq</i>
OM								1	<i>Es</i>	<i>Wk</i>
SCE									1	<i>LWk</i>
SRM										1

**Table IV.4** Linguistic Pairwise Comparison for Decision maker # 3

	DM	SCO	WMS	PSP	SPP	TMS	ITL	OM	SCE	SRM
DM	-	<i>LWk</i>	<i>LWk</i>	<i>LWk</i>	<i>LVs</i>	<i>Eq</i>	<i>LWk</i>	<i>LWk</i>	<i>LWk</i>	<i>Eq</i>
SCO		-	<i>LWk</i>	<i>LWk</i>	<i>LEs</i>	<i>LWk</i>	<i>Eq</i>	<i>Eq</i>	<i>Eq</i>	<i>Eq</i>
WMS			-	<i>Es</i>	<i>LWk</i>	<i>Eq</i>	<i>Wk</i>	<i>Eq</i>	<i>Es</i>	<i>Eq</i>
PSP				-	<i>LVs</i>	<i>LWk</i>	<i>Eq</i>	<i>Eq</i>	<i>Eq</i>	<i>LWk</i>
SPP					-	<i>Vs</i>	<i>Vs</i>	<i>Es</i>	<i>Eq</i>	<i>Es</i>
TMS						-	<i>Wk</i>	<i>Es</i>	<i>Wk</i>	<i>Eq</i>
ITL							-	<i>LWk</i>	<i>Eq</i>	<i>Eq</i>
OM								-	<i>Wk</i>	<i>Eq</i>
SCE									-	<i>Eq</i>
SRM										-

**Table IV.5** Linguistic Pairwise Comparison for Decision maker # 4

	DM	SCO	WMS	PSP	SPP	TMS	ITL	OM	SCE	SRM
DM	-	<i>LEs</i>	<i>LEs</i>	<i>Eq</i>	<i>Wk</i>	<i>LEs</i>	<i>Vs</i>	<i>Eq</i>	<i>Eq</i>	<i>Wk</i>
SCO		-	<i>Eq</i>	<i>Wk</i>	<i>Vs</i>	<i>Eq</i>	<i>Vs</i>	<i>Eq</i>	<i>Wk</i>	<i>Vs</i>
WMS			-	<i>Eq</i>	<i>Wk</i>	<i>Vs</i>	<i>Eq</i>	<i>Eq</i>	<i>Vs</i>	<i>Ab</i>
PSP				-	<i>Es</i>	<i>LWk</i>	<i>Wk</i>	<i>Eq</i>	<i>Vs</i>	<i>Vs</i>
SPP					-	<i>LWk</i>	<i>Wk</i>	<i>Eq</i>	<i>Wk</i>	<i>Wk</i>
TMS						-	<i>Vs</i>	<i>Eq</i>	<i>Vs</i>	<i>Ab</i>
ITL							-	<i>LWk</i>	<i>LWk</i>	<i>Eq</i>
OM								-	<i>Wk</i>	<i>Wk</i>
SCE									-	<i>Eq</i>
SRM										-

Where  $L$  = Less.

Applying the fuzzy numbers defined in Table III.3, it can transfer the linguistic scales to the corresponding fuzzy numbers as follows:

**Table IV.6** Fuzzy Scale for Decision Maker # 1

	DM	SCO	WMS	PSP	SPP	TMS	ITL	OM	SCE	SRM
DM	1	$\tilde{3}^{-1}$	$\tilde{5}^{-1}$	$\tilde{3}^{-1}$	$\tilde{3}^{-1}$	$\tilde{5}^{-1}$	$\tilde{7}^{-1}$	$\tilde{3}^{-1}$	$\tilde{5}^{-1}$	$\tilde{3}$
SCO	$\tilde{3}$	1	$\tilde{7}^{-1}$	$\tilde{1}$	$\tilde{5}^{-1}$	$\tilde{7}^{-1}$	$\tilde{1}$	$\tilde{7}^{-1}$	$\tilde{1}$	$\tilde{7}^{-1}$
WMS	$\tilde{5}$	$\tilde{7}$	1	$\tilde{3}$	$\tilde{5}^{-1}$	$\tilde{1}$	$\tilde{3}$	$\tilde{5}$	$\tilde{3}$	$\tilde{5}$
PSP	$\tilde{3}$	$\tilde{1}^{-1}$	$\tilde{3}^{-1}$	1	$\tilde{3}^{-1}$	$\tilde{7}^{-1}$	$\tilde{1}$	$\tilde{7}^{-1}$	$\tilde{1}$	$\tilde{7}^{-1}$
SPP	$\tilde{3}$	$\tilde{5}$	$\tilde{5}$	$\tilde{3}$	1	$\tilde{3}$	$\tilde{3}$	$\tilde{3}$	$\tilde{5}$	$\tilde{3}$
TMS	$\tilde{5}$	$\tilde{7}$	$\tilde{1}^{-1}$	$\tilde{7}$	$\tilde{3}^{-1}$	1	$\tilde{3}$	$\tilde{1}$	$\tilde{3}$	$\tilde{1}$
ITL	$\tilde{7}$	$\tilde{1}^{-1}$	$\tilde{3}^{-1}$	$\tilde{1}^{-1}$	$\tilde{3}^{-1}$	$\tilde{3}^{-1}$	1	$\tilde{7}^{-1}$	$\tilde{1}$	$\tilde{3}^{-1}$
OM	$\tilde{3}$	$\tilde{7}$	$\tilde{5}^{-1}$	$\tilde{7}$	$\tilde{3}^{-1}$	$\tilde{1}^{-1}$	$\tilde{7}$	1	$\tilde{3}$	$\tilde{1}$
SCE	$\tilde{5}$	$\tilde{1}^{-1}$	$\tilde{3}^{-1}$	$\tilde{1}^{-1}$	$\tilde{5}^{-1}$	$\tilde{3}^{-1}$	$\tilde{1}^{-1}$	$\tilde{3}^{-1}$	1	$\tilde{3}^{-1}$
SRM	$\tilde{3}^{-1}$	$\tilde{7}$	$\tilde{5}^{-1}$	$\tilde{7}$	$\tilde{3}^{-1}$	$\tilde{1}^{-1}$	$\tilde{3}$	$\tilde{1}^{-1}$	$\tilde{3}$	1

**Table IV.7** Fuzzy Scale for Decision Maker # 2

	DM	SCO	WMS	PSP	SPP	TMS	ITL	OM	SCE	SRM
DM	1	$\tilde{3}^{-1}$	$\tilde{3}^{-1}$	$\tilde{3}^{-1}$	$\tilde{7}^{-1}$	$\tilde{1}$	$\tilde{3}^{-1}$	$\tilde{3}^{-1}$	$\tilde{3}^{-1}$	$\tilde{1}$
SCO	$\tilde{3}$	1	$\tilde{3}^{-1}$	$\tilde{3}^{-1}$	$\tilde{5}^{-1}$	$\tilde{3}^{-1}$	$\tilde{1}$	$\tilde{1}$	$\tilde{1}$	$\tilde{1}$
WMS	$\tilde{3}$	$\tilde{3}$	1	$\tilde{5}$	$\tilde{3}^{-1}$	$\tilde{1}$	$\tilde{3}$	$\tilde{1}$	$\tilde{5}$	$\tilde{1}$
PSP	$\tilde{3}$	$\tilde{3}$	$\tilde{5}^{-1}$	1	$\tilde{7}^{-1}$	$\tilde{3}^{-1}$	$\tilde{1}$	$\tilde{1}$	$\tilde{1}$	$\tilde{3}^{-1}$
SPP	$\tilde{7}$	$\tilde{5}$	$\tilde{3}$	$\tilde{7}$	1	$\tilde{7}$	$\tilde{7}$	$\tilde{5}$	$\tilde{1}$	$\tilde{5}$
TMS	$\tilde{1}^{-1}$	$\tilde{3}$	$\tilde{1}^{-1}$	$\tilde{3}$	$\tilde{7}^{-1}$	1	$\tilde{3}$	$\tilde{5}$	$\tilde{3}$	$\tilde{1}$
ITL	$\tilde{3}$	$\tilde{1}^{-1}$	$\tilde{3}^{-1}$	$\tilde{1}^{-1}$	$\tilde{7}^{-1}$	$\tilde{3}^{-1}$	1	$\tilde{3}^{-1}$	$\tilde{1}$	$\tilde{1}$
OM	$\tilde{3}$	$\tilde{1}^{-1}$	$\tilde{1}^{-1}$	$\tilde{1}^{-1}$	$\tilde{5}^{-1}$	$\tilde{5}^{-1}$	$\tilde{3}$	1	$\tilde{3}$	$\tilde{1}$
SCE	$\tilde{3}$	$\tilde{1}^{-1}$	$\tilde{5}^{-1}$	$\tilde{1}^{-1}$	$\tilde{1}^{-1}$	$\tilde{3}^{-1}$	$\tilde{1}^{-1}$	$\tilde{3}^{-1}$	1	$\tilde{1}$
SRM	$\tilde{1}$	$\tilde{1}^{-1}$	$\tilde{1}^{-1}$	$\tilde{3}$	$\tilde{5}^{-1}$	$\tilde{1}^{-1}$	$\tilde{1}^{-1}$	$\tilde{1}^{-1}$	$\tilde{1}^{-1}$	1

**Table IV.8** Fuzzy Scale for Decision Maker # 3

	DM	SCO	WMS	PSP	SPP	TMS	ITL	OM	SCE	SRM
DM	1	$\tilde{1}$	$\tilde{3}^{-1}$	$\tilde{3}^{-1}$	$\tilde{5}^{-1}$	$\tilde{5}^{-1}$	$\tilde{1}$	$\tilde{1}$	$\tilde{3}^{-1}$	$\tilde{3}^{-1}$
SCO	$\tilde{1}^{-1}$	1	$\tilde{1}$	$\tilde{1}$	$\tilde{5}^{-1}$	$\tilde{3}^{-1}$	$\tilde{1}$	$\tilde{1}$	$\tilde{1}$	$\tilde{3}^{-1}$
WMS	$\tilde{3}$	$\tilde{1}^{-1}$	1	$\tilde{3}$	$\tilde{3}$	$\tilde{1}$	$\tilde{3}$	$\tilde{1}$	$\tilde{3}$	$\tilde{3}$
PSP	$\tilde{3}$	$\tilde{1}^{-1}$	$\tilde{3}^{-1}$	1	$\tilde{5}^{-1}$	$\tilde{3}^{-1}$	$\tilde{3}$	$\tilde{3}^{-1}$	$\tilde{1}$	$\tilde{1}$
SPP	$\tilde{5}$	$\tilde{5}$	$\tilde{3}^{-1}$	$\tilde{5}$	1	$\tilde{3}$	$\tilde{3}$	$\tilde{3}^{-1}$	$\tilde{5}^{-1}$	$\tilde{1}$
TMS	$\tilde{5}$	$\tilde{3}$	$\tilde{1}^{-1}$	$\tilde{3}$	$\tilde{3}^{-1}$	1	$\tilde{3}$	$\tilde{1}$	$\tilde{3}$	$\tilde{1}$
ITL	$\tilde{1}^{-1}$	$\tilde{1}^{-1}$	$\tilde{3}^{-1}$	$\tilde{3}^{-1}$	$\tilde{3}^{-1}$	$\tilde{3}^{-1}$	1	$\tilde{3}^{-1}$	$\tilde{3}$	$\tilde{1}$
OM	$\tilde{1}^{-1}$	$\tilde{1}^{-1}$	$\tilde{1}^{-1}$	$\tilde{3}$	$\tilde{3}$	$\tilde{1}^{-1}$	$\tilde{3}$	1	$\tilde{5}$	$\tilde{3}$
SCE	$\tilde{3}$	$\tilde{1}^{-1}$	$\tilde{3}^{-1}$	$\tilde{1}^{-1}$	$\tilde{5}$	$\tilde{3}^{-1}$	$\tilde{3}^{-1}$	$\tilde{5}^{-1}$	1	$\tilde{3}^{-1}$
SRM	$\tilde{3}$	$\tilde{3}$	$\tilde{3}^{-1}$	$\tilde{1}^{-1}$	$\tilde{1}^{-1}$	$\tilde{1}^{-1}$	$\tilde{1}^{-1}$	$\tilde{3}^{-1}$	$\tilde{3}$	1

**Table IV.9** Fuzzy Scale for Decision Maker # 4

	DM	SCO	WMS	PSP	SPP	TMS	ITL	OM	SCE	SRM
DM	1	$\tilde{5}^{-1}$	$\tilde{5}^{-1}$	$\tilde{1}$	$\tilde{3}$	$\tilde{5}^{-1}$	$\tilde{7}$	$\tilde{1}$	$\tilde{1}$	$\tilde{3}$
SCO	$\tilde{5}$	1	$\tilde{1}$	$\tilde{3}$	$\tilde{7}$	$\tilde{1}$	$\tilde{7}$	$\tilde{1}$	$\tilde{3}$	$\tilde{7}$
WMS	$\tilde{5}$	$\tilde{1}^{-1}$	1	$\tilde{1}$	$\tilde{3}$	$\tilde{1}$	$\tilde{7}$	$\tilde{1}$	$\tilde{7}$	$\tilde{9}$
PSP	$\tilde{1}$	$\tilde{3}^{-1}$	$\tilde{1}^{-1}$	1	$\tilde{5}$	$\tilde{3}^{-1}$	$\tilde{3}$	$\tilde{1}$	$\tilde{7}$	$\tilde{7}$
SPP	$\tilde{3}^{-1}$	$\tilde{7}^{-1}$	$\tilde{3}^{-1}$	$\tilde{5}^{-1}$	1	$\tilde{3}^{-1}$	$\tilde{3}$	$\tilde{1}$	$\tilde{3}$	$\tilde{3}$
TMS	$\tilde{5}$	$\tilde{1}^{-1}$	$\tilde{1}^{-1}$	$\tilde{3}$	$\tilde{3}$	1	$\tilde{7}$	$\tilde{1}$	$\tilde{7}$	$\tilde{9}$
ITL	$\tilde{7}^{-1}$	$\tilde{7}^{-1}$	$\tilde{7}^{-1}$	$\tilde{3}^{-1}$	$\tilde{3}^{-1}$	$\tilde{7}^{-1}$	1	$\tilde{3}^{-1}$	$\tilde{3}^{-1}$	$\tilde{1}$
OM	$\tilde{1}^{-1}$	$\tilde{1}^{-1}$	$\tilde{1}^{-1}$	$\tilde{1}^{-1}$	$\tilde{1}^{-1}$	$\tilde{1}^{-1}$	$\tilde{3}$	1	$\tilde{3}$	$\tilde{3}$
SCE	$\tilde{1}^{-1}$	$\tilde{3}^{-1}$	$\tilde{7}^{-1}$	$\tilde{7}^{-1}$	$\tilde{3}^{-1}$	$\tilde{7}^{-1}$	$\tilde{3}$	$\tilde{3}^{-1}$	1	$\tilde{1}$
SRM	$\tilde{3}^{-1}$	$\tilde{7}^{-1}$	$\tilde{9}^{-1}$	$\tilde{7}^{-1}$	$\tilde{3}^{-1}$	$\tilde{9}^{-1}$	$\tilde{1}^{-1}$	$\tilde{3}^{-1}$	$\tilde{1}^{-1}$	1

Computing of the main criterion DM fuzzy calculation is formed as methodology chapter that is:

$$\tilde{a}_{ij} = (\tilde{a}_{ij}^1 \otimes \tilde{a}_{ij}^2 \otimes \tilde{a}_{ij}^3 \otimes \tilde{a}_{ij}^4)^{1/4}, \text{ for } \tilde{a}_{12} \text{ as an example:}$$

$$\begin{aligned} \tilde{a}_{12} &= \left( \left( \frac{1}{5}, \frac{1}{3}, 1 \right) \otimes \left( \frac{1}{5}, \frac{1}{3}, 1 \right) \otimes (1, 1, 3) \otimes \left( \frac{1}{7}, \frac{1}{5}, \frac{1}{3} \right) \right)^{1/4} \\ &= \left( \left( \frac{1}{5} \times \frac{1}{5} \times 1 \times \frac{1}{7} \right)^{1/4}, \left( \frac{1}{3} \times \frac{1}{3} \times 1 \times \frac{1}{5} \right)^{1/4}, \left( 1 \times 1 \times 3 \times \frac{1}{3} \right)^{1/4} \right) \\ &= (0.275, 0.386, 1). \end{aligned}$$

It can be obtained the other matrix elements by the same computational procedure, therefore, the pairwise comparison matrices of the four representatives will be constructed as Table IV.2.

To obtain the fuzzy weights of dimensions for decision makers, that is:

$$\begin{aligned} \tilde{r}_1 &= (\tilde{a}_{11} \otimes \tilde{a}_{12} \otimes \tilde{a}_{13} \otimes \tilde{a}_{14} \otimes \tilde{a}_{15} \otimes \tilde{a}_{16} \otimes \tilde{a}_{17} \otimes \tilde{a}_{18} \otimes \tilde{a}_{19} \otimes \tilde{a}_{110})^{1/10} \\ &= ((1 \times 0.275 \times 0.169 \times \dots \times 0.253 \times 0.669)^{1/10}, \\ &\quad (1 \times 0.386 \times 0.258 \times \dots \times 0.340 \times 1.316)^{1/10}, \\ &\quad (1 \times 1.000 \times 0.577 \times \dots \times 0.760 \times 2.943)^{1/19}) \\ &= (0.357, 0.504, 1.070) \end{aligned}$$

Likewise, we can obtain the remaining  $\tilde{r}_i$ , that is,

$$\tilde{r}_2 = (0.640, 0.855, 1.721)$$

$$\tilde{r}_3 = (1.210, 2.078, 3.506)$$

$$\tilde{r}_4 = (0.520, 0.803, 1.539)$$

$$\tilde{r}_5 = (1.140, 2.014, 3.333)$$

$$\tilde{r}_6 = (1.019, 1.890, 2.935)$$

$$\tilde{r}_7 = (0.334, 0.519, 1.019)$$

$$\tilde{r}_8 = (0.580, 1.294, 1.760)$$

$$\tilde{r}_9 = (0.349, 0.631, 1.072)$$

$$\tilde{r}_{10} = (0.368, 0.729, 1.052)$$

**Table IV.10** The TFN evaluation matrix of the main criteria

	DM	SCO	WMS	PSP	SPP	TMS	ITL	OM	SCE	SRM
DM	1	(0.275, 0.386, 1.000)	(0.169, 0.258, 0.577)	(2.999, 0.439, 1.316)	(0.237, 0.411, 0.760)	(0.232, 0.299, 0.577)	(0.577, 0.760, 1.524)	(0.447, 0.577, 1.732)	(0.253, 0.340, 0.760)	(0.669, 1.316, 2.943)
SCO	(1.000, 2.590, 3.637)	1	(0.386, 0.467, 1.158)	(0.669, 1.000, 2.590)	(0.347, 0.486, 0.760)	(0.258, 0.355, 0.880)	(1.495, 1.627, 3.948)	(0.577, 0.615, 1.524)	(1.000, 1.316, 3.409)	(0.577, 0.760, 1.524)
WMS	(1.732, 3.873, 5.916)	(0.863, 2.141, 2.590)	1	(1.316, 2.590, 4.787)	(0.411, 0.880, 1.699)	(1.000, 3.000, 5.791)	(1.495, 3.708, 5.791)	(1.316, 1.495, 3.708)	(1.968, 4.213, 6.300)	(2.141, 3.409, 5.544)
PSP	(1.000, 2.280, 4.401)	(0.386, 1.000, 1.495)	(0.209, 0.386, 0.760)	1	(0.312, 0.467, 0.827)	(0.173, 0.270, 0.669)	(1.000, 1.732, 3.873)	(0.386, 0.467, 1.158)	(1.495, 1.627, 3.948)	(0.577, 0.760, 1.524)
SPP	(1.316, 2.432, 4.213)	(1.316, 2.056, 2.878)	(0.589, 1.136, 2.432)	(1.210, 2.141, 3.201)	1	(1.000, 2.141, 3.873)	(1.495, 3.708, 5.791)	(0.880, 1.495, 3.201)	(1.732, 2.943, 5.207)	(1.316, 2.590, 4.787)
TMS	(1.732, 3.344, 4.304)	(1.136, 2.817, 3.873)	(0.333, 1.000, 1.000)	(1.495, 3.708, 5.791)	(0.258, 0.467, 1.000)	1	(1.495, 3.708, 5.791)	(1.316, 1.495, 3.708)	(1.495, 3.708, 5.791)	(1.627, 1.732, 3.948)
ITL	(0.656, 1.316, 1.732)	(0.253, 0.615, 0.669)	(0.173, 0.270, 0.669)	(0.258, 0.577, 1.000)	(0.173, 0.270, 0.669)	(0.173, 0.270, 0.669)	1	(0.173, 0.270, 0.669)	(0.669, 0.760, 2.280)	(0.669, 0.760, 2.280)
OM	(0.577, 1.732, 2.236)	(0.656, 1.627, 1.732)	(0.270, 0.669, 0.760)	(0.333, 0.809, 1.000)	(0.312, 0.669, 1.136)	(0.270, 0.669, 0.760)	(1.495, 3.708, 5.791)	1	(1.000, 3.000, 5.000)	(1.000, 1.732, 3.873)
SCE	(1.000, 2.590, 3.637)	(0.293, 0.760, 1.000)	(0.159, 0.237, 0.508)	(0.253, 0.615, 0.669)	(0.411, 0.760, 1.236)	(0.173, 0.270, 0.669)	(0.386, 1.000, 1.495)	(0.184, 0.293, 0.760)	1	(0.447, 0.577, 1.732)
SRM	(0.447, 0.760, 1.968)	(0.656, 1.316, 1.732)	(0.180, 0.293, 0.467)	(0.253, 0.497, 0.669)	(0.209, 0.386, 0.760)	(0.253, 0.576, 0.615)	(0.439, 1.316, 1.495)	(0.258, 0.577, 1.000)	(0.577, 1.732, 2.236)	1

For the weight of each criterion, they can be done as follows:

$$\begin{aligned}
 \tilde{w}_1 &= \tilde{r}_1 \otimes (\tilde{r}_1 \oplus \tilde{r}_2 \oplus \tilde{r}_3 \oplus \tilde{r}_4 \oplus \tilde{r}_5 \oplus \tilde{r}_6 \oplus \tilde{r}_7 \oplus \tilde{r}_8 \oplus \tilde{r}_9 \oplus \tilde{r}_{10})^{-1} \\
 &= (0.357, 0.504, 1.070) \otimes (1 / (1.070 + \dots + 1.052), \\
 &\quad 1 / (0.504 + \dots + 0.729), 1 / (0.357 + \dots + 0.368) ) \\
 &= (0.019, 0.045, 0.164).
 \end{aligned}$$

Likewise,

$$\tilde{w}_2 = (0.034, 0.076, 0.264)$$

$$\tilde{w}_3 = (0.064, 0.184, 0.538)$$

$$\tilde{w}_4 = (0.027, 0.071, 0.236)$$

$$\tilde{w}_5 = (0.060, 0.178, 0.511)$$

$$\tilde{w}_6 = (0.054, 0.167, 0.450)$$

$$\tilde{w}_7 = (0.018, 0.046, 0.156)$$

$$\tilde{w}_8 = (0.031, 0.114, 0.270)$$

$$\tilde{w}_9 = (0.018, 0.056, 0.165)$$

$$\tilde{w}_{10} = (0.019, 0.064, 0.161)$$

Likewise, the same calculations have been done for secondary-criteria weights and evaluation data given in Appendix A and results are given in Table IV.11.

**Table IV.11** Weights of the 60 evaluation criteria

Criteria	Local weights (TFNs)	Global weights (TFNs)
<i>DM</i>	<i>(0.019, 0.045, 0.164)</i>	
DM1	(0.222, 0.414, 0.722)	(0.004, 0.019, 0.118)
DM2	(0.132, 0.258, 0.501)	(0.003, 0.012, 0.082)
DM3	(0.055, 0.088, 0.161)	(0.001, 0.004, 0.026)
DM4	(0.055, 0.101, 0.201)	(0.001, 0.005, 0.033)
DM5	(0.076, 0.153, 0.312)	(0.001, 0.007, 0.051)
<i>SCO</i>	<i>(0.034, 0.076, 0.264)</i>	
SCO1	(0.312, 0.515, 0.817)	(0.011, 0.039, 0.216)
SCO2	(0.119, 0.190, 0.302)	(0.004, 0.014, 0.080)
SCO3	(0.119, 0.226, 0.398)	(0.004, 0.017, 0.105)
SCO4	(0.065, 0.105, 0.208)	(0.002, 0.008, 0.055)
<i>WMS</i>	<i>(0.064, 0.184, 0.538)</i>	
WMS1	(0.092, 0.188, 0.367)	(0.006, 0.035, 0.197)
WMS2	(0.077, 0.168, 0.367)	(0.005, 0.031, 0.197)
WMS3	(0.061, 0.099, 0.189)	(0.004, 0.018, 0.102)
WMS4	(0.051, 0.088, 0.194)	(0.003, 0.016, 0.104)
WMS5	(0.042, 0.078, 0.188)	(0.003, 0.014, 0.101)
WMS6	(0.157, 0.326, 0.611)	(0.010, 0.060, 0.329)
<i>PSP</i>	<i>(0.027, 0.071, 0.236)</i>	
PSP1	(0.194, 0.306, 0.461)	(0.005, 0.022, 0.109)
PSP2	(0.194, 0.273, 0.384)	(0.005, 0.019, 0.091)
PSP3	(0.113, 0.191, 0.348)	(0.003, 0.014, 0.082)
PSP4	(0.053, 0.080, 0.126)	(0.001, 0.006, 0.030)
PSP5	(0.050, 0.077, 0.122)	(0.001, 0.005, 0.029)
PSP6	(0.025, 0.037, 0.060)	(0.001, 0.003, 0.014)
<i>SPP</i>	<i>(0.060, 0.178, 0.511)</i>	
SPP1	(0.075, 0.123, 0.248)	(0.004, 0.022, 0.127)
SPP2	(0.145, 0.245, 0.385)	(0.009, 0.044, 0.197)
SPP3	(0.077, 0.181, 0.516)	(0.004, 0.025, 0.158)
SPP4	(0.139, 0.239, 0.379)	(0.008, 0.043, 0.194)
SPP5	(0.148, 0.251, 0.396)	(0.009, 0.045, 0.202)
<i>TMS</i>	<i>(0.054, 0.167, 0.450)</i>	
TMS1	(0.278, 0.540, 0.959)	(0.015, 0.090, 0.432)
TMS2	(0.153, 0.297, 0.604)	(0.008, 0.050, 0.272)

**Table IV.11 (cont.)** Weights of the 60 evaluation criteria

TMS3	(0.096, 0.163, 0.333)	(0.005, 0.027, 0.150)
<i>ITL</i>	<i>(0.018, 0.046, 0.156)</i>	
ITL1	(0.156, 0.277, 0.451)	(0.003, 0.013, 0.070)
ITL2	(0.092, 0.150, 0.278)	(0.002, 0.007, 0.043)
ITL3	(0.152, 0.238, 0.398)	(0.003, 0.011, 0.062)
ITL4	(0.155, 0.274, 0.449)	(0.003, 0.013, 0.070)
ITL5	(0.038, 0.059, 0.103)	(0.001, 0.003, 0.016)
<i>OM</i>	<i>(0.031, 0.114, 0.270)</i>	
OM1	(0.183, 0.348, 0.598)	(0.006, 0.040, 0.162)
OM2	(0.050, 0.082, 0.157)	(0.002, 0.009, 0.042)
OM3	(0.060, 0.092, 0.181)	(0.002, 0.010, 0.049)
OM4	(0.076, 0.124, 0.212)	(0.002, 0.014, 0.057)
OM5	(0.068, 0.110, 0.198)	(0.002, 0.013, 0.053)
OM6	(0.096, 0.211, 0.411)	(0.003, 0.024, 0.111)
<i>SCE</i>	<i>(0.018, 0.056, 0.165)</i>	
SCE1	(0.104, 0.178, 0.284)	(0.002, 0.010, 0.047)
SCE2	(0.044, 0.067, 0.109)	(0.001, 0.004, 0.018)
SCE3	(0.041, 0.061, 0.096)	(0.001, 0.003, 0.016)
SCE4	(0.016, 0.025, 0.044)	(0.000, 0.001, 0.007)
SCE5	(0.037, 0.055, 0.090)	(0.001, 0.003, 0.015)
SCE6	(0.088, 0.144, 0.227)	(0.002, 0.008, 0.037)
SCE7	(0.040, 0.059, 0.090)	(0.001, 0.003, 0.015)
SCE8	(0.104, 0.178, 0.248)	(0.002, 0.010, 0.047)
SCE9	(0.051, 0.109, 0.216)	(0.001, 0.006, 0.036)
SCE10	(0.040, 0.056, 0.094)	(0.001, 0.003, 0.016)
<i>SRM</i>	<i>(0.019, 0.064, 0.161)</i>	
SRM1	(0.029, 0.048, 0.093)	(0.001, 0.003, 0.015)
SRM2	(0.029, 0.052, 0.105)	(0.001, 0.003, 0.017)
SRM3	(0.045, 0.085, 0.158)	(0.001, 0.005, 0.025)
SRM4	(0.049, 0.088, 0.163)	(0.001, 0.006, 0.026)
SRM5	(0.074, 0.151, 0.303)	(0.001, 0.010, 0.049)
SRM6	(0.029, 0.048, 0.093)	(0.001, 0.003, 0.015)
SRM7	(0.127, 0.229, 0.393)	(0.002, 0.015, 0.063)
SRM8	(0.127, 0.248, 0.444)	(0.002, 0.016, 0.071)
SRM9	(0.045, 0.085, 0.158)	(0.001, 0.005, 0.025)

From the F-AHP results, for decision makers, we are able to find the most important and the least important criteria. Due to given result we can say most important criteria are WMS (0.064, 0.184, 0.538), SPP (0.060, 0.178, 0.511), and TMS (0.054, 0.167, 0.450) and the least important criteria are SRM (0.019, 0.064, 0.161), DM (0.019, 0.045, 0.164), and SCE (0.018, 0.056, 0.165). While main criteria was ranking, secondary criteria' global weights can be ranked like most important to; TMS1 (0.015, 0.090, 0.432), TMS2 (0.008, 0.050, 0.272), and SCO1 (0.011, 0.039, 0.216) and the least important secondary criteria are SCE4 (0.001, 0.003, 0.0079) and PSP6 (0.001, 0.003, 0.014). Such data can be used to understand the impact of criteria and secondary criteria in decision-making process. In addition, enable company to determine the criteria are necessary for their operational process.

According to global weights, decision makers evaluate system alternatives. Decision makers were questioned to evaluate each alternative system efficiency according to each criterion using the linguistic assessment. After this phase, we apply F-TOPSIS methodology for ranking alternative systems due to decision makers preferences and the F-AHP weights.

Given the accepted criteria structure and the related importance weights, decision makers have evaluated seven SCCEM systems. The alternatives were rated with linguistic variables for each criterion, which in turn correspond to the TFNs as illustrated in Table III.2. The linguistic rating preserves the property that the ranges of normalized TFNs belong  $[0,1]$ ; thus, there is no need for a normalization procedure.

After evaluation of alternatives a sample of one decision maker's evaluation proposal given in Table IV.12.

**Table IV.12** Linguistic Variables for the preference rating of alternatives

Table III.5 Linguistic variable	Corresponding triangular fuzzy numbers
Very poor (VP)	(0.0, 0.0, 0.2)
Poor (P)	(0.0, 0.2, 0.4)
Fair (F)	(0.3, 0.5, 0.7)
Good (G)	(0.6, 0.8, 1.0)
Very Good (VG)	(0.8, 1.0, 1.0)

**Table IV.13** Linguistic evaluation data related with alternative system 1 for decision maker # 1

	System1	System2	System3	System4	System5	System6	System7
DM1	F	P	F	P	P	P	P
DM2	VG	VG	VG	G	VG	VG	G
DM3	G	F	G	F	F	G	F
DM4	VG	G	F	F	G	VG	G
DM5	F	VG	VG	VG	VP	VP	VP
SCO1	VG	G	VG	G	F	G	VG
SCO2	G	F	G	F	VG	VG	G
SCO3	VG	VG	VG	F	P	F	F
SCO4	VG	G	VG	G	VG	VG	VG
WMS1	F	F	F	VG	VG	G	P
WMS2	G	F	VG	F	G	VG	F
WMS3	VG	VG	G	F	VG	VG	F
WMS4	G	G	VG	VG	VG	VG	VG
WMS5	VG	F	G	F	VG	VG	G
WMS6	G	P	F	F	VG	G	F
PSP1	VG	F	VG	VP	G	G	VP
PSP2	F	VG	F	P	G	G	F
PSP3	G	G	P	VG	G	P	F
PSP4	G	F	VG	F	F	VG	VG
PSP5	G	VG	G	F	P	P	G
PSP6	VG	P	G	VP	VG	F	F
SPP1	G	F	VG	VG	VP	G	P
SPP2	VG	VG	G	F	F	F	F
SPP3	F	F	F	F	G	G	VG
SPP4	VG	G	VG	VG	F	VG	G
SPP5	F	VG	F	VP	F	VP	G
TMS1	G	VP	G	F	VG	G	VG
TMS2	F	F	VG	F	G	F	VG
TMS3	P	F	G	VG	VP	P	VG
ITL1	F	F	G	F	F	VG	F
ITL2	G	VP	VG	VG	VG	G	F
ITL3	VG	VP	G	F	VP	F	VP
ITL4	G	VG	G	F	F	VG	G
ITL5	F	F	VG	VP	VG	F	F
OM1	VG	VG	P	F	G	P	VG
OM2	VG	G	VG	G	VG	G	G
OM3	G	F	VG	F	F	F	G
OM4	G	VP	F	VG	VP	VG	VP
OM5	F	F	F	P	VG	VP	VG
OM6	F	G	VG	P	VG	P	G

**Table IV.13.** Linguistic evaluation data related with alternative system 1 for decision maker # 1 (cont.)

	System1	System2	System3	System4	System5	System6	System7
SCE1	G	VG	G	VG	VP	F	F
SCE2	F	F	VP	F	G	G	VG
SCE3	VG	P	F	F	VP	VG	P
SCE4	F	P	F	P	P	F	P
SCE5	F	G	VP	VG	VP	F	F
SCE6	VG	F	F	F	VG	F	G
SCE7	F	P	VG	F	F	G	G
SCE8	G	F	G	G	G	F	F
SCE9	VG	VG	VG	VP	VG	F	P
SCE10	F	F	F	F	F	VP	G
SCE11	G	G	VG	VG	VG	VG	F
SRM1	F	VG	F	VP	VP	F	VG
SRM2	G	F	VG	G	G	VG	G
SRM3	VG	VP	F	VG	VG	G	F
SRM4	G	F	VG	F	VP	VG	P
SRM5	F	G	G	G	VG	VP	G
SRM6	VG	VG	F	F	VP	VG	G
SRM7	VG	F	VG	VG	VG	F	F
SRM8	G	F	G	G	G	F	VG
SRM9	F	G	F	F	VG	G	F

Other decision makers' linguistic evaluation data is given in Appendix B. A sample of group decision makers' alternative system 1 calculation for DM1 criterion is follows:

**Table IV.14** Linguistic evaluation for DM1 criterion and corresponding TFNs for SCEM system alternative 1

Alternative system 1	Decision maker 1	Decision maker 2	Decision maker 3	Decision maker 4
	F	G	G	G
DM1	(0.3, 0.5, 0.7)	(0.6, 0.8, 1.0)	(0.6, 0.8, 1.0)	(0.6, 0.8, 1.0)

$$\begin{aligned}
 \tilde{x}_{ij}^k &= \left(\frac{1}{4}\right) \otimes (\tilde{x}_{ij}^1 \oplus \tilde{x}_{ij}^2 \oplus \tilde{x}_{ij}^3 \oplus \tilde{x}_{ij}^4) \\
 &= \frac{1}{4} \otimes ((0.3, 0.5, 0.7) \oplus \dots \oplus (0.6, 0.8, 1.0)) \\
 &= (0.525, 0.725, 0.925)
 \end{aligned}$$

Same calculations are done for all SCEM system alternatives and given in Appendix C. A sample of fuzzy group decision evaluation is given in Table.IV.15.

**Table IV.15** Fuzzy group decision evaluation results for Alternative System 1

Alternative System1			
<i>Criteria</i>	<i>TFNs</i>	<i>Criteria</i>	<i>TFNs</i>
DM1	(0.525, 0.725, 0.925)	OM4	(0.700, 0.900, 1.000)
DM2	(0.750, 0.950, 1.000)	OM5	(0.500, 0.700, 0.850)
DM3	(0.700, 0.900, 1.000)	OM6	(0.375, 0.575, 0.775)
DM4	(0.750, 0.950, 1.000)	SCE1	(0.450, 0.650, 0.850)
DM5	(0.450, 0.650, 0.850)	SCE2	(0.300, 0.500, 0.700)
SCO1	(0.700, 0.900, 1.000)	SCE3	(0.750, 0.950, 1.000)
SCO2	(0.600, 0.800, 1.000)	SCE4	(0.500, 0.700, 0.850)
SCO3	(0.750, 0.950, 1.000)	SCE5	(0.500, 0.700, 0.850)
SCO4	(0.750, 0.950, 1.000)	SCE6	(0.700, 0.900, 1.000)
WMS1	(0.425, 0.625, 0.775)	SCE7	(0.450, 0.650, 0.850)
WMS2	(0.575, 0.775, 0.925)	SCE8	(0.600, 0.800, 1.000)
WMS3	(0.700, 0.900, 1.000)	SCE9	(0.700, 0.900, 1.000)
WMS4	(0.700, 0.900, 1.000)	SCE10	(0.450, 0.650, 0.850)
WMS5	(0.700, 0.900, 1.000)	SCE11	(0.625, 0.825, 0.925)
WMS6	(0.575, 0.775, 0.925)	SRM1	(0.300, 0.500, 0.700)
PSP1	(0.700, 0.900, 1.000)	SRM2	(0.450, 0.650, 0.850)
PSP2	(0.450, 0.650, 0.850)	SRM3	(0.750, 0.950, 1.000)
PSP3	(0.450, 0.650, 0.850)	SRM4	(0.525, 0.725, 0.925)
PSP4	(0.575, 0.775, 0.925)	SRM5	(0.450, 0.650, 0.850)
PSP5	(0.700, 0.900, 1.000)	SRM6	(0.750, 0.900, 1.000)
PSP6	(0.700, 0.900, 1.000)	SRM7	(0.800, 1.000, 1.000)
SPP1	(0.650, 0.850, 1.000)	SRM8	(0.700, 0.900, 1.000)
SPP2	(0.750, 0.950, 1.000)	SRM9	(0.450, 0.650, 0.850)
SPP3	(0.450, 0.650, 0.850)		
SPP4	(0.700, 0.900, 1.000)		
SPP5	(0.375, 0.575, 0.775)		
TMS1	(0.500, 0.700, 0.850)		
TMS2	(0.375, 0.575, 0.775)		
TMS3	(0.150, 0.350, 0.550)		
ITL1	(0.300, 0.500, 0.700)		
ITL2	(0.450, 0.650, 0.850)		
ITL3	(0.750, 0.950, 1.000)		
ITL4	(0.650, 0.850, 1.000)		
ITL5	(0.500, 0.700, 0.850)		
OM1	(0.750, 0.950, 1.000)		
OM2	(0.700, 0.950, 1.000)		
OM3	(0.700, 0.900, 1.000)		

After constructing the decision matrix, the normalized weighted fuzzy decision matrix is obtained using Equation III.25. We have to note that the normalized matrix is the same as the fuzzy decision matrix because of the scale selected for linguistic variables. Part of System 1 calculation is given in below:

$$\begin{array}{l}
 \text{System1 } (\tilde{r}_{ij}) \\
 \begin{array}{l}
 \text{DM1} \\
 \text{DM2} \\
 \text{DM3} \\
 \text{DM4} \\
 \text{DM5} \\
 \text{SCO1} \\
 \text{SCO2} \\
 \text{SCO3} \\
 \text{SCO4}
 \end{array}
 \begin{bmatrix}
 0,5250 & 0,7250 & 0,9250 \\
 0,7500 & 0,9500 & 1,0000 \\
 0,7000 & 0,9000 & 1,0000 \\
 0,7500 & 0,9500 & 1,0000 \\
 0,4500 & 0,6500 & 0,8500 \\
 0,7000 & 0,9000 & 1,0000 \\
 0,6000 & 0,8000 & 1,0000 \\
 0,7500 & 0,9500 & 1,0000 \\
 0,7500 & 0,9500 & 1,0000
 \end{bmatrix}
 \times
 \begin{array}{l}
 w_j \\
 \begin{bmatrix}
 0,004 & 0,019 & 0,118 \\
 0,003 & 0,012 & 0,082 \\
 0,001 & 0,004 & 0,026 \\
 0,001 & 0,005 & 0,033 \\
 0,001 & 0,007 & 0,051 \\
 0,011 & 0,039 & 0,216 \\
 0,004 & 0,014 & 0,080 \\
 0,004 & 0,017 & 0,105 \\
 0,002 & 0,008 & 0,055
 \end{bmatrix}
 \end{array}
 \end{array}$$

$$\tilde{v}_{ij} = \begin{array}{l}
 \text{System1 weights} \\
 \begin{bmatrix}
 0,0022 & 0,0135 & 0,1096 \\
 0,0019 & 0,0110 & 0,0821 \\
 0,0007 & 0,0036 & 0,0265 \\
 0,0008 & 0,0043 & 0,0330 \\
 0,0006 & 0,0045 & 0,0435 \\
 0,0074 & 0,0352 & 0,2156 \\
 0,0024 & 0,0115 & 0,0798 \\
 0,0030 & 0,0163 & 0,1050 \\
 0,0017 & 0,0076 & 0,0548
 \end{bmatrix}
 \end{array}$$

According to sample calculation, it is seen that the elements  $\tilde{v}_{ij}$ ,  $\forall i, j$  are normalized triangular fuzzy numbers and their ranges belong to the closed interval  $[0,1]$ . Thus, we can define the fuzzy positive ideal solution (FPIS)  $(d_i^*)$  and negative ideal solution FNIS  $(d_i^-)$  as  $\tilde{v}_j^* = w_j \times (1,1,1)$  and  $\tilde{v}_j^- = w_j \times (0,0,0)$  for each criterion. Then the distance of each alternative form  $d^*$  and  $d^-$  can be currently calculated using Eq. III.28. As the last step, SCEM system alternatives are ranked according to their relative closeness to the ideal solution. For this reason, CC of each system is determined. The results are given in Table IV.16.

**Table IV.16** The distances of alternatives to positive / negative ideal solutions, the related closeness coefficients

Alternatives	$d_i^*$	$d_i^-$	$CC$
System 1	0.7369	0.2767	0.2730
System 2	0.8016	0.2882	0.2640
System 3	0.7338	0.2758	0.2732
System 4	0.8426	0.2832	0.2520
System 5	0.7291	0.2699	0.2700
System 6	0.7278	0.2652	0.2670
System 7	0.7456	0.2684	0.2647

Based on the  $CC$  values, the ranking of the alternatives in descending order is given in Table IV.17.

**Table IV.17** Ranking of alternatives

Rank	Alternatives	$CC$
1	System 3	0.2732
2	System 1	0.2730
3	System 5	0.2700
4	System 6	0.2670
5	System 7	0.2647
6	System 2	0.2640
7	System 4	0.2520

As can be read from Table IV.17 values are close to each other but System 3 has the highest value in the entire values. System 3 is slightly ahead than System 1 only the last digit is different. System 4 has the lowest value with 0.2520 value.

#### **IV.2.1.1. Results of F-AHP and F-TOPSIS method**

From a set of seven alternatives, four decision makers make an evaluation with F-AHP approach to determine criteria weights. In the first phase, we determined the importance of weights was to be considered, and then the second phase detailed evaluation by the F-TOPSIS approach was conducted. Ranking of alternatives is the result of second phase.

The most desirable alternative corresponds to the one with the highest score; System 3 and System 1 would be declared as the preferable and considered as

possible SCEMS systems. Although, the obtained results indicate that System 3 and System 1 get the highest values, ranking values between results very close to each other. Proximity of these values affects our decision to select which system to be chosen best. There is not enough difference between alternative Systems 3 and 1 to declare our selected system.

#### **IV.2.2. Application of F-ANP Model**

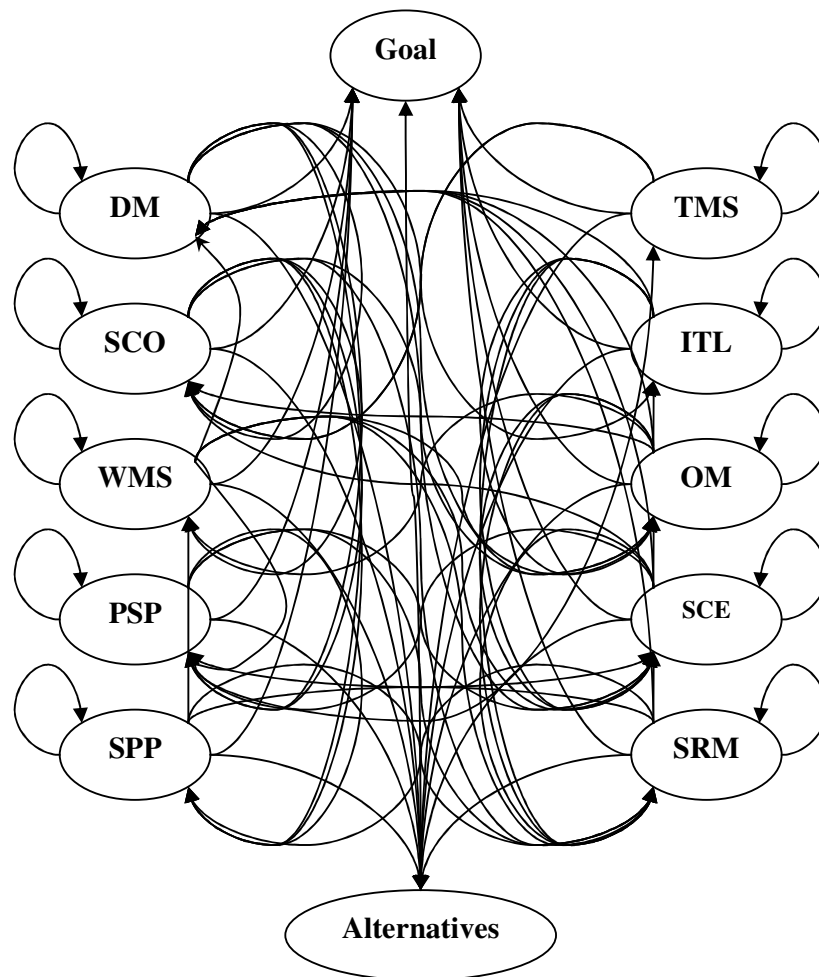
In this model our goal, criteria, secondary criteria and alternatives are same as F-AHP and F-TOPSIS model. The only differences is we take account only the secondary criteria to get a conclusion about applying only secondary criteria weights would be used to define alternative system evaluation. Therefore, secondary criteria inner dependencies are get more critical role to evaluate systems significantly. Decision makers were issued the preliminary questionnaire in which sixty evaluation criteria were incorporated. Based on obtained criteria a consensus among decision makers can be reached to establish a hierarchical structure. Decision makers got a consensus about relationship between each criterion, which has an effect on each other. Figure IV.2 presents a general relationship among goal, criteria and alternatives. However, secondary criteria inner dependence built up our main model to demonstrate importance of relationship secondary criteria in evaluation process. Based on the decision makers interview, acquiring the inner dependence among the secondary criteria is analyzed next. The schematic representation of the relationship among secondary criteria is presented in Figure IV.3

The generic question to be answered by making pair wise comparisons is: Given a control criterion (secondary-criterion), a component of the network, and given a pair of components, how much more does a given member of the pair influence that component with respect to the control criterion (secondary-criterion) than the other member ? Pairwise comparison calculations are as same as F-AHP methodology.

Then, the F-ANP model was formed by goal, secondary criteria, and alternatives. Decision makers assume that all secondary criteria have same importance weight to affect goal. So we compute goal weight for each criterion 0.0167 by dividing 1/60 criteria. Then the unweighted supermatrix is composed of pairwise comparisons by decision makers. Dependence among the criteria is

determined by analyzing the impact of each criterion on every other criterion using pairwise comparisons. An example of pairwise computation is presented in the next pages.

The resulting relative importance weights of these matrices were calculated. The relative importance weights of the inner dependence among detailed criteria are represented in Table IV.19. These weights are listed in Table IV.19 separately for each criterion. “0” values presented in Table IV.19 mean that there is no dependence between two criteria and the numerical values show the degree of relative impact between two criteria. Then we compose weighted supermatrix normalizing each column sum to 1 that is given in Table IV.20. The completely unweighted supermatrix table and weighted supermatrix table are given in Appendix D and E.



**Figure IV.2** General relationship among main criteria



The interdependencies among secondary criteria which are in this stage are taken into account and by this way the effects of the secondary criteria on each other are analyzed.

We only present criterion weight calculations for F-ANP pairwise comparison that is DM1 criterion. Paired comparison values, which were completed with linguistic judgments of decision makers, have been transformed into a consensus value with taking their geometric average.

**Table IV.18** Decision makers linguistic evaluation for criterion DM1

Decision maker #1					Decision maker #2				
<i>DM1</i>	DM2	DM3	DM4	DM5	<i>DM1</i>	DM2	DM3	DM4	DM5
DM2	-	Es	Es	Wk	DM2	-	Wk	Es	LWk
DM3		-	Eq	LWk	DM3		-	Es	LWk
DM4			-	LWk	DM4			-	LAB
DM5				-	DM5				-
Decision maker #3					Decision maker #4				
<i>DM1</i>	DM2	DM3	DM4	DM5	<i>DM1</i>	DM2	DM3	DM4	DM5
DM2	-	Eq	Les	LEs	DM2	-	LEs	Es	LWk
DM3		-	Es	Es	DM3		-	Eq	LEs
DM4			-	LEs	DM4			-	LWk
DM5				-	DM5				-

The consensus of decision makers unweighted TFN for DM1 is computed; DM2 (0.771, 1.184, 1.731), DM3 (0.758, 1.142, 1.626), DM3 (0.343, 0.500, 0.676), DM4 (1.088, 1.479, 2.483) is defined. To convert these TFNs to crisp value we use COA defuzzification method, which is detailed in methodology chapter. As a result we calculate weights (1.2284, 1.1752, 0.5060, 1.6838) for DM2, DM3, DM4, and DM5 respectively. To insert weights to unweighted supermatrix we normalized those weights for DM1 criterion which  $(0.2675, 0.2559, 0.1102, 0.3665)^T$  their sum is equal to 1. This weights can be seen in the unweighted supermatrix in Table IV.19. The other pairwise computations are done for all secondary criteria and input to matrix.

**Table IV.19 Unweighted Supermatrix**

	Goal	DM1	DM2	DM3	DM4	DM5	SCO1	SCO2	SCO3	SCO4	WMS1	WMS2	WMS3
Goal	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DM1	0.0167	0.0000	0.5277	0.4492	0.4492	0.4216	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DM2	0.0167	0.2675	0.0000	0.2838	0.2838	0.3227	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DM3	0.0167	0.2559	0.1251	0.0000	0.0997	0.1416	0.0000	0.0000	0.0000	0.0000	1.0000	1.0000	0.0000
DM4	0.0167	0.1102	0.1251	0.0997	0.0000	0.1141	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DM5	0.0167	0.3665	0.2222	0.1673	0.1673	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCO1	0.0167	0.0000	0.0000	0.0000	0.5000	0.0000	0.0000	0.2841	0.2727	0.7135	0.0000	0.0000	0.0000
SCO2	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.4361	0.0000	0.6070	0.1433	0.0000	0.0000	0.0000
SCO3	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.3792	0.5757	0.0000	0.1433	0.0000	0.0000	0.0000
SCO4	0.0167	0.0000	0.0000	0.0000	0.5000	0.0000	0.1848	0.1402	0.1204	0.0000	1.0000	1.0000	1.0000
WMS1	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2183	0.0000	0.1839	0.1347
WMS2	0.0167	0.0000	0.0000	0.0000	1.0000	0.0000	1.0000	0.0000	0.0000	0.3622	0.1394	0.0000	0.0912
WMS3	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1295	0.2180	0.1339	0.0000
WMS4	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0905	0.2798	0.1656	0.4133
WMS5	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1186	0.1448	0.3735	0.2397
WMS6	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0809	0.2180	0.1431	0.1212
PSP1	0.0167	0.0000	1.0000	0.1382	0.2035	0.0000	0.2719	0.0000	0.0000	0.0000	0.4017	0.2406	0.0000
PSP2	0.0167	0.0000	0.0000	0.2346	0.0000	0.0000	0.4048	0.0000	0.0000	0.0000	0.0000	0.1234	0.0000
PSP3	0.0167	0.0000	0.0000	0.0000	0.7965	0.0000	0.3233	0.0000	0.0000	0.0000	0.0000	0.1348	0.0000
PSP4	0.0167	0.0000	0.0000	0.3984	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2705	0.2612	0.0000
PSP5	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PSP6	0.0167	0.0000	0.0000	0.2288	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3279	0.2401	0.0000
SPP1	0.0167	0.0000	0.0000	0.0757	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SPP2	0.0167	0.0000	0.0000	0.2088	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SPP3	0.0167	0.0000	0.0000	0.2938	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SPP4	0.0167	0.0000	0.0000	0.4218	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SPP5	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TMS1	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TMS2	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TMS3	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ITL1	0.0167	0.0677	0.0000	0.0000	0.5000	0.0000	0.7965	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ITL2	0.0167	0.1285	0.0000	0.0000	0.5000	0.0000	0.2035	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ITL3	0.0167	0.3327	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ITL4	0.0167	0.1232	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000
ITL5	0.0167	0.3480	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
OM1	0.0167	0.3560	0.1686	0.5039	0.3560	0.0000	0.5757	0.0000	0.0000	0.0000	0.7427	0.2630	0.0000
OM2	0.0167	0.6441	0.0000	0.1971	0.6441	0.0000	0.2841	0.0000	0.0000	1.0000	0.2573	0.6296	0.0000
OM3	0.0167	0.0000	0.8314	0.0000	0.0000	0.0000	0.1402	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
OM4	0.0167	0.0000	0.0000	0.1161	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1074	0.0000
OM5	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
OM6	0.0167	0.0000	0.0000	0.1829	0.0000	0.0000	0.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000
SCEM1	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.4277
SCEM2	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2973
SCEM3	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.4696	0.1434
SCEM4	0.0167	0.0000	0.5000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM5	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM6	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.7427	0.0000	0.2964	0.0000
SCEM7	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2573	0.0000	0.0000	0.1317
SCEM8	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM9	0.0167	0.0000	0.5000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1219	0.0000
SCEM10	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	1.0000	0.0000	0.0000	0.1122	0.0000
SCEM11	0.0167	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM1	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.5000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM2	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM3	0.0167	0.0000	0.0000	1.0000	0.0000	0.0000	0.5000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM4	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6441	0.0000
SRM5	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM6	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3560	0.0000
SRM7	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM8	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM9	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
S1	0.0000	0.2005	0.1641	0.1881	0.1731	0.1726	0.1659	0.1536	0.2077	0.1550	0.1332	0.1583	0.1635
S2	0.0000	0.1175	0.1520	0.1248	0.1538	0.2013	0.1388	0.1104	0.2000	0.1248	0.1259	0.1043	0.1635
S3	0.0000	0.2005	0.1702	0.1718	0.1394	0.2389	0.1722	0.1392	0.1827	0.1607	0.1588	0.1809	0.1572
S4	0.0000	0.1382	0.0912	0.1085	0.0962	0.2013	0.1451	0.1248	0.1154	0.1435	0.1898	0.1357	0.1226
S5	0.0000	0.1590	0.1520	0.1248	0.1106	0.0465	0.0813	0.1664	0.0635	0.1306	0.1898	0.1670	0.1698
S6	0.0000	0.0668	0.1383	0.1573	0.1667	0.0553	0.1308	0.1664	0.1154	0.1306	0.1588	0.1809	0.1572
S7	0.0000	0.1175	0.1322	0.1248	0.1603	0.0841	0.1659	0.1392	0.1154	0.1550	0.0438	0.0730	0.0660

**Table IV.20** The weighted supermatrix

	Goal	DM1	DM2	DM3	DM4	DM5	SCO1	SCO2	SCO3	SCO4	WMS1	WMS2	WMS3
Goal	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DM1	0.0167	0.0000	0.1055	0.0642	0.0642	0.2108	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DM2	0.0167	0.0669	0.0000	0.0405	0.0405	0.1614	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DM3	0.0167	0.0640	0.0250	0.0000	0.0142	0.0708	0.0000	0.0000	0.0000	0.0000	0.1429	0.1250	0.0000
DM4	0.0167	0.0275	0.0250	0.0142	0.0000	0.0571	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DM5	0.0167	0.0916	0.0444	0.0239	0.0239	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCO1	0.0167	0.0000	0.0000	0.0000	0.0714	0.0000	0.0000	0.0568	0.0545	0.1427	0.0000	0.0000	0.0000
SCO2	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0545	0.0000	0.1214	0.0287	0.0000	0.0000	0.0000
SCO3	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0474	0.1151	0.0000	0.0287	0.0000	0.0000	0.0000
SCO4	0.0167	0.0000	0.0000	0.0000	0.0714	0.0000	0.0231	0.0280	0.0241	0.0000	0.1429	0.1250	0.2500
WMS1	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0437	0.0000	0.0230	0.0337
WMS2	0.0167	0.0000	0.0000	0.0000	0.1429	0.0000	0.1250	0.0000	0.0000	0.0724	0.0199	0.0000	0.0228
WMS3	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0259	0.0311	0.0167	0.0000
WMS4	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0181	0.0400	0.0207	0.1033
WMS5	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0237	0.0207	0.0467	0.0599
WMS6	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0162	0.0311	0.0179	0.0303
PSP1	0.0167	0.0000	0.2000	0.0197	0.0291	0.0000	0.0340	0.0000	0.0000	0.0000	0.0574	0.0301	0.0000
PSP2	0.0167	0.0000	0.0000	0.0335	0.0000	0.0000	0.0506	0.0000	0.0000	0.0000	0.0000	0.0154	0.0000
PSP3	0.0167	0.0000	0.0000	0.0000	0.1138	0.0000	0.0404	0.0000	0.0000	0.0000	0.0000	0.0168	0.0000
PSP4	0.0167	0.0000	0.0000	0.0569	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0386	0.0326	0.0000
PSP5	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PSP6	0.0167	0.0000	0.0000	0.0327	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0468	0.0300	0.0000
SPP1	0.0167	0.0000	0.0000	0.0108	0.0000	0.0000	0.1250	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SPP2	0.0167	0.0000	0.0000	0.0298	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SPP3	0.0167	0.0000	0.0000	0.0420	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SPP4	0.0167	0.0000	0.0000	0.0603	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SPP5	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TMS1	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TMS2	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TMS3	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ITL1	0.0167	0.0169	0.0000	0.0000	0.0714	0.0000	0.0996	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ITL2	0.0167	0.0321	0.0000	0.0000	0.0714	0.0000	0.0254	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ITL3	0.0167	0.0832	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ITL4	0.0167	0.0308	0.0000	0.0000	0.0000	0.0000	0.0000	0.2000	0.2000	0.0000	0.0000	0.0000	0.0000
ITL5	0.0167	0.0870	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
OM1	0.0167	0.0890	0.0337	0.0720	0.0509	0.0000	0.0720	0.0000	0.0000	0.0000	0.1061	0.0329	0.0000
OM2	0.0167	0.1610	0.0000	0.0282	0.0920	0.0000	0.0355	0.0000	0.0000	0.2000	0.0368	0.0787	0.0000
OM3	0.0167	0.0000	0.1663	0.0000	0.0000	0.0000	0.0175	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
OM4	0.0167	0.0000	0.0000	0.0166	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0134	0.0000
OM5	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
OM6	0.0167	0.0000	0.0000	0.0261	0.0000	0.0000	0.0000	0.2000	0.2000	0.0000	0.0000	0.0000	0.0000
SCEM1	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1069
SCEM2	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0743
SCEM3	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1429	0.0587	0.0358
SCEM4	0.0167	0.0000	0.1000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM5	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM6	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1485	0.0000	0.0370	0.0000
SCEM7	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0515	0.0000	0.0000	0.0329
SCEM8	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM9	0.0167	0.0000	0.1000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0152	0.0000
SCEM10	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2000	0.2000	0.0000	0.0000	0.0140	0.0000
SCEM11	0.0167	0.0000	0.0000	0.1429	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM1	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0625	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM2	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM3	0.0167	0.0000	0.0000	0.1429	0.0000	0.0000	0.0625	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM4	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0805	0.0000
SRM5	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM6	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0445	0.0000
SRM7	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM8	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM9	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
S1	0.0000	0.0501	0.0328	0.0269	0.0247	0.0863	0.0207	0.0307	0.0415	0.0310	0.0190	0.0198	0.0409
S2	0.0000	0.0294	0.0304	0.0178	0.0220	0.1007	0.0173	0.0221	0.0400	0.0250	0.0180	0.0130	0.0409
S3	0.0000	0.0501	0.0340	0.0245	0.0199	0.1195	0.0215	0.0278	0.0365	0.0321	0.0227	0.0226	0.0393
S4	0.0000	0.0346	0.0182	0.0155	0.0137	0.1007	0.0181	0.0250	0.0231	0.0287	0.0271	0.0170	0.0307
S5	0.0000	0.0397	0.0304	0.0178	0.0158	0.0232	0.0102	0.0333	0.0127	0.0261	0.0271	0.0209	0.0425
S6	0.0000	0.0167	0.0277	0.0225	0.0238	0.0277	0.0163	0.0333	0.0231	0.0261	0.0227	0.0226	0.0393
S7	0.0000	0.0294	0.0264	0.0178	0.0229	0.0420	0.0207	0.0278	0.0231	0.0310	0.0063	0.0091	0.0165

**Table IV.21** The limit supermatrix

	Goal	DM1	DM2	DM3	DM4	DM5	...	SRM6	SRM7	SRM8	SRM9	S1	S2	S3	S4	S5	S6	S7
Goal	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	...	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DM1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	...	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DM2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	...	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DM3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	...	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DM4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	...	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DM5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	...	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
SRM1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	...	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	...	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	...	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	...	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	...	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	...	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	...	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	...	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	...	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
S1	<b>0.1707</b>	0.1854	0.1803	0.1787	0.1742	0.1771	...	0.1820	0.1810	0.1723	0.1642	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
S2	<b>0.1333</b>	0.1251	0.1383	0.1340	0.1317	0.1664	...	0.1411	0.1296	0.1458	0.1411	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
S3	<b>0.1751</b>	0.1873	0.1828	0.1734	0.1709	0.2105	...	0.1691	0.1812	0.1675	0.1623	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000
S4	<b>0.1242</b>	0.1322	0.1102	0.1227	0.1245	0.1621	...	0.1227	0.1269	0.1173	0.1223	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000
S5	<b>0.1325</b>	0.1354	0.1388	0.1343	0.1319	0.0912	...	0.1281	0.1330	0.1268	0.1330	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000
S6	<b>0.1337</b>	0.1156	0.1346	0.1345	0.1398	0.0913	...	0.1406	0.1298	0.1231	0.1426	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
S7	<b>0.1285</b>	0.1190	0.1147	0.1223	0.1269	0.1015	...	0.1163	0.1184	0.1471	0.1344	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000

A weighted supermatrix is transformed first to be stochastic as shown in Table IV.20. After entering the normalized values into the supermatrix and completing the column stochastic, the supermatrix is then raised to sufficiently large power until convergence occurs. The current super-matrix reached convergence and attained eigenvector. Table IV.21 provides the final limit supermatrix. This limit supermatrix is represents the final eigenvector.

In our F-ANP model, we did not consider main criteria weight to demonstrate power of secondary criteria pairwise comparison. In addition, we consider each secondary criterion weight equally to demonstrate inner dependence of criterion importance. From this process, we get the F-ANP results from the goal column that is given in the Table IV.21.

#### **IV.2.2.1. Results of F-ANP**

The data below shows us which alternative is the best one in Table IV.22. The goal column presents us priority values of each alternative SCEM system in Table IV.21. The limit supermatrix results determine the third alternative system has the high priority with 0.1751 values then system 1 comes with a 0.1707 value. That means alternative system 3 could be selected as a best alternatives. The ranking of the alternatives are given in Table IV.22.

**Table IV.22** Ranking of alternatives

Alternatives	Weights	Ranking
System 3	0.1751	1
System 1	0.1707	2
System 6	0.1337	3
System 2	0.1333	4
System 5	0.1325	5
System 7	0.1285	6
System 4	0.1242	7

From the calculated weights, decision makers could decide system 3 as a best alternative system. As it seen in Table IV.22 System 3 and System 1 has 0.0044 value differences and enables to select System 3 obviously.

### IV.3. COMPARISON OF F-AHP\_F-TOPSIS AND F-ANP RESULTS

While F-AHP and F-TOPSIS model considering hierarchical structure, F-ANP model considers inner dependences among secondary criteria. Both MADM model come out with a similar results. According to results, we could verify that both models give us same result. System 3 is the best alternative, System 1 is the second choice and System 4 is the worst choice to be chosen.

**Table IV.23** Comparison of models

F-AHP and F-TOPSIS model		F-ANP model	
Ranking	Alternatives	Ranking	Alternatives
1	System 3	1	System 3
2	System 1	2	System 1
3	System 5	3	System 6
4	System 6	4	System 2
5	System 7	5	System 5
6	System 2	6	System 7
7	System 4	7	System 4

Table IV.17 and IV.22 show the results obtained with each model of the study. There are noticeable differences between both decision analysis models. The F-AHP\_F-TOPSIS model provides similar results for alternative System 3 and System 1, all two with a priority value 0.273. By constant, although in the network-based model these two alternatives are also the best options, there differences in their priority values, alternative system 3 being the best rated option with a high priority value. If we look at the Table IV.23, we can observe that the order of the alternatives ranked in the last positions is also same in both models System 4 appearing in the last position.

As can be observed in the Table IV.17 and IV.22, the priority values of the alternatives in both models are different. This is because the information is handled differently in each model. In the F-AHP\_F-TOPSIS model, the weights obtained reflect the inherent importance that the decision makers give to each criterion. In the hierarchy model, the priorities are independent of the analyzed SCEM systems and the influences among criteria are not taken into consideration.

Applying F-AHP\_F-TOPSIS and F-ANP with the same input, as in our SCEM system evaluation example, resulted in different rankings for four of seven alternative systems. However, the absolute differences in alternatives among the ranks are small, ranging from 0.0002 between ranks 1 and 2 in F-AHP\_F-TOPSIS (Table IV.17) to as much as 0.0044 between ranks 1 and 2 in F-ANP (Table IV.22). Then we can ask if rankings in multi criteria decision making analyze are important, when differences in cumulative priorities among alternatives are at the size of a few 0.0002 s. It is difficult to judge if a decision maker needs to be concerned about which alternative to choose, due to the differences in cumulative priorities or due to different ranks when using different approaches. If there is a need to find inherently robust alternatives, it might be useful to apply more sophisticated methods such as F-ANP, or to compare results of different approaches. We may also have to accept that each method shapes the preferences of the decision makers in a particular way. The process of evaluation and decision-making might in some cases is more important than the ranking results.

However, the results of the F-ANP model show the complexity of the problem. In the network model, the priorities are affected by the influences among criteria. The fact that some criteria influence upon others, but even more important, the fact that we are analyzing certain specific SCEM system alternatives makes some secondary criteria, which seem very important in the hierarchy. The entries of the weighted supermatrix itself give the direct influence of any criterion on any other. Nevertheless, a criterion can influence a second criterion indirectly through its influence on some third criterion and then by the influence of that criterion on the second. There can be many hidden influences through indirect relationships. The F-ANP model takes into consideration all the influences perceived by the decision makers, whereas F-AHP\_F-TOPSIS does not consider influences among criteria. The F-ANP model is more complex than the F-AHP\_F-TOPSIS model and this fact is the main weakness as well as the main strength of the F-ANP method: Weakness in the sense of the complexity of the model, and strength in the sense of the reflections, experience and better understanding by the decision makers on the case study.

In the first model The F-AHP, method is proposed to determine the SCEM system evaluation criteria weights and the F-TOPSIS method for to rank alternative systems. In the second model, we consider the inner dependence of secondary

criteria to come out with similar evaluation results, which states the model verifies same outcomes with the first model. That enables proposed F-ANP model could be used as decision-making model. For all that, the differences in the ranking alternative systems occur from the nature of analytic processes. It is not expected to get a certain results from those two different decision model approaches. The results are gained admission for our decision makers considering company goals.

Moreover, we would able to get certain results from F-ANP model to evaluate alternative SCCEM systems. Due to certain values and subjectively distant values from each system, enables us to decide on alternative system without giving any suspicious. In that way, we propose a decision making model for the evaluation SCCEM systems. We suggest to use F-ANP model due to it is certain results and taking consider the inner dependences between secondary criteria. That means considering inner dependences among secondary criteria have an important affect on evaluation such systems.

#### **IV.4. VALIDATION of the MODELS**

The importance of testing the validity of models that are developed in operation research studies is a well-known fact. However, it can be seen that the validity of the theoretical base (Saaty, 1996). Of the suggested F-ANP model has been neglected and specific criteria for testing it have not been developed. This shortcoming can be seen in any study that applies the F-ANP technique (Lee and Kim, 2001; Meade and Sarkis, 1998; Niemira and Saaty, 2004, Yurdakul, 2003). Similar to other works, the presented study has also faced some limitations and difficulties with testing the validity of the suggested model.

The first of these difficulties stems from the fact that the factors in the F-ANP model are not quantitative by nature. As mentioned above F-ANP is a technique that is used in solving multiple-criteria decision-making problems where there is dependency between factors that are both qualitative and quantitative in nature. Moreover, problems that are modeled by the ANP pairwise comparison matrices used to determine the priority values for the factors are determined by the judgment of decision makers. However, it is not always possible to objectively assign numerical measurements to the elements in a decision-making problem, nor is it possible to come up with the same results each time. This is because the data used in

pairwise comparison matrices may change depending on the subjective views of the decision makers. Thus, it is impossible to arrive at the same results using data obtained from different case studies. However, this limitation is embedded in the very nature of decision-making problems. Likewise, it is a well-known fact that different preferences are made under different conditions. Consequently, the fact that the values of the pairwise comparative factors change depending on the views of decision makers should not be a reason for rejecting the validity of studies using the suggested models.

Another problem that is encountered when testing the validity of the model is that the model has not been analyzed using past data, due to the unavailability of past data for the particular management case under study. This problem, however, should not be viewed as a significant shortcoming when evaluating the validity of the model. The comparison matrices that are the inputs to the suggested model are defined under known conditions. Thus, it is possible to achieve different results since different pairwise comparison matrices may be obtained at different points in time.

In consideration of the problems mentioned above, the validity of the proposed model in this study was debated and evaluated in two ways. First, the results from the F-AHP and F-TOPSIS model were compared with F-ANP model. The results obtained using the both models are presented in Table IV.23, and demonstrate the best-choice system for the case evaluation SCEM systems. Similar results are obtained when the F-ANP and F-AHP\_F-TOPSIS methods are implemented, despite them using the different pairwise comparison matrices. However, such a small difference is expected because F-AHP does not take into account dependencies among factors while F-ANP does. For this reason, the F-ANP method is also able to model real world situations as compared to the F-AHP\_F-TOPSIS method. Both models allow yielding results that are more realistic. Not only has the suggested model enabled us to satisfy the objective of our study but it has also demonstrated the functionality of the model.

Another criterion for model validity in this study was the views of management strategists. This criterion was used in the techniques in this study. The management strategists of the company on which the case study was conducted have said that they have found the results obtained from the suggested model to be meaningful and useful and satisfy company expectations.

In addition, suggested alternative system has the highest market share in SCEM market. The study results correspond to market share of alternative system. That is not detailed in the study because of respect of other alternative systems. Due to company principle, decision makers decided not to declare system names but they remarked that the alternative system is the leader on the supply chain software market. That additional knowledge could be count as a validation for our suggested model.

# CHAPTER V

## CONCLUSION

### V.1. CONCLUDING REMARKS

The main contribution of the study is to create decision-making model, propose selection methodologies, and apply them for supply chain execution and management (SCEM) system evaluation. Supply chain management is one of the most important activities covering crucial decisions for the survival of a company and SCEM system evaluation and selection has to be realized in a careful manner in order to provide the expected benefits. The demand for decision support tools that could help decision makers in selecting the most appropriate SCEM systems has consequently increased. It is clear that the selection among SCEM systems is a difficult and sensitive issue which has quantitative and qualitative aspects, complexity, and imprecision. The managers and executors may spend most of their time to take critical decisions in each level of the organization. For this reason, the study proposed a decision making model for the evaluation SCEM systems.

The criteria of SCEM system requirements have been derived with a survey of the existing literature, investigation existing SCEM systems, and by consulting industrial experts. A comprehensive SCEM module analysis is done and the criteria for the determination of the company were conducted. Combining many detailed criteria in an evaluation study and synthesizing them to obtain a decision-making methodological framework for evaluating SCEM systems is another main contribution of this study.

A decision making group from different management levels with the intention of providing a more accurate and mutually acceptable solution have been participated in the study. The decision makers are not asked to give accurate values for the evaluations. Contrarily, both the criteria evaluations and the alternative evaluations are started with the linguistic preferences. The importance weights of criteria and the ratings of alternatives are assessed in linguistic terms by triangular fuzzy numbers.

The ambiguities involved in the assessment data could be effectively represented and processed to assure a more convincing and effective evaluation process. This situation increases the usefulness and easiness of the methodologies. The models developed in this study are based on multiple attribute decision making techniques such as AHP, TOPSIS, ANP that accommodate inclusion of techniques that extend their applicability in meaningful ways such as adding fuzzy set theory to allow decision makers to improve establishing a standardized means of selecting SCEM system.

This study applied two fuzzy multi attribute decision making frameworks to solve SCEM system evaluation problem under fuzzy environment effectively F-AHP and F-TOPSIS integrated model and F-ANP model, respectively. As compared to the F-AHP\_F-TOPSIS, the analysis using the F-ANP is relatively cumbersome, because a great deal of pairwise comparison matrices should be constructed for a typical study. In our study, we built great deal of pairwise matrices. Acquiring the relationships among determinants, dimensions and attribute-enablers required very long and exhaustive effort. On the other hand, advantage of the F-ANP method is to capture interdependencies across and along the decision hierarchies. It means that the F-ANP provides more reliable solution than the F-AHP\_F-TOPSIS. The full support of management in the F-ANP will help to use their long experience and thus eliminate the biases in the weights for conceptual design alternatives. Although the F-AHP\_F-TOPSIS is easier to apply than the F-ANP, in this study, we selected the F-ANP, both due to the fact that its holistic view and interdependencies accounted in the F-ANP, and due to the fact that it generates more reliable solution than the F-AHP\_F-TOPSIS. F-AHP method is utilized to determine the weights of the main and secondary criteria of the performance evaluation hierarchy. In the second part of the methodology, the F-TOPSIS method is used for ranking of alternative systems. F-AHP is an easy and efficient method in utilizing both qualitative and quantitative data and it was successfully applied to the SCEM system evaluation. The developed two-phase multi-attribute decision-making approach seems to be usable for the solution of this problem. The F-ANP model covers and gives the best solution to the vagueness of the pairwise comparison process considerably. The F-ANP model encompasses and solves the ambiguity and imprecision of the pairwise comparison process substantially. Using this fuzzified structure also gives flexibility to the

decision makers and represents probable changes in the nature of the comparisons. Our proposed method can handle the effects of dependences; it is relatively useful and makes the evaluation result to be more certain. We have proposed an effective method based on the F-ANP. As a conclusion, F-ANP model is preferred due to consideration inner dependences between secondary criteria that we should not be ignored effectiveness of the criteria to each other. Making wrong decision in selecting the best system can put a company into undesired risk in terms of losing market share, cost and time.

Although the methods presented in this study are applied to the SCEM system evaluation problem, it can also be used to help decision makers to identify acceptable compromises in many SCEM system evaluation problems. Each model could be used as a decision making model for the evaluation SCEM systems.

We found no literature on methodologies for SCEM system considering supply chain modules; hence, there are no benchmark studies with, which we can compare our results. The structured methodologies outlined in this study provide a significant contribution to supply chain management because they are first published results that address this problem.

The analytic models illustrated in this study have a few limitations as well. For example, the outcome of the model is dependent on the inputs provided by the decision-makers. The possibility of bias of the decision-maker towards any particular alternative should not be ruled out while applying this model.

## **V.2. RECOMENDATIONS**

For further researches, different fuzzy analytic approaches and fuzzy optimization models may be utilized to compare with the results obtained in this study. We have employed different ranking, selection and multi-criteria decision-making techniques in our study, which we consider the most appropriate. The influence of other methods such as analytic neural networks, non-fuzzy analytic processes on the final quality and accuracy of decisions has to be evaluated. Similar approaches have to be provided to increase the efficiency of other critical decisions in SCEM system evaluation process.

All the fuzzy classes and decision maker judgments must be modified for any new case. The values of variables fit for one problem are not necessarily best values for another.

The evaluation process would be considered and compared by software developer experts or advisor' of consultant companies. Advisor already contains detailed information about the solutions you are comparing. Vendor information is based on the same feature or function models that you use to define your requirements, you can be sure that you and the vendors are speaking the same language. That might be useful for company to see the differences between their choice and the consultant'. It also enables sensitivity analysis that to show you how the ranking of your short-listed solutions changes as different features and functions are deemed more or less important.

Furthermore, a knowledge-based or an expert system can be integrated to help the decision-makers both make fuzzy pair wise calculations more concisely, and interpret the results in each step of the F-ANP.

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**APPENDIX A. F-AHP Linguistic pairwise comparison**

D1	DM1	DM2	DM3	DM4	DM5
DM1	-	Wk	Es	Es	Es
DM2		-	Wk	Es	Wk
DM3			-	Eq	LWk
DM4				-	Lwk
DM5					-

D2	DM1	DM2	DM3	DM4	DM5
DM1	-	Es	Es	Wk	Wk
DM2		-	Es	Wk	Wk
DM3			-	Wk	Eq
DM4				-	Eq
DM5					-

D3	DM1	DM2	DM3	DM4	DM5
DM1	-	Wk	Wk	Wk	Wk
DM2		-	Wk	Eq	Eq
DM3			-	Eq	Wk
DM4				-	Eq
DM5					-

D4	DM1	DM2	DM3	DM4	DM5
DM1	-	Eq	Eq	Es	Es
DM2		-	Wk	Wk	Eq
DM3			-	Eq	LEs
DM4				-	LWk
DM5					-

D1	SCO1	SCO2	SCO3	SCO4
SCO1	-	Wk	Wk	Es
SCO2		-	Eq	Wk
SCO3			-	Wk
SCO4				-

D2	SCO1	SCO2	SCO3	SCO4
SCO1	-	Wk	Wk	Wk
SCO2		-	Eq	Eq
SCO3			-	Eq
SCO4				-

D3	SCO1	SCO2	SCO3	SCO4
SCO1	-	Eq	Es	Wk
SCO2		-	Wk	Eq
SCO3			-	Eq
SCO4				-

D4	SCO1	SCO2	SCO3	SCO4
SCO1	-	Eq	Eq	Wk
SCO2		-	Eq	Wk
SCO3			-	Wk
SCO4				-

D1	WMS1	WMS2	WMS3	WMS4	WMS5	WMS6
WMS1	-	Eq	Wk	Wk	Wk	LWk
WMS2		-	Wk	Wk	Wk	LWk
WMS3			-	Eq	Eq	LEs
WMS4				-	Eq	LEs
WMS5					-	LEs
WMS6						-

D2	WMS1	WMS2	WMS3	WMS4	WMS5	WMS6
WMS1	-	Wk	Wk	Wk	Eq	LWk
WMS2		-	Eq	Eq	Wk	LEs
WMS3			-	Eq	Wk	LWk
WMS4				-	Wk	LWk
WMS5					-	LWk
WMS6						-

D3	WMS1	WMS2	WMS3	WMS4	WMS5	WMS6
WMS1	-	Eq	Eq	Wk	Es	Eq
WMS2		-	Wk	LWk	Eq	Eq
WMS3			-		Eq	Eq
WMS4				-	Eq	LWk
WMS5					-	Eq
WMS6						-

D4	WMS1	WMS2	WMS3	WMS4	WMS5	WMS6
WMS1	-	Eq	Wk	Eq	Eq	LEs
WMS2		-	Wk	Eq	Wk	LEs
WMS3			-	Eq	Eq	LWk
WMS4				-	Wk	LWk
WMS5					-	LEs
WMS6						-

D1	PSP1	PSP2	PSP3	PSP4	PSP5	PSP6
PSP1	-	Eq	Wk	Es	Es	Es
PSP2		-	Wk	Es	Es	Es
PSP3			-	Es	Es	Es
PSP4				-	Eq	Wk
PSP5					-	Wk
PSP6						-

D2	PSP1	PSP2	PSP3	PSP4	PSP5	PSP6
PSP1	-	Wk	Es	Wk	Es	Vs
PSP2		-	Es	Es	Wk	Ab
PSP3			-	Es	Wk	Wk
PSP4				-	Eq	Es
PSP5					-	Es
PSP6						-

D3	PSP1	PSP2	PSP3	PSP4	PSP5	PSP6
PSP1	-	Eq	Wk	Es	Wk	Es
PSP2		-	Wk	Wk	Eq	Vs
PSP3			-	Wk	Eq	Eq
PSP4				-	Wk	Eq
PSP5					-	Wk
PSP6						-

D4	PSP1	PSP2	PSP3	PSP4	PSP5	PSP6
PSP1	-	Wk	Eq	Wk	Wk	Wk
PSP2		-	Es	Eq	Eq	Wk
PSP3			-	Wk	Wk	Wk
PSP4				-	Eq	Eq
PSP5					-	Eq
PSP6						-

D1	SPP1	SPP2	SPP3	SPP4	SPP5
SPP1	-	LWk	Eq	LWk	LWk
SPP2		-	Wk	Eq	Eq
SPP3			-	LWk	LWk
SPP4				-	Eq
SPP5					-

D2	SPP1	SPP2	SPP3	SPP4	SPP5
SPP1	-	LWk	LWk	LWk	LWk
SPP2		-	Eq	Eq	Eq
SPP3			-	LWk	LWk
SPP4				-	Wk
SPP5					-

D3	SPP1	SPP2	SPP3	SPP4	SPP5
SPP1	-	Eq	Eq	Lwk	Lwk
SPP2		-	Wk	Lwk	Eq
SPP3			-	Eq	Eq
SPP4				-	Eq
SPP5					-

D4	SPP1	SPP2	SPP3	SPP4	SPP5
SPP1	-	Wk	LWk	Eq	Eq
SPP2		-	Wk	Eq	Lwk
SPP3			-	Wk	Eq
SPP4				-	LWk
SPP5					-

D1	TMS1	TMS2	TMS3
TMS1	-	Wk	Es
TMS2		-	Wk
TMS3			-

D2	TMS1	TMS2	TMS3
TMS1	-	Wk	Wk
TMS2		-	Wk
TMS3			-

D3	TMS1	TMS2	TMS3
TMS1	-	Wk	Es
TMS2		-	Es
TMS3			-

D4	TMS1	TMS2	TMS3
TMS1	-	Eq	Eq
TMS2		-	Eq
TMS3			-

D1	ITL1	ITL2	ITL3	ITL4	ITL5
ITL1	-	Wk	Wk	Eq	Es
ITL2		-	Eq	LWk	Es
ITL3			-	Vs	Es
ITL4				-	Es
ITL5					-

D2	ITL1	ITL2	ITL3	ITL4	ITL5
ITL1	-	Es	Wk	Wk	Vs
ITL2		-	Wk	Eq	Wk
ITL3			-	Es	Wk
ITL4				-	Wk
ITL5					-

D3	ITL1	ITL2	ITL3	ITL4	ITL5
ITL1	-	Wk	Eq	Eq	Es
ITL2		-	Eq	Eq	Es
ITL3			-	Vs	Vs
ITL4				-	Vs
ITL5					-

D4	ITL1	ITL2	ITL3	ITL4	ITL5
ITL1	-	Eq	Eq	Eq	Wk
ITL2		-		LWk	Wk
ITL3			-	Eq	Wk
ITL4				-	Wk
ITL5					-

D1	OM1	OM2	OM3	OM4	OM5	OM6
OM1	-	Es	Es	Es	Es	Wk
OM2		-	Eq	Eq	Eq	LWk
OM3			-	Eq	Eq	LWk
OM4				-	Eq	LWk
OM5					-	LWk
OM6						-

D2	OM1	OM2	OM3	OM4	OM5	OM6
OM1	-	Wk	Wk	Es	Es	Es
OM2		-	LWk	Wk	Eq	Eq
OM3			-	Wk	Lwk	LWk
OM4				-	Eq	Eq
OM5					-	Eq
OM6						-

D3	OM1	OM2	OM3	OM4	OM5	OM6
OM1	-	Es	Es	Es	Es	Es
OM2		-	Eq	Eq	Eq	Eq
OM3			-	Eq	Eq	Eq
OM4				-	LWk	LWk
OM5					-	LWk
OM6						-

D4	OM1	OM2	OM3	OM4	OM5	OM6
OM1	-	Es	Eq	Wk	Wk	Wk
OM2		-	LWk	LWk	Wk	Wk
OM3			-	Eq	Wk	Eq
OM4				-	Eq	Eq
OM5					-	Eq
OM6						-

D1	SCE1	SCE2	SCE3	SCE4	SCE5	SCE6	SCE7	SCE8	SCE9	SCE10	SCE11
SCE1	-	Es	Es	Vs	Es	Eq	Es	Eq	Wk	Es	Es
SCE2		-	Eq	Es	Eq	LEs	Eq	LEs	LWk	Eq	Eq
SCE3			-	Es	Eq	LEs	LEs	LEs	LWk	Eq	Eq
SCE4				-	LEs	LVs	LEs	LVs	LVS	LEs	LEs
SCE5					-	LEs	Eq	LEs	LWk	Eq	Eq
SCE6						-	Es	Eq	Wk	Es	Es
SCE7							-	LEs	LWk	Eq	Eq
SCE8								-	Wk	Es	Es
SCE9									-	Wk	Wk
SCE10										-	Eq
SCE11											-

D2	SCE1	SCE2	SCE3	SCE4	SCE5	SCE6	SCE7	SCE8	SCE9	SCE10	SCE11
SCE1	-	Wk	Wk	Es	Wk	Wk	Wk	Wk	Wk	Es	Es
SCE2		-	Eq	Es	Eq	Eq	Eq	Eq	LWk	Wk	Eq
SCE3			-	Es	Eq	LEs	LWk	LEs	LWk	Eq	Eq
SCE4				-	LEs	LVs	Les	LWk	LWk	LWk	LWk
SCE5					-	LEs	Eq	Eq	LWk	LWk	Wk
SCE6						-	Es	Eq	Wk	Es	Es
SCE7							-	LEs	LWk	Eq	Eq
SCE8								-	Wk	Eq	Wk
SCE9									-	Wk	Wk
SCE10										-	Eq
SCE11											-

D3	SCE1	SCE2	SCE3	SCE4	SCE5	SCE6	SCE7	SCE8	SCE9	SCE10	SCE11
SCE1	-	Eq	Es	Vs	Vs	Wk	Wk	Wk	Wk	Wk	Es
SCE2		-	Wk	Wk	Eq	LEs	Eq	Eq	Eq	Eq	Wk
SCE3			-	Es	Eq	LWk	Wk	LEs	LWk	Eq	Eq
SCE4				-	LWk	LEs	LWk	LWk	LWk	LWk	LWk
SCE5					-	LWk	Eq	Eq	LVs	Wk	LWk
SCE6						-	Wk	Eq	Wk	Es	Es
SCE7							-	Eq	LWk	Eq	Wk
SCE8								-	Wk	Eq	Wk
SCE9									-	Wk	Eq
SCE10										-	Wk
SCE11											-

D4	SCE1	SCE2	SCE3	SCE4	SCE5	SCE6	SCE7	SCE8	SCE9	SCE10	SCE11
SCE1	-	Es	Es	Es	Es	Es	Wk	Wk	Wk	Wk	Vs
SCE2		-	Wk	Eq	Eq	LEs	Eq	LWk	LWk	LWk	LWk
SCE3			-	Es	LVs	LWk	Eq	LWk	LWk	Eq	Eq
SCE4				-	LEs	LVs	LVs	LVs	LVs	LWk	LWk
SCE5					-	LWk	Eq	Eq	Eq	Eq	Wk
SCE6						-	Wk	Eq	Es	Es	Es
SCE7							-	Les	LWk	LWk	LWk
SCE8								-	Wk	Wk	Wk
SCE9									-	Wk	Wk
SCE10										-	Wk
SCE11											-

D1	SRM1	SRM2	SRM3	SRM4	SRM5	SRM6	SRM7	SRM8	SRM9
SRM1	-	Eq	LWk	LWk	LEs	Eq	LVs	LVS	LWk
SRM2		-	LWk	LWk	LEs	Eq	LVs	LVS	LWk
SRM3			-	Eq	LWk	Wk	Les	LEs	Eq
SRM4				-	LWk	Wk	LEs	LEs	Eq
SRM5					-	Es	LWk	LWk	Wk
SRM6						-	LVs	LVs	LWk
SRM7							-	Eq	Es
SRM8								-	Es
SRM9									-

D2	SRM1	SRM2	SRM3	SRM4	SRM5	SRM6	SRM7	SRM8	SRM9
SRM1	-	Eq	Eq	Eq	LWk	Eq	LWk	LWk	LWk
SRM2		-	Eq	Eq	LWk	Eq	LEs	LWk	LEs
SRM3			-	Eq	Eq	Eq	LWk	LWk	Wk
SRM4				-	Eq	Wk	LEs	LWk	LWk
SRM5					-	Wk	Eq	Eq	Es
SRM6						-	LVs	LVs	LEs
SRM7							-	Wk	Wk
SRM8								-	Eq
SRM9									-

D3	SRM1	SRM2	SRM3	SRM4	SRM5	SRM6	SRM7	SRM8	SRM9
SRM1	-	Wk	Eq	LWk	LWk	Wk	LEs	LVs	LEs
SRM2		-	LWk	LWk	LWk	LWk	LWk	LWk	LWk
SRM3			-	Eq	Eq	Wk	LEs	LEs	Eq
SRM4				-	LEs	Wk	LWk	Eq	Eq
SRM5					-	Es	LWk	LWk	Wk
SRM6						-	LVs	LEs	LEs
SRM7							-	Wk	Wk
SRM8								-	Eq
SRM9									-

D4	SRM1	SRM2	SRM3	SRM4	SRM5	SRM6	SRM7	SRM8	SRM9
SRM1	-	Eq	Eq	Eq	LWk	Eq	Eq	LVs	LWk
SRM2		-	LWk	LWk	LWk	Wk	Les	Eq	Eq
SRM3			-	Eq	Eq	Wk	LWk	Eq	Eq
SRM4				-	LWk	Wk	LEs	LEs	Wk
SRM5					-	Es	LWk	LWk	Wk
SRM6						-	LVs	LEs	LEs
SRM7							-	Wk	Wk
SRM8								-	Es
SRM9									-

## APPENDIX B. Linguistic assessment of alternatives

	Decision Maker 2						
	System1	System2	System3	System4	System5	System6	System7
DM1	G	F	G	G	G	P	P
DM2	G	G	VG	P	G	G	G
DM3	VG	F	F	F	F	G	G
DM4	G	G	G	F	F	G	G
DM5	F	G	VG	F	VP	F	P
SCO1	G	F	VG	F	P	G	G
SCO2	G	F	F	G	G	G	F
SCO3	G	G	F	F	P	F	F
SCO4	VG	F	VG	G	F	G	VG
WMS1	F	F	G	G	G	G	P
WMS2	F	G	G	G	G	G	F
WMS3	G	G	VG	G	VG	G	F
WMS4	VG	F	VG	G	VG	VG	G
WMS5	G	G	G	G	G	VG	VG
WMS6	VG	F	G	F	VG	VG	F
PSP1	G	P	G	F	VG	VG	VP
PSP2	G	F	G	P	VG	F	F
PSP3	F	F	F	VG	G	P	F
PSP4	VG	F	G	G	F	F	VG
PSP5	G	G	G	F	F	F	F
PSP6	G	F	G	P	F	F	F
SPP1	G	F	G	G	P	F	F
SPP2	VG	G	G	G	P	F	F
SPP3	G	F	F	F	F	F	G
SPP4	G	G	G	G	F	F	G
SPP5	F	VG	F	P	P	F	G
TMS1	F	P	F	P	G	G	VG
TMS2	G	P	G	F	G	P	G
TMS3	F	F	G	VG	P	P	G
ITL1	F	P	VG	G	P	VG	F
ITL2	F	P	VG	VG	VG	G	F
ITL3	G	P	G	G	P	F	VP
ITL4	G	G	G	F	F	VG	G
ITL5	G	G	F	VP	G	F	F
OM1	VG	G	G	P	G	P	VG
OM2	G	G	G	G	VG	G	G
OM3	G	G	G	F	F	G	F
OM4	VG	F	G	G	P	VG	VP
OM5	G	F	G	P	G	VP	G
OM6	G	G	VG	P	G	P	F
SCEM1	F	G	VG	G	P	P	F
SCEM2	F	G	G	P	G	P	G
SCEM3	G	F	F	F	VP	G	P
SCEM4	G	F	F	F	P	P	P
SCEM5	G	F	P	VG	P	P	F
SCEM6	G	F	P	G	G	F	VG
SCEM7	G	F	G	G	G	F	VG
SCEM8	G	G	G	F	F	F	G
SCEM9	G	G	VG	P	G	F	VP
SCEM10	G	G	F	P	F	F	F
SRM1	F	VG	F	VP	P	F	G
SRM2	F	F	F	G	P	VG	G
SRM3	VG	F	F	G	G	VG	F
SRM4	G	P	VG	F	P	VG	VP
SRM5	G	F	G	G	VG	P	P
SRM6	G	F	F	G	G	G	P
SRM7	VG	G	G	G	VG	F	F
SRM8	G	G	VG	F	F	F	G

	Decision Maker 3						
	System1	System2	System3	System4	System5	System6	System7
DM1	G	F	G	F	F	VP	F
DM2	VG	G	VG	F	G	G	F
DM3	VG	F	VG	F	F	G	F
DM4	VG	G	G	F	F	G	G
DM5	G	G	G	G	F	P	F
SCO1	G	G	G	G	F	P	G
SCO2	G	G	G	G	G	G	G
SCO3	VG	G	G	F	F	F	F
SCO4	G	G	VG	G	G	F	G
WMS1	VG	G	G	G	G	F	P
WMS2	G	F	G	G	G	G	P
WMS3	G	G	G	G	G	G	P
WMS4	VG	F	G	F	G	G	G
WMS5	G	F	VG	F	F	G	G
WMS6	F	F	F	F	F	G	G
PSP1	G	F	G	P	F	G	F
PSP2	G	F	G	P	F	G	F
PSP3	F	G	G	F	F	F	F
PSP4	F	G	G	F	F	F	F
PSP5	VG	VG	VG	F	F	VP	F
PSP6	G	G	VG	P	VG	P	G
SPP1	VG	G	VG	F	F	P	F
SPP2	G	G	G	P	F	P	G
SPP3	G	F	G	P	VG	G	G
SPP4	G	G	G	G	G	VG	G
SPP5	G	G	F	VP	G	F	G
TMS1	F	P	F	P	G	F	G
TMS2	F	P	G	P	G	F	G
TMS3	F	P	F	G	F	VP	VG
ITL1	F	F	G	G	P	G	G
ITL2	F	F	VG	G	F	G	G
ITL3	VG	P	G	F	VP	G	F
ITL4	VG	G	G	F	P	F	G
ITL5	VG	P	VG	F	G	F	G
OM1	G	G	P	F	G	VP	F
OM2	VG	G	F	F	G	P	F
OM3	VG	G	G	F	P	P	F
OM4	VG	P	G	F	P	F	F
OM5	F	P	F	P	F	VP	F
OM6	F	P	F	P	G	P	G
SCEM1	F	G	F	F	VP	F	VG
SCEM2	F	F	G	F	G	F	VG
SCEM3	VG	F	G	F	P	G	F
SCEM4	VG	VP	G	P	P	G	F
SCEM5	VG	F	G	G	P	G	F
SCEM6	G	F	G	F	F	G	G
SCEM7	G	F	VG	F	G	F	F
SCEM8	G	G	VG	F	VG	F	F
SCEM9	G	G	VG	P	VG	F	P
SCEM10	G	G	VG	P	F	P	P
SCEM11	F	VG	G	VG	F	F	P
SRM1	F	VG	G	P	F	P	VG
SRM2	F	G	VG	G	F	F	VG
SRM3	G	F	VG	G	G	P	P
SRM4	F	F	VG	G	P	F	P
SRM5	G	F	VG	G	P	P	F
SRM6	VG	F	G	G	P	F	F
SRM7	VG	G	G	F	P	G	F
SRM8	VG	G	G	F	P	G	VG
SRM9	G	VG	G	F	F	G	G

## Decision Maker 4

	System1	System2	System3	System4	System5	System6	System7
DM1	G	F	G	F	G	F	G
DM2	VG	G	VG	F	G	F	G
DM3	G	G	VG	F	G	F	F
DM4	VG	G	G	F	F	VG	VG
DM5	G	F	VG	G	VP	VP	F
SCO1	VG	G	VG	VG	F	VG	VG
SCO2	G	F	G	F	VG	VG	G
SCO3	VG	VG	VG	F	P	F	F
SCO4	VG	G	VG	VG	G	G	VG
WMS1	F	F	G	VG	VG	G	P
WMS2	VG	P	VG	F	G	VG	P
WMS3	VG	VG	G	F	VG	G	P
WMS4	G	G	VG	G	G	G	G
WMS5	VG	P	G	F	G	VG	G
WMS6	G	P	F	G	VG	G	G
PSP1	VG	F	VG	VP	G	VG	VP
PSP2	F	VG	F	P	F	G	F
PSP3	G	G	P	G	F	P	P
PSP4	G	F	VG	F	F	VG	VG
PSP5	VG	VG	G	F	P	P	G
PSP6	VG	P	G	P	G	F	P
SPP1	G	P	VG	VG	VP	F	P
SPP2	VG	VG	G	F	F	F	F
SPP3	F	F	G	G	VG	G	VG
SPP4	VG	G	VG	G	F	VG	G
SPP5	F	G	F	P	F	P	G
TMS1	VG	P	G	P	VG	G	VG
TMS2	F	F	VG	F	VG	F	G
TMS3	P	F	G	VG	F	VP	G
ITL1	F	G	G	F	F	VG	F
ITL2	G	VP	VG	VG	VG	G	F
ITL3	VG	VP	G	F	VP	F	VP
ITL4	G	VG	G	F	F	VG	G
ITL5	F	F	VG	VP	VG	P	G
OM1	VG	G	P	F	G	P	VG
OM2	VG	G	VG	G	VG	G	G
OM3	VG	F	VG	F	F	F	G
OM4	G	VP	F	VG	VP	VG	P
OM5	VG	F	F	P	G	P	VG
OM6	F	G	VG	F	VG	P	G
SCEM1	G	VG	G	VG	VP	F	F
SCEM2	F	F	VP	F	F	G	VG
SCEM3	VG	P	G	F	VP	VG	P
SCEM4	F	F	G	P	P	F	VP
SCEM5	F	G	F	VG	VP	P	VP
SCEM6	VG	F	G	F	F	F	G
SCEM7	F	P	VG	F	F	G	G
SCEM8	G	F	G	VG	G	F	F
SCEM9	VG	VG	VG	VP	VG	F	P
SCEM10	F	F	F	F	F	VP	F
SCEM11	VG	G	VG	VG	VG	VG	F
SRM1	F	G	F	VP	VG	P	F
SRM2	G	F	VG	G	G	VG	G
SRM3	VG	VP	F	VG	VG	G	F
SRM4	G	F	VG	G	VP	G	F
SRM5	F	G	G	G	F	VP	G
SRM6	VG	VG	F	F	F	VG	F
SRM7	VG	F	VG	VG	F	F	F
SRM8	VG	F	G	G	G	F	G
SRM9	F	G	G	G	VG	VG	G

**APPENDIX C. F-ANP Pairwise Comparison**

DM1 (D1)	ITL1	ITL2	ITL3	ITL4	ITL5
ITL1	-	LEs	LVs	Eq	LEs
ITL2		-	LWk	Eq	LAB
ITL3			-	Eq	Es
ITL4				-	LVs
ITL5					-

DM1 (D2)	ITL1	ITL2	ITL3	ITL4	ITL5
ITL1	-	LWk	LVs	Eq	LVs
ITL2		-	LEs	Wk	LWk
ITL3			-	Eq	Es
ITL4				-	LWk
ITL5					-

DM1 (D3)	ITL1	ITL2	ITL3	ITL4	ITL5
ITL1	-	LWk	LWk	Eq	Eq
ITL2		-	LEs	Wk	LWk
ITL3			-	Wk	Wk
ITL4				-	Eq
ITL5					-

DM1 (D4)	ITL1	ITL2	ITL3	ITL4	ITL5
ITL1	-	LEs	LEs	LWk	LWk
ITL2		-	LWk	Wk	LWk
ITL3			-	Eq	Es
ITL4				-	LEs
ITL5					-

DM1 (D1)	ITL1	ITL2
ITL1	-	LEs
ITL2		-

DM1 (D1)	ITL1	ITL2
ITL1	-	LEs
ITL2		-

DM1 (D1)	ITL1	ITL2
ITL1	-	LWk
ITL2		-

DM1 (D1)	ITL1	ITL2
ITL1	-	LEs
ITL2		-

DM2 (D1)	DM1	DM3	DM4	DM5
DM1	-	Es	Es	Es
DM3		-	Eq	LWk
DM4			-	LWk
DM5				-

DM2 (D2)	DM1	DM3	DM4	DM5
DM1	-	Vs	Vs	Es
DM3		-	Eq	LEs
DM4			-	LWk
DM5				-

DM2 (D3)	DM1	DM3	DM4	DM5
DM1	-	Wk	Eq	Vs
DM3		-	LWk	LWk
DM4			-	LWk
DM5				-

DM2 (D4)	DM1	DM3	DM4	DM5
DM1	-	Vs	Vs	Es
DM3		-	Eq	LWk
DM4			-	Eq
DM5				-

DM2 (D1)	OM1	OM3
OM1	-	LVs
OM3		-

DM2 (D2)	OM1	OM3
OM1	-	LEs
OM3		-

DM2 (D3)	OM1	OM3
OM1	-	LVs
OM3		-

DM2 (D4)	OM1	OM3
OM1	-	LWk
OM3		-

DM2 (D1)	SCE4	SCE9
SCE4	-	Eq
SCE9		-

DM2 (D2)	SCE4	SCE9
SCE4	-	Eq
SCE9		-

DM2 (D3)	SCE4	SCE9
SCE4	-	Eq
SCE9		-

DM2 (D4)	SCE4	SCE9
SCE4	-	Wk
SCE9		-

DM3(D1)	DM1	DM2	DM4	DM5
DM1	-	Wk	Es	Es
DM3		-	Eq	Es
DM4			-	LWk
DM5				-

DM3 (D2)	DM1	DM2	DM4	DM5
DM1	-	Wk	Wk	Es
DM3		-	Wk	Wk
DM4			-	Eq
DM5				-

DM3(D3)	DM1	DM2	DM4	DM5
DM1	-	Eq	Eq	Wk
DM3		-	Es	Es
DM4			-	Wk
DM5				-

DM3 (D4)	DM1	DM2	DM4	DM5
DM1	-	Wk	Wk	Eq
DM3		-	Wk	Wk
DM4			-	LWk
DM5				-

DM3(D1)	PSP1	PSP2	PSP4	PSP6
PSP1	-	LEs	LEs	Eq
PSP2		-	LEs	Eq
PSP4			-	Eq
PSP6				-

DM3 (D2)	PSP1	PSP2	PSP4	PSP6
PSP1	-	LWk	LWk	LWk
PSP2		-	Eq	Eq
PSP4			-	Eq
PSP6				-

DM3(D3)	PSP1	PSP2	PSP4	PSP6
PSP1	-	LEs	LWk	Eq
PSP2		-	LWk	Eq
PSP4			-	LWk
PSP6				-

DM3 (D4)	PSP1	PSP2	PSP4	PSP6
PSP1	-	LEs	LEs	Eq
PSP2		-	LWk	Eq
PSP4			-	LWk
PSP6				-

**APPENDIX D. Table of the unweighted supermatrix**

	Goal	DM1	DM2	DM3	DM4	DM5	SCO1	SCO2	SCO3	SCO4	WMS1	WMS2	WMS3
Goal	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DM1	0.0167	0.0000	0.5277	0.4492	0.4492	0.4216	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DM2	0.0167	0.2675	0.0000	0.2838	0.2838	0.3227	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DM3	0.0167	0.2559	0.1251	0.0000	0.0997	0.1416	0.0000	0.0000	0.0000	0.0000	1.0000	1.0000	0.0000
DM4	0.0167	0.1102	0.1251	0.0997	0.0000	0.1141	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DM5	0.0167	0.3665	0.2222	0.1673	0.1673	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCO1	0.0167	0.0000	0.0000	0.0000	0.5000	0.0000	0.0000	0.2841	0.2727	0.7135	0.0000	0.0000	0.0000
SCO2	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.4361	0.0000	0.6070	0.1433	0.0000	0.0000	0.0000
SCO3	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.3792	0.5757	0.0000	0.1433	0.0000	0.0000	0.0000
SCO4	0.0167	0.0000	0.0000	0.0000	0.5000	0.0000	0.1848	0.1402	0.1204	0.0000	1.0000	1.0000	1.0000
WMS1	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2183	0.0000	0.1839	0.1347
WMS2	0.0167	0.0000	0.0000	0.0000	1.0000	0.0000	1.0000	0.0000	0.0000	0.3622	0.1394	0.0000	0.0912
WMS3	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1295	0.2180	0.1339	0.0000
WMS4	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0905	0.2798	0.1656	0.4133
WMS5	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1186	0.1448	0.3735	0.2397
WMS6	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0809	0.2180	0.1431	0.1212
PSP1	0.0167	0.0000	1.0000	0.1382	0.2035	0.0000	0.2719	0.0000	0.0000	0.0000	0.4017	0.2406	0.0000
PSP2	0.0167	0.0000	0.0000	0.2346	0.0000	0.0000	0.4048	0.0000	0.0000	0.0000	0.0000	0.1234	0.0000
PSP3	0.0167	0.0000	0.0000	0.0000	0.7965	0.0000	0.3233	0.0000	0.0000	0.0000	0.0000	0.1348	0.0000
PSP4	0.0167	0.0000	0.0000	0.3984	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2705	0.2612	0.0000
PSP5	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PSP6	0.0167	0.0000	0.0000	0.2288	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3279	0.2401	0.0000
SPP1	0.0167	0.0000	0.0000	0.0757	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SPP2	0.0167	0.0000	0.0000	0.2088	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SPP3	0.0167	0.0000	0.0000	0.2938	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SPP4	0.0167	0.0000	0.0000	0.4218	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SPP5	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TMS1	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TMS2	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TMS3	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ITL1	0.0167	0.0677	0.0000	0.0000	0.5000	0.0000	0.7965	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ITL2	0.0167	0.1285	0.0000	0.0000	0.5000	0.0000	0.2035	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ITL3	0.0167	0.3327	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ITL4	0.0167	0.1232	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000
ITL5	0.0167	0.3480	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
OM1	0.0167	0.3560	0.1686	0.5039	0.3560	0.0000	0.5757	0.0000	0.0000	0.0000	0.7427	0.2630	0.0000
OM2	0.0167	0.6441	0.0000	0.1971	0.6441	0.0000	0.2841	0.0000	0.0000	1.0000	0.2573	0.6296	0.0000
OM3	0.0167	0.0000	0.8314	0.0000	0.0000	0.0000	0.1402	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
OM4	0.0167	0.0000	0.0000	0.1161	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1074	0.0000
OM5	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
OM6	0.0167	0.0000	0.0000	0.1829	0.0000	0.0000	0.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000
SCEM1	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.4277
SCEM2	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2973
SCEM3	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.4696	0.1434
SCEM4	0.0167	0.0000	0.5000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM5	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM6	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.7427	0.0000	0.2964	0.0000
SCEM7	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2573	0.0000	0.0000	0.1317
SCEM8	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM9	0.0167	0.0000	0.5000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1219	0.0000
SCEM10	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	1.0000	0.0000	0.0000	0.1122	0.0000
SCEM11	0.0167	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM1	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.5000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM2	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM3	0.0167	0.0000	0.0000	1.0000	0.0000	0.0000	0.5000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM4	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6441	0.0000
SRM5	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM6	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3560	0.0000
SRM7	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM8	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM9	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
S1	0.0000	0.2005	0.1641	0.1881	0.1731	0.1726	0.1659	0.1536	0.2077	0.1550	0.1332	0.1583	0.1635
S2	0.0000	0.1175	0.1520	0.1248	0.1538	0.2013	0.1388	0.1104	0.2000	0.1248	0.1259	0.1043	0.1635
S3	0.0000	0.2005	0.1702	0.1718	0.1394	0.2389	0.1722	0.1392	0.1827	0.1607	0.1588	0.1809	0.1572
S4	0.0000	0.1382	0.0912	0.1085	0.0962	0.2013	0.1451	0.1248	0.1154	0.1435	0.1898	0.1357	0.1226
S5	0.0000	0.1590	0.1520	0.1248	0.1106	0.0465	0.0813	0.1664	0.0635	0.1306	0.1898	0.1670	0.1698
S6	0.0000	0.0668	0.1383	0.1573	0.1667	0.0553	0.1308	0.1664	0.1154	0.1306	0.1588	0.1809	0.1572
S7	0.0000	0.1175	0.1322	0.1248	0.1603	0.0841	0.1659	0.1392	0.1154	0.1550	0.0438	0.0730	0.0660

Table Unweighted Supermatrix (cont.)

	WMS4	WMS5	WMS6	PSP1	PSP2	PSP3	PSP4	PSP5	PSP6	SPP1	SPP2	SPP3
Goal	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DM1	0.0000	0.0000	0.0000	0.5985	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DM2	0.0000	0.0000	0.0000	0.2952	0.1143	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DM3	0.0000	0.0000	0.0000	0.0000	0.4429	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DM4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DM5	0.0000	0.0000	0.0000	0.1063	0.4429	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCO1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	1.0000	0.0000	0.0000	0.0000
SCO2	0.0000	0.0000	0.2032	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCO3	0.0000	0.0000	0.7968	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCO4	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000
WMS1	0.4031	0.2196	0.3464	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
WMS2	0.1557	0.2746	0.2271	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.3560	0.2574	0.0000
WMS3	0.2172	0.1924	0.1640	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
WMS4	0.0000	0.1567	0.1486	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
WMS5	0.1277	0.0000	0.1139	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
WMS6	0.0964	0.1567	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6441	0.7425	0.0000
PSP1	0.0000	0.0000	0.0000	0.0000	0.4966	0.2415	0.2706	0.2556	0.3947	0.0000	0.0000	0.0000
PSP2	0.0000	0.0000	0.0000	0.4100	0.0000	0.3785	0.2160	0.2354	0.2100	0.0000	0.0000	0.0000
PSP3	0.0000	0.0000	0.0000	0.2179	0.1334	0.0000	0.2160	0.2014	0.1277	0.0000	0.0000	0.0000
PSP4	0.5000	0.0000	0.0000	0.1720	0.1252	0.1520	0.0000	0.2308	0.1400	0.0000	0.0000	0.0000
PSP5	0.0000	0.0000	0.0000	0.1259	0.1196	0.1312	0.1701	0.0000	0.1277	0.0000	0.0000	0.0000
PSP6	0.5000	1.0000	0.0000	0.0743	0.1252	0.0968	0.1274	0.0768	0.0000	0.0000	0.0000	0.0000
SPP1	0.0000	0.0000	0.0000	0.0000	0.6441	0.0000	0.0000	0.0000	0.0000	0.0000	0.4590	0.2891
SPP2	0.0000	0.0000	0.5000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2532	0.0000	0.4911
SPP3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2834	0.2546	0.0000
SPP4	0.0000	0.0000	0.5000	0.0000	0.3560	0.0000	0.0000	0.0000	0.0000	0.2103	0.1316	0.1189
SPP5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2532	0.1549	0.1008
TMS1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TMS2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TMS3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ITL1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ITL2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ITL3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ITL4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ITL5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
OM1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
OM2	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
OM3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
OM4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
OM5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
OM6	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM4	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM6	0.0000	0.4665	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM8	0.0000	0.1761	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM9	0.0000	0.3574	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6441	0.0000	0.0000	0.0000	0.0000
SCEM11	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3560	0.0000	0.0000	0.0000	0.0000
SRM1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM2	0.6441	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM3	0.0000	0.0000	0.0000	0.0000	0.0000	0.3560	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM7	0.0000	0.0000	0.0000	0.0000	0.0000	0.6441	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM8	0.3560	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000
SRM9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
S1	0.1509	0.1646	0.1661	0.2080	0.1576	0.1649	0.1574	0.1996	0.2162	0.2041	0.2004	0.1388
S2	0.1132	0.0949	0.0766	0.1020	0.1737	0.1839	0.1194	0.2073	0.1060	0.1224	0.1929	0.1068
S3	0.1567	0.1582	0.1259	0.2080	0.1576	0.1078	0.1799	0.1919	0.2079	0.2204	0.1781	0.1388
S4	0.1321	0.1092	0.1259	0.0500	0.0485	0.2008	0.1194	0.1152	0.0416	0.1939	0.1113	0.1068
S5	0.1509	0.1440	0.1807	0.1820	0.1657	0.1649	0.1038	0.0806	0.1975	0.0510	0.0946	0.1690
S6	0.1509	0.1709	0.1825	0.2080	0.1758	0.0698	0.1488	0.0557	0.1060	0.1224	0.0946	0.1548
S7	0.1451	0.1582	0.1423	0.0420	0.1212	0.1078	0.1713	0.1497	0.1247	0.0857	0.1280	0.1851

Table Unweighted Supermatrix (cont.)

	SPP4	SPP5	TMS1	TMS2	TMS3	ITL1	ITL2	ITL3	ITL4	ITL5	OM1	OM2
Goal	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DM1	0.0000	0.0000	0.0000	0.0000	0.0000	0.1690	0.0000	0.0000	0.0000	0.2035	0.0000	0.0000
DM2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DM3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000
DM4	0.0000	0.0000	0.0000	0.0000	0.0000	0.8311	0.0000	0.0000	0.0000	0.7965	0.0000	0.0000
DM5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCO1	0.0000	0.0000	0.1729	0.2139	0.3333	0.0000	0.0000	0.0000	0.1961	0.0000	0.0000	0.0000
SCO2	0.0000	0.0000	0.3079	0.3166	0.3333	0.0000	0.0000	0.0000	0.3857	0.0000	0.0000	0.0000
SCO3	0.0000	0.0000	0.5193	0.4695	0.3333	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCO4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.4182	0.0000	0.0000	1.0000
WMS1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
WMS2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	1.0000
WMS3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
WMS4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
WMS5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
WMS6	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PSP1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.3560
PSP2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PSP3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6441
PSP4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PSP5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PSP6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SPP1	0.1950	0.1928	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SPP2	0.2460	0.1928	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SPP3	0.1146	0.1298	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SPP4	0.0000	0.4846	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6441	0.0000	0.0000	0.0000
SPP5	0.4443	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3560	0.0000	0.0000	0.0000
TMS1	0.0000	0.0000	0.0000	0.7428	0.3560	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TMS2	0.0000	0.0000	0.5000	0.0000	0.6441	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TMS3	0.0000	0.0000	0.5000	0.2572	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000
ITL1	0.0000	0.0000	0.1166	0.1429	0.1517	0.0000	0.1752	0.2563	0.1844	0.2295	0.0000	0.0000
ITL2	0.0000	0.0000	0.1878	0.2910	0.1923	0.1145	0.0000	0.4361	0.5324	0.1577	0.0000	1.0000
ITL3	0.0000	0.0000	0.2860	0.2704	0.2434	0.1622	0.4645	0.0000	0.1136	0.2123	0.0000	0.0000
ITL4	0.0000	0.0000	0.2867	0.1771	0.2252	0.1084	0.1027	0.1229	0.0000	0.4005	0.0000	0.0000
ITL5	0.0000	0.0000	0.1230	0.1187	0.1874	0.6149	0.2577	0.1846	0.1696	0.0000	0.0000	0.0000
OM1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0980
OM2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3571	0.0000	0.3055	0.0000
OM3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3435	0.4220
OM4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1764	0.0000	0.1063	0.1865
OM5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1384	0.0787
OM6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.4665	0.0000	0.1063	0.2147
SCEM1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.5432	0.7968
SCEM7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2480	0.0000
SCEM10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.2032
SCEM11	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2088	0.0000
SRM1	0.0000	0.0000	0.0000	0.0000	0.0000	0.6440	0.0000	0.0000	0.0000	0.4048	0.1517	0.0000
SRM2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM3	0.0000	0.0000	0.0000	0.0000	0.0000	0.3559	0.0000	0.0000	0.0000	0.0000	0.1927	0.0000
SRM4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2573	0.0000	0.2333	0.0000
SRM5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3233	0.4223	0.0000
SRM7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2719	0.0000	0.0000
SRM8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.7427	0.0000	0.0000	0.0000
SRM9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
S1	0.1557	0.1558	0.1602	0.1335	0.0942	0.1161	0.1329	0.2762	0.1650	0.1657	0.2093	0.1639
S2	0.1437	0.2348	0.0391	0.0812	0.1143	0.1161	0.0426	0.0409	0.1716	0.1212	0.1938	0.1457
S3	0.1557	0.1354	0.1523	0.2012	0.1951	0.1934	0.1908	0.2455	0.1584	0.2000	0.0814	0.1442
S4	0.1497	0.0361	0.0645	0.0986	0.2422	0.1509	0.1840	0.1765	0.0990	0.0424	0.0988	0.1320
S5	0.1033	0.1354	0.2031	0.1934	0.0852	0.0812	0.1687	0.0307	0.0842	0.2101	0.1860	0.1639
S6	0.1482	0.0858	0.1699	0.0986	0.0359	0.2089	0.1635	0.1765	0.1634	0.1030	0.0388	0.1184
S7	0.1437	0.2167	0.2109	0.1934	0.2332	0.1335	0.1175	0.0537	0.1584	0.1576	0.1919	0.1320

Table Unweighted Supermatrix (cont.)

	OM3	OM4	OM5	OM6	SCEM1	SCEM2	SCEM3	SCEM4	SCEM5	SCEM6	SCEM7
Goal	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DM1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1848	0.0000	0.0000	0.0000
DM2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.4361	0.0000	0.0000	0.0000
DM3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DM4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DM5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3792	0.0000	0.0000	0.0000
SCO1	0.2571	1.0000	1.0000	0.1505	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCO2	0.0000	0.0000	0.0000	0.4247	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCO3	0.0000	0.0000	0.0000	0.4247	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCO4	0.7429	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000
WMS1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
WMS2	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.5000	0.0000	0.0000	0.0000	0.0000
WMS3	0.0000	1.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000
WMS4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
WMS5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.5000	0.0000	0.0000	0.0000	0.0000
WMS6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PSP1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000
PSP2	0.7429	0.7429	1.0000	0.0000	1.0000	0.0000	0.0000	0.0000	1.0000	1.0000	0.0000
PSP3	0.2571	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PSP4	0.0000	0.2571	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	1.0000
PSP5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PSP6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SPP1	0.0000	0.2088	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SPP2	0.0000	0.2480	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SPP3	0.0000	0.5432	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	1.0000	0.0000
SPP4	0.0000	0.0000	0.0000	0.7427	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SPP5	0.0000	0.0000	0.0000	0.2573	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TMS1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TMS2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TMS3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ITL1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ITL2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ITL3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ITL4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ITL5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000
OM1	0.0547	0.0903	0.0836	0.0667	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
OM2	0.1606	0.2770	0.2357	0.1466	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000
OM3	0.0000	0.1648	0.1676	0.1232	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
OM4	0.1974	0.0000	0.4610	0.4010	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
OM5	0.4029	0.4006	0.0000	0.2625	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
OM6	0.1845	0.0673	0.0522	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0436	0.3535	0.0358	0.0551	0.1068	0.2445
SCEM2	0.0000	0.0000	0.0000	0.0000	0.2158	0.0000	0.1545	0.0352	0.0425	0.0371	0.1063
SCEM3	0.0000	0.0000	0.0000	0.0000	0.1984	0.0319	0.0000	0.0428	0.0417	0.0912	0.1747
SCEM4	0.0000	0.0000	0.0000	0.0000	0.0521	0.0392	0.0660	0.0000	0.0509	0.0514	0.0543
SCEM5	0.0000	0.7429	1.0000	0.0000	0.0381	0.0862	0.0628	0.0320	0.0000	0.0391	0.0337
SCEM6	0.5000	0.0000	0.0000	0.0000	0.0472	0.1036	0.0628	0.1705	0.1538	0.0000	0.0594
SCEM7	0.0000	0.0000	0.0000	0.0000	0.2035	0.1429	0.0628	0.1110	0.1009	0.0727	0.0000
SCEM8	0.0000	0.2571	0.0000	0.0000	0.0610	0.1655	0.0628	0.1302	0.1902	0.1572	0.1095
SCEM9	0.5000	0.0000	0.0000	0.0000	0.0477	0.0733	0.0628	0.1914	0.1919	0.2135	0.0684
SCEM10	0.0000	0.0000	0.0000	1.0000	0.0457	0.0733	0.0628	0.1929	0.1116	0.1761	0.0694
SCEM11	0.0000	0.0000	0.0000	0.0000	0.0904	0.2404	0.0493	0.0582	0.0614	0.0550	0.0800
SRM1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM4	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM6	0.0000	0.1690	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM9	0.0000	0.8311	1.0000	0.0000	0.0000	1.0000	0.0000	0.0000	1.0000	0.0000	1.0000
S1	0.1944	0.2353	0.1934	0.1397	0.1548	0.1210	0.2471	0.2384	0.1911	0.1881	0.1434
S2	0.1458	0.0566	0.1203	0.1579	0.2063	0.1391	0.0961	0.1105	0.1818	0.1085	0.0772
S3	0.1944	0.1765	0.1627	0.2004	0.1806	0.1048	0.1785	0.2267	0.1096	0.1248	0.1985
S4	0.1122	0.2149	0.0566	0.0668	0.1885	0.1028	0.1373	0.0959	0.2517	0.1248	0.1268
S5	0.0953	0.0362	0.2146	0.2105	0.0238	0.1754	0.0275	0.0698	0.0373	0.1483	0.1434
S6	0.1122	0.2240	0.0283	0.0486	0.1012	0.1391	0.2380	0.1744	0.1189	0.1248	0.1434
S7	0.1458	0.0566	0.2241	0.1761	0.1448	0.2177	0.0755	0.0843	0.1096	0.1808	0.1673

Table Unweighted Supermatrix (cont.)

	SCEM8	SCEM9	SCEM10	SCEM11	SRM1	SRM2	SRM3	SRM4	SRM5	SRM6	SRM7
Goal	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DM1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1424	0.2573	0.0000	0.5000
DM2	0.0000	0.1764	0.0000	0.0000	0.0000	0.0000	0.0000	0.3451	0.0000	1.0000	0.0000
DM3	0.0000	0.3571	0.0000	0.0000	0.0000	0.7427	0.0000	0.0000	0.7427	0.0000	0.0000
DM4	0.0000	0.0000	0.0000	0.0000	1.0000	0.2573	1.0000	0.5125	0.0000	0.0000	0.5000
DM5	0.0000	0.4665	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCO1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCO2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCO3	0.0000	0.0000	0.5000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCO4	0.0000	0.0000	0.5000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
WMS1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
WMS2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
WMS3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
WMS4	0.0000	0.0000	0.3333	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
WMS5	0.0000	0.0000	0.3333	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
WMS6	0.0000	0.0000	0.3333	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PSP1	0.0000	1.0000	0.0000	1.0000	0.0000	0.3560	0.0000	0.0000	0.0000	0.1729	0.0000
PSP2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PSP3	0.0000	0.0000	0.0000	0.0000	0.0000	0.6441	1.0000	0.0000	0.0000	0.5193	0.0000
PSP4	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.3079	0.0000
PSP5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PSP6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SPP1	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SPP2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SPP3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SPP4	0.0000	0.0000	0.5000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SPP5	0.0000	0.0000	0.5000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TMS1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TMS2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TMS3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ITL1	0.0000	0.0000	0.0000	0.0000	1.0000	0.3560	0.0000	0.5000	0.0000	0.0000	0.0000
ITL2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000
ITL3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ITL4	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ITL5	0.0000	0.0000	0.0000	0.0000	0.0000	0.6441	0.0000	0.5000	0.0000	0.0000	1.0000
OM1	0.0000	0.5000	0.0000	0.0000	0.0000	0.3560	1.0000	0.0000	0.0000	0.0000	0.0000
OM2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
OM3	0.0000	0.5000	0.0000	0.0000	0.0000	0.6441	0.0000	0.0000	0.0000	0.0000	0.0000
OM4	0.5000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6441	0.0000
OM5	0.5000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3560	0.0000
OM6	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM1	0.2459	0.0540	0.0681	0.0752	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM2	0.0679	0.0370	0.0652	0.1900	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM3	0.1015	0.0921	0.1343	0.1378	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM4	0.0507	0.1700	0.1221	0.0940	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000
SCEM5	0.0485	0.0399	0.0370	0.0328	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM6	0.0771	0.1654	0.1447	0.0940	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM7	0.1152	0.0793	0.0925	0.0940	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM8	0.0000	0.1193	0.0971	0.0940	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM9	0.0970	0.0000	0.1347	0.0940	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
SCEM10	0.0716	0.1207	0.0000	0.0940	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM11	0.1246	0.1223	0.1042	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM1	0.0000	0.0000	0.0000	0.0000	0.0000	0.1968	0.1557	0.1865	0.1603	0.1882	0.1085
SRM2	0.0000	0.0000	0.0000	0.0000	0.2062	0.0000	0.3021	0.1753	0.1370	0.2183	0.1061
SRM3	0.0000	0.0000	0.0000	0.0000	0.1989	0.2223	0.0000	0.1753	0.1249	0.1441	0.1256
SRM4	0.0000	0.0000	0.0000	1.0000	0.1737	0.1614	0.1461	0.0000	0.2269	0.1877	0.1504
SRM5	0.0000	0.0000	0.0000	0.0000	0.1080	0.0654	0.0801	0.1055	0.0000	0.0976	0.2055
SRM6	0.0000	0.0000	0.0000	0.0000	0.1989	0.1747	0.1643	0.1509	0.1031	0.0000	0.1851
SRM7	0.0000	0.0000	0.0000	0.0000	0.0461	0.0429	0.0480	0.0926	0.1538	0.0985	0.0000
SRM8	0.0000	0.0000	1.0000	0.0000	0.0305	0.1027	0.0631	0.0590	0.0490	0.0327	0.0445
SRM9	0.0000	0.0000	0.0000	0.0000	0.0377	0.0339	0.0406	0.0550	0.0450	0.0330	0.0743
S1	0.1667	0.1985	0.1875	0.1477	0.1373	0.1279	0.1942	0.1859	0.1518	0.1989	0.1882
S2	0.1354	0.1985	0.1875	0.1617	0.2471	0.1131	0.0612	0.1090	0.1518	0.1584	0.1311
S3	0.1736	0.2137	0.1755	0.1617	0.1579	0.1623	0.1313	0.2393	0.1946	0.1271	0.1748
S4	0.1424	0.0305	0.1010	0.1680	0.0275	0.1574	0.1871	0.1667	0.1868	0.1436	0.1597
S5	0.1580	0.2061	0.1442	0.1477	0.1167	0.1131	0.1871	0.0342	0.1498	0.0866	0.1294
S6	0.1042	0.1145	0.0601	0.1477	0.0961	0.1623	0.1475	0.2030	0.0311	0.1750	0.1160
S7	0.1198	0.0382	0.1442	0.0653	0.2174	0.1639	0.0917	0.0620	0.1342	0.1105	0.1008



**APPENDIX E.** Table of the weighted supermatrix

	Goal	DM1	DM2	DM3	DM4	DM5	SCO1	SCO2	SCO3	SCO4	WMS1	WMS2	WMS3
Goal	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DM1	0.0167	0.0000	0.1055	0.0642	0.0642	0.2108	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DM2	0.0167	0.0669	0.0000	0.0405	0.0405	0.1614	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DM3	0.0167	0.0640	0.0250	0.0000	0.0142	0.0708	0.0000	0.0000	0.0000	0.0000	0.1429	0.1250	0.0000
DM4	0.0167	0.0275	0.0250	0.0142	0.0000	0.0571	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DM5	0.0167	0.0916	0.0444	0.0239	0.0239	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCO1	0.0167	0.0000	0.0000	0.0000	0.0714	0.0000	0.0000	0.0568	0.0545	0.1427	0.0000	0.0000	0.0000
SCO2	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0545	0.0000	0.1214	0.0287	0.0000	0.0000	0.0000
SCO3	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0474	0.1151	0.0000	0.0287	0.0000	0.0000	0.0000
SCO4	0.0167	0.0000	0.0000	0.0000	0.0714	0.0000	0.0231	0.0280	0.0241	0.0000	0.1429	0.1250	0.2500
WMS1	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0437	0.0000	0.0230	0.0337
WMS2	0.0167	0.0000	0.0000	0.0000	0.1429	0.0000	0.1250	0.0000	0.0000	0.0724	0.0199	0.0000	0.0228
WMS3	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0259	0.0311	0.0167	0.0000
WMS4	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0181	0.0400	0.0207	0.1033
WMS5	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0237	0.0207	0.0467	0.0599
WMS6	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0162	0.0311	0.0179	0.0303
PSP1	0.0167	0.0000	0.2000	0.0197	0.0291	0.0000	0.0340	0.0000	0.0000	0.0000	0.0574	0.0301	0.0000
PSP2	0.0167	0.0000	0.0000	0.0335	0.0000	0.0000	0.0506	0.0000	0.0000	0.0000	0.0000	0.0154	0.0000
PSP3	0.0167	0.0000	0.0000	0.0000	0.1138	0.0000	0.0404	0.0000	0.0000	0.0000	0.0000	0.0168	0.0000
PSP4	0.0167	0.0000	0.0000	0.0569	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0386	0.0326	0.0000
PSP5	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PSP6	0.0167	0.0000	0.0000	0.0327	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0468	0.0300	0.0000
SPP1	0.0167	0.0000	0.0000	0.0108	0.0000	0.0000	0.1250	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SPP2	0.0167	0.0000	0.0000	0.0298	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SPP3	0.0167	0.0000	0.0000	0.0420	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SPP4	0.0167	0.0000	0.0000	0.0603	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SPP5	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TMS1	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TMS2	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TMS3	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ITL1	0.0167	0.0169	0.0000	0.0000	0.0714	0.0000	0.0996	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ITL2	0.0167	0.0321	0.0000	0.0000	0.0714	0.0000	0.0254	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ITL3	0.0167	0.0832	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ITL4	0.0167	0.0308	0.0000	0.0000	0.0000	0.0000	0.0000	0.2000	0.2000	0.0000	0.0000	0.0000	0.0000
ITL5	0.0167	0.0870	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
OM1	0.0167	0.0890	0.0337	0.0720	0.0509	0.0000	0.0720	0.0000	0.0000	0.0000	0.1061	0.0329	0.0000
OM2	0.0167	0.1610	0.0000	0.0282	0.0920	0.0000	0.0355	0.0000	0.0000	0.2000	0.0368	0.0787	0.0000
OM3	0.0167	0.0000	0.1663	0.0000	0.0000	0.0000	0.0175	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
OM4	0.0167	0.0000	0.0000	0.0166	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0134	0.0000
OM5	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
OM6	0.0167	0.0000	0.0000	0.0261	0.0000	0.0000	0.0000	0.2000	0.2000	0.0000	0.0000	0.0000	0.0000
SCEM1	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1069
SCEM2	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0743
SCEM3	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1429	0.0587	0.0358
SCEM4	0.0167	0.0000	0.1000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM5	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM6	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1485	0.0000	0.0370	0.0000
SCEM7	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0515	0.0000	0.0000	0.0329
SCEM8	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM9	0.0167	0.0000	0.1000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0152	0.0000
SCEM10	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2000	0.2000	0.0000	0.0000	0.0140	0.0000
SCEM11	0.0167	0.0000	0.0000	0.1429	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM1	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0625	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM2	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM3	0.0167	0.0000	0.0000	0.1429	0.0000	0.0000	0.0625	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM4	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0805	0.0000
SRM5	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM6	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0445	0.0000
SRM7	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM8	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM9	0.0167	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
S1	0.0000	0.0501	0.0328	0.0269	0.0247	0.0863	0.0207	0.0307	0.0415	0.0310	0.0190	0.0198	0.0409
S2	0.0000	0.0294	0.0304	0.0178	0.0220	0.1007	0.0173	0.0221	0.0400	0.0250	0.0180	0.0130	0.0409
S3	0.0000	0.0501	0.0340	0.0245	0.0199	0.1195	0.0215	0.0278	0.0365	0.0321	0.0227	0.0226	0.0393
S4	0.0000	0.0346	0.0182	0.0155	0.0137	0.1007	0.0181	0.0250	0.0231	0.0287	0.0271	0.0170	0.0307
S5	0.0000	0.0397	0.0304	0.0178	0.0158	0.0232	0.0102	0.0333	0.0127	0.0261	0.0271	0.0209	0.0425
S6	0.0000	0.0167	0.0277	0.0225	0.0238	0.0277	0.0163	0.0333	0.0231	0.0261	0.0227	0.0226	0.0393
S7	0.0000	0.0294	0.0264	0.0178	0.0229	0.0420	0.0207	0.0278	0.0231	0.0310	0.0063	0.0091	0.0165

Table The weighted supermatrix (cont.)

	WMS4	WMS5	WMS6	PSP1	PSP2	PSP3	PSP4	PSP5	PSP6	SPP1	SPP2	SPP3
Goal	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DM1	0.0000	0.0000	0.0000	0.1995	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DM2	0.0000	0.0000	0.0000	0.0984	0.0286	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DM3	0.0000	0.0000	0.0000	0.0000	0.1107	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DM4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DM5	0.0000	0.0000	0.0000	0.0354	0.1107	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCO1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1667	0.0000	0.0000	0.0000	0.0000
SCO2	0.0000	0.0000	0.0406	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCO3	0.0000	0.0000	0.1594	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCO4	0.1667	0.1667	0.0000	0.0000	0.0000	0.0000	0.1429	0.1667	0.0000	0.0000	0.0000	0.0000
WMS1	0.0672	0.0366	0.0693	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
WMS2	0.0259	0.0458	0.0454	0.0000	0.0000	0.0000	0.1429	0.0000	0.0000	0.1187	0.0858	0.0000
WMS3	0.0362	0.0321	0.0328	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
WMS4	0.0000	0.0261	0.0297	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
WMS5	0.0213	0.0000	0.0228	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
WMS6	0.0161	0.0261	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2147	0.2475	0.0000
PSP1	0.0000	0.0000	0.0000	0.0000	0.1242	0.0483	0.0387	0.0426	0.1973	0.0000	0.0000	0.0000
PSP2	0.0000	0.0000	0.0000	0.1367	0.0000	0.0757	0.0309	0.0392	0.1050	0.0000	0.0000	0.0000
PSP3	0.0000	0.0000	0.0000	0.0726	0.0333	0.0000	0.0309	0.0336	0.0638	0.0000	0.0000	0.0000
PSP4	0.0833	0.0000	0.0000	0.0573	0.0313	0.0304	0.0000	0.0385	0.0700	0.0000	0.0000	0.0000
PSP5	0.0000	0.0000	0.0000	0.0420	0.0299	0.0262	0.0243	0.0000	0.0638	0.0000	0.0000	0.0000
PSP6	0.0833	0.1667	0.0000	0.0248	0.0313	0.0194	0.0182	0.0128	0.0000	0.0000	0.0000	0.0000
SPP1	0.0000	0.0000	0.0000	0.0000	0.1610	0.0000	0.0000	0.0000	0.0000	0.0000	0.1530	0.1446
SPP2	0.0000	0.0000	0.1000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0844	0.0000	0.2456
SPP3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0945	0.0849	0.0000
SPP4	0.0000	0.0000	0.1000	0.0000	0.0890	0.0000	0.0000	0.0000	0.0000	0.0701	0.0439	0.0595
SPP5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0844	0.0516	0.0504
TMS1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TMS2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TMS3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ITL1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ITL2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ITL3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ITL4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ITL5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
OM1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
OM2	0.1667	0.1667	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
OM3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1429	0.0000	0.0000	0.0000	0.0000	0.0000
OM4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
OM5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
OM6	0.0000	0.0000	0.2000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM4	0.0000	0.0000	0.0000	0.0000	0.0000	0.2000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM6	0.0000	0.0778	0.0000	0.0000	0.0000	0.0000	0.1429	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM8	0.0000	0.0294	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM9	0.0000	0.0596	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1073	0.0000	0.0000	0.0000	0.0000
SCEM11	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0593	0.0000	0.0000	0.0000	0.0000
SRM1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM2	0.1073	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0712	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1429	0.0000	0.0000	0.0000	0.0000	0.0000
SRM6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM7	0.0000	0.0000	0.0000	0.0000	0.0000	0.1288	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM8	0.0593	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1667	0.0000	0.0000	0.0000	0.0000
SRM9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
S1	0.0252	0.0274	0.0332	0.0693	0.0394	0.0330	0.0225	0.0333	0.1081	0.0680	0.0668	0.0694
S2	0.0189	0.0158	0.0153	0.0340	0.0434	0.0368	0.0171	0.0345	0.0530	0.0408	0.0643	0.0534
S3	0.0261	0.0264	0.0252	0.0693	0.0394	0.0216	0.0257	0.0320	0.1040	0.0735	0.0594	0.0694
S4	0.0220	0.0182	0.0252	0.0167	0.0121	0.0402	0.0171	0.0192	0.0208	0.0646	0.0371	0.0534
S5	0.0252	0.0240	0.0361	0.0607	0.0414	0.0330	0.0148	0.0134	0.0988	0.0170	0.0315	0.0845
S6	0.0252	0.0285	0.0365	0.0693	0.0439	0.0140	0.0213	0.0093	0.0530	0.0408	0.0315	0.0774
S7	0.0242	0.0264	0.0285	0.0140	0.0303	0.0216	0.0245	0.0250	0.0624	0.0286	0.0427	0.0925

Table The weighted supermatrix (cont.)

	SPP4	SPP5	TMS1	TMS2	TMS3	ITL1	ITL2	ITL3	ITL4	ITL5	OM1	OM2
Goal	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DM1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0422	0.0000	0.0000	0.0000	0.0509	0.0000	0.0000
DM2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DM3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1250
DM4	0.0000	0.0000	0.0000	0.0000	0.0000	0.2078	0.0000	0.0000	0.0000	0.1991	0.0000	0.0000
DM5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCO1	0.0000	0.0000	0.0432	0.0535	0.0833	0.0000	0.0000	0.0000	0.0218	0.0000	0.0000	0.0000
SCO2	0.0000	0.0000	0.0770	0.0792	0.0833	0.0000	0.0000	0.0000	0.0429	0.0000	0.0000	0.0000
SCO3	0.0000	0.0000	0.1298	0.1174	0.0833	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCO4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0465	0.0000	0.0000	0.1250
WMS1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
WMS2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1111	0.0000	0.0000	0.1250
WMS3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
WMS4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
WMS5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
WMS6	0.3333	0.3333	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PSP1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2000	0.0445
PSP2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PSP3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0805
PSP4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PSP5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PSP6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SPP1	0.0650	0.0643	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SPP2	0.0820	0.0643	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SPP3	0.0382	0.0433	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SPP4	0.0000	0.1615	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0716	0.0000	0.0000	0.0000
SPP5	0.1481	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0396	0.0000	0.0000	0.0000
TMS1	0.0000	0.0000	0.0000	0.1857	0.0890	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TMS2	0.0000	0.0000	0.1250	0.0000	0.1610	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TMS3	0.0000	0.0000	0.1250	0.0643	0.0000	0.0000	0.0000	0.0000	0.1111	0.0000	0.0000	0.0000
ITL1	0.0000	0.0000	0.0292	0.0357	0.0379	0.0000	0.0876	0.1282	0.0205	0.0574	0.0000	0.0000
ITL2	0.0000	0.0000	0.0469	0.0727	0.0481	0.0286	0.0000	0.2180	0.0592	0.0394	0.0000	0.1250
ITL3	0.0000	0.0000	0.0715	0.0676	0.0609	0.0405	0.2322	0.0000	0.0126	0.0531	0.0000	0.0000
ITL4	0.0000	0.0000	0.0717	0.0443	0.0563	0.0271	0.0513	0.0615	0.0000	0.1001	0.0000	0.0000
ITL5	0.0000	0.0000	0.0307	0.0297	0.0469	0.1537	0.1288	0.0923	0.0188	0.0000	0.0000	0.0000
OM1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0123
OM2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0397	0.0000	0.0611	0.0000
OM3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0687	0.0528
OM4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0196	0.0000	0.0213	0.0233
OM5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0277	0.0098
OM6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0518	0.0000	0.0213	0.0268
SCEM1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1086	0.0996
SCEM7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0496	0.0000
SCEM10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1111	0.0000	0.0000	0.0254
SCEM11	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0418	0.0000
SRM1	0.0000	0.0000	0.0000	0.0000	0.0000	0.1610	0.0000	0.0000	0.0000	0.1012	0.0303	0.0000
SRM2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0890	0.0000	0.0000	0.0000	0.0000	0.0385	0.0000
SRM4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0286	0.0000	0.0467	0.0000
SRM5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0808	0.0845	0.0000
SRM7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0680	0.0000	0.0000
SRM8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0825	0.0000	0.0000	0.0000
SRM9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
S1	0.0519	0.0519	0.0400	0.0334	0.0235	0.0290	0.0664	0.1381	0.0183	0.0414	0.0419	0.0205
S2	0.0479	0.0783	0.0098	0.0203	0.0286	0.0290	0.0213	0.0205	0.0191	0.0303	0.0388	0.0182
S3	0.0519	0.0451	0.0381	0.0503	0.0488	0.0484	0.0954	0.1228	0.0176	0.0500	0.0163	0.0180
S4	0.0499	0.0120	0.0161	0.0247	0.0605	0.0377	0.0920	0.0882	0.0110	0.0106	0.0198	0.0165
S5	0.0344	0.0451	0.0508	0.0484	0.0213	0.0203	0.0843	0.0153	0.0094	0.0525	0.0372	0.0205
S6	0.0494	0.0286	0.0425	0.0247	0.0090	0.0522	0.0818	0.0882	0.0182	0.0258	0.0078	0.0148
S7	0.0479	0.0722	0.0527	0.0484	0.0583	0.0334	0.0588	0.0269	0.0176	0.0394	0.0384	0.0165

Table The weighted supermatrix (cont.)

	OM3	OM4	OM5	OM6	SCEM1	SCEM2	SCEM3	SCEM4	SCEM5	SCEM6	SCEM7
Goal	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DM1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0370	0.0000	0.0000	0.0000
DM2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0872	0.0000	0.0000	0.0000
DM3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DM4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DM5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0758	0.0000	0.0000	0.0000
SCO1	0.0367	0.1250	0.1667	0.0301	0.2000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCO2	0.0000	0.0000	0.0000	0.0849	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCO3	0.0000	0.0000	0.0000	0.0849	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCO4	0.1061	0.0000	0.0000	0.0000	0.0000	0.0000	0.1667	0.0000	0.0000	0.0000	0.0000
WMS1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
WMS2	0.1429	0.0000	0.0000	0.0000	0.0000	0.0000	0.0833	0.0000	0.0000	0.0000	0.0000
WMS3	0.0000	0.1250	0.0000	0.0000	0.2000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2000
WMS4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
WMS5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0833	0.0000	0.0000	0.0000	0.0000
WMS6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PSP1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2000	0.0000	0.0000	0.0000
PSP2	0.1061	0.0929	0.1667	0.0000	0.2000	0.0000	0.0000	0.0000	0.2000	0.2500	0.0000
PSP3	0.0367	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PSP4	0.0000	0.0321	0.0000	0.0000	0.0000	0.0000	0.1667	0.0000	0.0000	0.0000	0.2000
PSP5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PSP6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SPP1	0.0000	0.0261	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SPP2	0.0000	0.0310	0.0000	0.0000	0.0000	0.2000	0.0000	0.0000	0.0000	0.0000	0.0000
SPP3	0.0000	0.0679	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2000	0.2500	0.0000
SPP4	0.0000	0.0000	0.0000	0.1485	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SPP5	0.0000	0.0000	0.0000	0.0515	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TMS1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TMS2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TMS3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ITL1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ITL2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ITL3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ITL4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ITL5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2000	0.0000	0.0000	0.0000
OM1	0.0078	0.0113	0.0139	0.0133	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
OM2	0.0229	0.0346	0.0393	0.0293	0.0000	0.0000	0.1667	0.0000	0.0000	0.0000	0.0000
OM3	0.0000	0.0206	0.0279	0.0246	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
OM4	0.0282	0.0000	0.0768	0.0802	0.0000	0.2000	0.0000	0.0000	0.0000	0.0000	0.0000
OM5	0.0576	0.0501	0.0000	0.0525	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
OM6	0.0264	0.0084	0.0087	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0087	0.0589	0.0072	0.0110	0.0267	0.0489
SCEM2	0.0000	0.0000	0.0000	0.0000	0.0432	0.0000	0.0257	0.0070	0.0085	0.0093	0.0213
SCEM3	0.0000	0.0000	0.0000	0.0000	0.0397	0.0064	0.0000	0.0086	0.0083	0.0228	0.0349
SCEM4	0.0000	0.0000	0.0000	0.0000	0.0104	0.0078	0.0110	0.0000	0.0102	0.0128	0.0109
SCEM5	0.0000	0.0929	0.1667	0.0000	0.0076	0.0172	0.0105	0.0064	0.0000	0.0098	0.0067
SCEM6	0.0714	0.0000	0.0000	0.0000	0.0094	0.0207	0.0105	0.0341	0.0308	0.0000	0.0119
SCEM7	0.0000	0.0000	0.0000	0.0000	0.0407	0.0286	0.0105	0.0222	0.0202	0.0182	0.0000
SCEM8	0.0000	0.0321	0.0000	0.0000	0.0122	0.0331	0.0105	0.0260	0.0380	0.0393	0.0219
SCEM9	0.0714	0.0000	0.0000	0.0000	0.0095	0.0147	0.0105	0.0383	0.0384	0.0534	0.0137
SCEM10	0.0000	0.0000	0.0000	0.2000	0.0091	0.0147	0.0105	0.0386	0.0223	0.0440	0.0139
SCEM11	0.0000	0.0000	0.0000	0.0000	0.0181	0.0481	0.0082	0.0116	0.0123	0.0137	0.0160
SRM1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM4	0.1429	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM6	0.0000	0.0211	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM9	0.0000	0.1039	0.1667	0.0000	0.0000	0.2000	0.0000	0.0000	0.2000	0.0000	0.2000
S1	0.0278	0.0294	0.0322	0.0279	0.0310	0.0242	0.0412	0.0477	0.0382	0.0470	0.0287
S2	0.0208	0.0071	0.0200	0.0316	0.0413	0.0278	0.0160	0.0221	0.0364	0.0271	0.0154
S3	0.0278	0.0221	0.0271	0.0401	0.0361	0.0210	0.0297	0.0453	0.0219	0.0312	0.0397
S4	0.0160	0.0269	0.0094	0.0134	0.0377	0.0206	0.0229	0.0192	0.0503	0.0312	0.0254
S5	0.0136	0.0045	0.0358	0.0421	0.0048	0.0351	0.0046	0.0140	0.0075	0.0371	0.0287
S6	0.0160	0.0280	0.0047	0.0097	0.0202	0.0278	0.0397	0.0349	0.0238	0.0312	0.0287
S7	0.0208	0.0071	0.0373	0.0352	0.0290	0.0435	0.0126	0.0169	0.0219	0.0452	0.0335

Table The weighted supermatrix (cont.)

	SCEM8	SCEM9	SCEM10	SCEM11	SRM1	SRM2	SRM3	SRM4	SRM5	SRM6	SRM7
Goal	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DM1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0356	0.0643	0.0000	0.1000
DM2	0.0000	0.0353	0.0000	0.0000	0.0000	0.0000	0.0000	0.0863	0.0000	0.1667	0.0000
DM3	0.0000	0.0714	0.0000	0.0000	0.0000	0.1238	0.0000	0.0000	0.1857	0.0000	0.0000
DM4	0.0000	0.0000	0.0000	0.0000	0.2000	0.0429	0.2000	0.1281	0.0000	0.0000	0.1000
DM5	0.0000	0.0933	0.0000	0.2000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCO1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCO2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCO3	0.0000	0.0000	0.0625	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCO4	0.0000	0.0000	0.0625	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
WMS1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
WMS2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
WMS3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
WMS4	0.0000	0.0000	0.0417	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
WMS5	0.0000	0.0000	0.0417	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
WMS6	0.0000	0.0000	0.0417	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PSP1	0.0000	0.2000	0.0000	0.2000	0.0000	0.0593	0.0000	0.0000	0.0000	0.0288	0.0000
PSP2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PSP3	0.0000	0.0000	0.0000	0.0000	0.0000	0.1073	0.2000	0.0000	0.0000	0.0865	0.0000
PSP4	0.0000	0.0000	0.0000	0.0000	0.2000	0.0000	0.0000	0.0000	0.0000	0.0513	0.0000
PSP5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PSP6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SPP1	0.2500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SPP2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SPP3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SPP4	0.0000	0.0000	0.0625	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SPP5	0.0000	0.0000	0.0625	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TMS1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TMS2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TMS3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ITL1	0.0000	0.0000	0.0000	0.0000	0.2000	0.0593	0.0000	0.1250	0.0000	0.0000	0.0000
ITL2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2500	0.0000	0.0000
ITL3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ITL4	0.0000	0.0000	0.1250	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ITL5	0.0000	0.0000	0.0000	0.0000	0.0000	0.1073	0.0000	0.1250	0.0000	0.0000	0.2000
OM1	0.0000	0.1000	0.0000	0.0000	0.0000	0.0593	0.2000	0.0000	0.0000	0.0000	0.0000
OM2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
OM3	0.0000	0.1000	0.0000	0.0000	0.0000	0.1073	0.0000	0.0000	0.0000	0.0000	0.0000
OM4	0.1250	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1073	0.0000
OM5	0.1250	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0593	0.0000
OM6	0.0000	0.0000	0.1250	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM1	0.0615	0.0108	0.0085	0.0150	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM2	0.0170	0.0074	0.0082	0.0380	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM3	0.0254	0.0184	0.0168	0.0276	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM4	0.0127	0.0340	0.0153	0.0188	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2000
SCEM5	0.0121	0.0080	0.0046	0.0066	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM6	0.0193	0.0331	0.0181	0.0188	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM7	0.0288	0.0159	0.0116	0.0188	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM8	0.0000	0.0239	0.0121	0.0188	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM9	0.0242	0.0000	0.0168	0.0188	0.0000	0.0000	0.0000	0.0000	0.0000	0.1667	0.0000
SCEM10	0.0179	0.0241	0.0000	0.0188	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SCEM11	0.0312	0.0245	0.0130	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRM1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0328	0.0311	0.0466	0.0401	0.0314	0.0217
SRM2	0.0000	0.0000	0.0000	0.0000	0.0412	0.0000	0.0604	0.0438	0.0342	0.0364	0.0212
SRM3	0.0000	0.0000	0.0000	0.0000	0.0398	0.0370	0.0000	0.0438	0.0312	0.0240	0.0251
SRM4	0.0000	0.0000	0.0000	0.2000	0.0347	0.0269	0.0292	0.0000	0.0567	0.0313	0.0301
SRM5	0.0000	0.0000	0.0000	0.0000	0.0216	0.0109	0.0160	0.0264	0.0000	0.0163	0.0411
SRM6	0.0000	0.0000	0.0000	0.0000	0.0398	0.0291	0.0329	0.0377	0.0258	0.0000	0.0370
SRM7	0.0000	0.0000	0.0000	0.0000	0.0092	0.0071	0.0096	0.0231	0.0384	0.0164	0.0000
SRM8	0.0000	0.0000	0.1250	0.0000	0.0061	0.0171	0.0126	0.0147	0.0123	0.0055	0.0089
SRM9	0.0000	0.0000	0.0000	0.0000	0.0075	0.0057	0.0081	0.0138	0.0113	0.0055	0.0149
S1	0.0417	0.0397	0.0234	0.0295	0.0275	0.0213	0.0388	0.0465	0.0379	0.0331	0.0376
S2	0.0339	0.0397	0.0234	0.0323	0.0494	0.0189	0.0122	0.0272	0.0379	0.0264	0.0262
S3	0.0434	0.0427	0.0219	0.0323	0.0316	0.0270	0.0263	0.0598	0.0486	0.0212	0.0350
S4	0.0356	0.0061	0.0126	0.0336	0.0055	0.0262	0.0374	0.0417	0.0467	0.0239	0.0319
S5	0.0395	0.0412	0.0180	0.0295	0.0233	0.0189	0.0374	0.0085	0.0375	0.0144	0.0259
S6	0.0260	0.0229	0.0075	0.0295	0.0192	0.0270	0.0295	0.0507	0.0078	0.0292	0.0232
S7	0.0299	0.0076	0.0180	0.0131	0.0435	0.0273	0.0183	0.0155	0.0336	0.0184	0.0202



## **Autobiography**

**Sinan APAK** received a BSc degree in mechanical engineering from Balıkesir University, Balıkesir, Turkey in 2001, and MSc degree in systems engineering from Yeditepe University, Istanbul, Turkey in 2005, respectively. He joined the Department of International Logistics and Transportation in the Faculty of Commerce at Yeditepe University, Istanbul, Turkey, in 2001, where he has been working as a research assistant since 2001. His master thesis was about “Improving Methods for Controlling of Logistics Performance”. His research interests include supply chain management, operations management and logistics performance measurement.

**MARMARA UNIVERSITY**  
**THE INSTITUTE FOR**  
**GRADUATE STUDIES IN PURE AND APPLIED SCIENCES**

## **ACCEPTANCE AND APPROVAL DOCUMENT**

The jury established by the Executive Board of the *INSTITUTE FOR GRADUATE STUDIES IN PURE AND APPLIED SCIENCES* on **12.04.2010 (2010/07-05)** has accepted Mr. Sinan APAK's thesis titled "A Decision Making Model for the Evaluation of Supply Chain Execution and Management Systems" as Doctor of Philosophy thesis in Engineering Management.


Advisor : Assoc. Prof. Dr. Özalp VAYVAY  
Member of the jury : Prof. Dr. Melek BAŞAK  
Member of the jury : Assoc. Prof. Dr. Orhan FEYZİOĞLU  
Member of the jury : Prof. Dr. Şükran KADIPAŞAOĞLU  
Member of the jury : Assoc. Prof. Dr. Emine ÇOBANOĞLU

Date : **18.05.2010**

### **APPROVAL**

Mr. Sinan APAK has satisfactorily completed the requirements for the degree of Doctor of Philosophy in Engineering Management at Marmara University. The Executive Committee approves that he be granted the degree of Doctor of Philosophy on . **07.06.2010**

**2010/11-02**

  
**DIRECTOR OF THE INSTITUTE**  
Prof. Dr. Meral ÜNAL

