Strategic Logistics Outsourcing:

Integrated Models for Evaluating and Selecting Logistics Service Providers (LSPs) Upstream/Downstream Supply Chain Comparison

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ABSTRACT

This research aims to maximize the logistics outsourcing benefits through developing new hybrid models for evaluating and selecting Logistics Service Providers (LSPs). The growing demand for logistics outsourcing and the increase in the number and type of LSPs highlight the increasing importance of the LSP evaluation and selection process. Firms use various approaches to evaluate and select their LSP partners. Most of these approaches seem to have overlooked the strategic side of the logistics outsourcing process. Additionally, the uncertainty issue of data, the complexity of the decision and the large number of criteria involved increase the attractiveness of the Multi-Criteria Decision-Making (MCDM) approaches.

A comparative literature review was used in order to identify crucial factors and methods that are used in logistics literature in fragmented ways and therefore, to establish and design a conceptual framework and models for logistics outsourcing. First, a long list of evaluation criteria was developed. Three main dimensions were identified: logistics performance, logistics resources and logistics services. Then a conceptual framework was developed using the three main dimensions with their related factors. Based on the comparative literature review outcomes, a number of integrated models have been developed and used to achieve this aim with emphasis given to FDEMATEL, FTOPSIS and FQFD techniques. Whereas the FDEMATEL technique contributed to construct influence relationships between factors under each dimension, develop impact-relationship maps and identify dependent and independent success factors (ISFs), the FTOPSIS technique used the weighted success factors to evaluate, rank and select the best LSP in three case studies. Twenty-one ISFs have been identified to be used in the final approach. These ISFs consist of eight LKPIs, seven logistics services and six logistics resources and capabilities. All of the factors were used to evaluate and select the best LSP alternative and ISFs were used to conduct the evaluation process. Different sensitivity analysis tests are used to confirm models' robustness. Based on the outcomes of both cases, decision makers can use independent factors alone to evaluate and select the best LSP, which simplified the logistics outsourcing process in our study. The FQFD technique was used to link the LSUs strategic objectives with logistics requirements and the ISFs to develop a new strategic logistics outsourcing approach. Finally, two case studies representing the supply chain upstream and downstream are used to demonstrate the new hybrid approach effectiveness. The comparison of both cases' findings highlighted their differences in terms of strategic objectives, logistics requirements and ISFs.

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In the name of Allah, the Entirely Merciful, the Especially Merciful

All praise due to Allah Lord of the worlds. The Entirely Merciful The Especially Merciful. Sovereign of the Day of Recompense. (1-4/1)

All praise due to Allah who has sent down upon His Servant the Book and has not made therein any deviance. He has made it straight, to warn of severe punishment from Him and to give good tidings to the believers who do righteous deeds that they will have a good reward. In which they will remain forever. And to warn those who say 'Allah has taken a son'. (1-3/18)

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Used Terms and Abbreviations

Term/ Abbreviation	Description	1st Appearance In Chapter…
1PL	First Party Logistics	2
2PL	Second Party Logistics	2
3PL/TPL	Third Party Logistics	2
4PL	Fourth Party Logistics	2
5PL	Fifth Party Logistics	2
AHP	Analytic Hierarchy Process	2
ANP	Analytic Network Process	2
ASE	Amman Stock Exchange	4
BSC	Balanced Scorecard	2
CC	Closeness Coefficient	3
DC	Distribution Centre	2
DEA	Data Envelopment Analysis	2
DEMATEL	Decision-making trial and evaluation laboratory	1
DM	Decision Maker	1
DST	Decision Support Tool	1
EVA	Economic Value Added	2
FDEMATEL	Fuzzy decision-making trial and evaluation laboratory	1
FNIS	Fuzzy Negative Ideal Solution	3
FPIS	Fuzzy Positive Ideal Solution	3
FQFD	Fuzzy Quality Function Deployment	1
FTOPSIS	Fuzzy technique for order preference by similarity to ideal solution	1
IRM	Impact-Relationship Map	3
ISF	Independent Success Factor	1
JLA	Jordan Logistics Association	4
JLSP	Jordanian Logistics Service Provider	4
LKPI	Logistics Key Performance Indicator	1
LLP	Lead Logistics Providers	2
LSP	Logistics Service Provider	1
LSU	Logistics Service User	1
MCDM	Multi-Criteria Decision-Making	1
MNA	Middle East and North Africa	4
NIS	Negative Ideal Solution	3
PIS	Positive Ideal Solution	3
QFD	Quality function deployment	1
R&D	Research and Development	2
RBL	Resource-Based Logistics	2
RBV	Resource-Based View	2
ROA	Return On Assets	3
ROE	Return On Equity	3
ROI	Return On Investment	3
SBSC	Sustainable Balanced ScoreCard	2
SCM	Supply Chain Management	2
TFN	Triangular Fuzzy Number	3
TOPSIS	Technique for order preference by similarity to ideal solution	1
TQM	Total Quality Management	3

Chapter 1: Introduction

Summary

This chapter introduces the thesis. Firstly, research area, aims and objectives are defined and research significance is clarified. Then, research stages and thesis structure are presented.

1.1. Introduction

During the last two decades, firms throughout the world have gradually developed more interest in logistics outsourcing as a main source of competitive advantage **(**Krakovics et al., 2008). Due to its high fixed cost and heavy investment requirements, logistics is one of the activities that many firms seek to outsource. Outsourcing logistics can reduce fixed costs and increase flexibility, allowing greater focus on the core activities, reduce heavy asset investments and improve the quality of the provided service (Hsu et al., 2012**)**. At the same time, the decision to outsource includes a number of risks related to loss of control over the logistics process, long term commitment and the issue that some logistics service providers (LSPs) fail to perform their logistics operations (Farahani et al., 2011). The increasing importance of logistics outsourcing and availability of LSPs highlights the significance and complexity of the LSP evaluation and selection process. Firms use various approaches for analysing, evaluating and selecting their LSP partners. The complexity of the decision and the large number of criteria involved increase the attractiveness of the Multi Criteria Decision Making (MCDM) approaches. LSP performance is a vital dimension in the evaluation process. Most existing LSP evaluation and selection studies use historical performance data and assume decision criteria independence (Straight, 1999**;** Lai et al., 2002**;** Liu and Lyons, 2011). Using past performance records alone is insufficient for performing a comprehensive evaluation. There is no guarantee that an LSP is capable to replicate its past performance under uncertain work conditions. Moreover, the availability, accessibility and accuracy of performance measures are matters of investigation. The quality of criteria and the extent they are relevant to the intended goal should be investigated too. Additionally, many studies of LSP evaluation and selection have failed to address the inherent uncertainty in data and the interdependencies of the LSPs' evaluation and selection criteria – an area that has not been extensively studied. Narrow frameworks and models presented by various studies have not helped decision makers (DMs) to take effective logistics-based decisions. To overcome the aforementioned shortcomings, this research aims to develop an advanced methodology for strategic logistics outsourcing under uncertain decision-making environments.

1.2. Research Problem

This research aims to help firms in their logistics outsourcing decision, therefore the main focus of this thesis will be on the 'evaluation and selection' phases of the logistics outsourcing process. Other phases that are pre and post this phase such as decide to outsource or not, preparing stages, data collection about LSP alternatives and firm-LSP relationship management are different research context outside the scope of current research.

1.3. Research Objectives

This research aims to develop a number of integrated models for the logistics outsourcing process under high uncertainties. This research sets out to identify and provide a comprehensive LSPs' framework taking into account various stakeholders perspectives engaged in the evaluation process, using the most relevant evaluation and selection criteria (in addition to performance indicators as globally accepted selection criteria). Bearing this in mind, the core research question of this thesis is: *What are the crucial factors and methods that are needed to perform an effective strategic logistics outsourcing process from the LSUs and LSPs perspectives?*

The following objectives have been developed to achieve this aim:

1. To identify most important/used LSPs evaluation and selection criteria to model a new multi-dimension framework that covers the LSPs' performance; resources & capabilities; and logistics services dimensions

2. To analyse the impact-relationship of the LSPs framework elements using the Fuzzy Decision Making Trial Evaluation Laboratory (FDEMATEL) technique and in turn to identify independent factors

3. To develop a fuzzy DEMATEL-TOPSIS techniques for evaluating and selecting LSPs based on their logistics performance, resources and services:

- **a.** To develop a new technique for evaluating and selecting LSPs based on their logistics resources and capabilities
- **b.** To develop an advanced model for quantifying LSPs' performance measurement and evaluation based on the Logistics Key Performance Indicators (LKPIs)
- **c.** To develop a new model for evaluating and selecting LSPs' based on their value-added logistics services

4. To integrate the three models' outcomes into one comprehensive strategic logistics outsourcing approach using fuzzy logic and the Quality Function Deployments (QFD) approach

5. To conduct some case studies to verify the proposed techniques and to show how these models can help DMs to perform an effective and efficient strategic logistics outsourcing process

The First objective aims to identify a set of critical LSPs evaluation and selection factors that are used to develop an advanced LSPs evaluation and selection framework. The literature review provides an initial view of the evaluation and selection factors and then questionnaires are used to ascertain logistics experts' opinions to test the validity and feasibility of the framework. Collected data are used for further framework development.

The Second and the Third objectives try to analyse the new LSPs' framework impact-relationship. The output of this analysis helps to understand the causal relationships of these factors and in turn to identify dependent and independent ones for further uses. Moreover, this objective aims to develop new three models to evaluate and select LSPs. The first one is a new model for evaluating and selecting LSPs' based on their logistics resources and capabilities. This model integrates the FDEMATEL and the Fuzzy Technique for Order Preference by Similarity to Ideal Solution (FTOPSIS) to analyse the logistics resources and capabilities impact-relationship, identify independent factors and therefore, evaluate and rank LSP alternatives based on their scores. The second one is a new model for quantifying LSPs performance measurement and evaluation. This new model integrates the FDEMATEL and FTOPSIS to analyse the LKPIs impact-relationship, identifies independent factors and therefore, evaluates and ranks LSP alternatives based on their performance scores. The third one is a new model for evaluating the value-added of the logistics services. This model integrates the FDEMATEL and FTOPSIS techniques to analysis the logistics services value-added impact-relationship, to identify independent services and therefore to evaluate and rank LSP alternatives based on their value-added scores. The Fourth objective aims to integrate the three models outcomes -the LSPs independent success factors (ISFs) - in one advanced strategic logistics outsourcing approach. The new approach uses the logic of the Fuzzy QFD (FQFD) technique to link the logistics service user (LSU)'s strategic objectives, logistics requirements and LSPs ISFs in one approach. This linkage enables the LSUs to be sure that the logistics outsourcing process is congruent with their strategic objectives and in turn to select the right LSP that is capable of providing logistics requirements to achieve their strategic objectives.

The Fifth objective aims to validate the effectiveness of the new integrated models through conducting case studies. These case studies show how DMs can improve their strategic logistics outsourcing through implementing the new integrated models.

1.4. Research Significance and Academic Contributions

There are a number of reasons why a research in logistics outsourcing is significant and is highly needed:

- The strategic importance of logistics outsourcing for all other sectors, not only in terms of transport but also as a strategic partner supports the LSUs to achieve their strategic objectives effectively and efficiently by taking the heavy load of logistics activities.
- The nature of LSPs-LSUs relationship has changed to be strategic in nature rather than a supportive one. Firms seek a dependable LSP to build a long-term strategic relationship as a kind of strategic partnership to achieve mutual objectives, which increase the importance of this research.
- The growing demand for logistics services worldwide and increasing the number of LSPs and their range of services increase the importance and complexity of the logistics outsourcing decision. The general trend is towards more complex and strategic outsourcing; several logistics activities and sometimes the entire logistics process is outsourced (Visuddhisat, 2009; Ho et al., 2015).
- Reviewing logistics literature shows that some logistics outsourcing studies failed to address the data uncertainty and factor interdependency problems. To overcome these deficiencies, this study aims to integrate the Fuzzy Logic, MCDM models and business models. This integration increases the popularity and applicability of such integrations to solve business and logistics problems.

In terms of academic contributions:

- By addressing an acknowledged gap in the logistics literature, this study enriches the literature by providing a comprehensive LSP evaluation framework reflecting the strategic nature of the logistics outsourcing process and considering the logistics data uncertainty and factor interdependency problems.
- Impact-relationship analysis helps to understand the logistics factors interdependency relationships and in turn to identify independent factors that are critical to the logistics outsourcing process.
- There is a crucial need to integrate research outcomes in one approach that helps DMs in their logistics outsourcing decisions. The new logistics outsourcing approach provides a more comprehensive evaluation process to be used by both upstream and downstream supply chain members.

- Testing new models and approaches in case studies provides empirical evidence to support the theoretical framework. The outputs of the testing case studies provide significant ideas and suggestions to improve the logistics outsourcing process.

1.5. Thesis Structure

The primary scope of this thesis is to develop an advanced methodology for strategic logistics outsourcing to enhance logistics-based decisions under uncertainty. Moreover, the scope of this research covers factors identification, framework development, impact-relationship analysis and the new strategic logistics outsourcing approach development. In order to achieve these research purposes in a systematic rational approach, this research was broken down into four main stages. These stages consist of:

1- Framework development and factors verification/validation

2- Impact-relationship analyses and independent factors identification

3- Strategic logistics-outsourcing approach development

4- Sets of industrial case-study validation

These four stages represent the key elements of the structural design of research methodology (Figure 1-1) and therefore, they directed thesis structure and data collection/analysis.

Stage One: Framework Development and Validation

At an early stage of this research, a comparative logistics outsourcing literature review was conducted and compared with previous literature review studies. Both the LSPs and LSUs perspectives were used to identify and verify the most important and/or used factors to develop the first LSP comprehensive framework. **Chapter 2** presents a comparative review of the logistics-base decision-making studies during the 2008-2013 periods. This review summarises the findings of logistics outsourcing studies, identifies the LSP evaluation and selection criteria/factors and methods, compares results with previous literature review studies, identifies problems in current literature and therefore to help in developing a new comprehensive LSP framework and suggests new techniques to help DMs in their logistics outsourcing decision-making process. **Chapter 3** summarises the research methodology, data collections toll and systematically presents the implementation procedures for the FDEMATEL and FTOPSIS integrated model to be used in stage two (Chapters **5, 6** and **7**). **Chapter 4** is based on the Jordanian LSPs and LSUs' perspectives to evaluate the level of importance and degree of use for each element of the new LSP framework and presents the first Jordanian logistics study using both primary and secondary data.

Stage Two: Impact-Relationship Analyses and Independent Factors Identification

In order to identify ISFs to be used in the logistics outsourcing process, factors' impact-relationships need to be analysed first. Chapters **5**, **6** and **7** integrate the FDEMATL and FTOPSIS techniques for evaluating and selecting the best LSP using various perspectives:

Chapter 5 introduces a new technique for evaluating and selecting LSPs based on their logistics resources and capabilities. This is the first approach that analyse the logistics resources interdependency and their impact-relationship. This approach combines the FDEMATEL and FTOPSIS techniques to address the impact-relationship between decision criteria and ranks LSP alternatives against the weighted resources and capabilities. The effectiveness of this approach is demonstrated through case study and a sensitivity analysis confirmed its robustness.

Chapter 6 introduces a hybrid model for quantifying LSPs' performance measurement and evaluation. This new model integrates the FDEMATEL and FTOPSIS techniques to address the impact-relationship between the LKPIs, identify independent indicators and rank LSPs against the weighted LKPIs to select the most appropriate one. Case-study data was used to demonstrate the new hybrid model effectiveness and a sensitivity analysis was used to confirm its strength.

Chapter 7 introduces a new model for evaluating the value-added of logistics services. This model integrates the FDEMATEL and FTOPSIS techniques to evaluate the impact-relationship between logistics services and in turn to evaluate LSP alternatives based on their expected logistics services value-added. Again, the effectiveness of this approach is demonstrated through case study and the sensitivity analysis tests confirmed its robustness. These three chapters analyse the framework factors impact-relationship and identify the ISFs to be used in the third stage (logistics outsourcing approach).

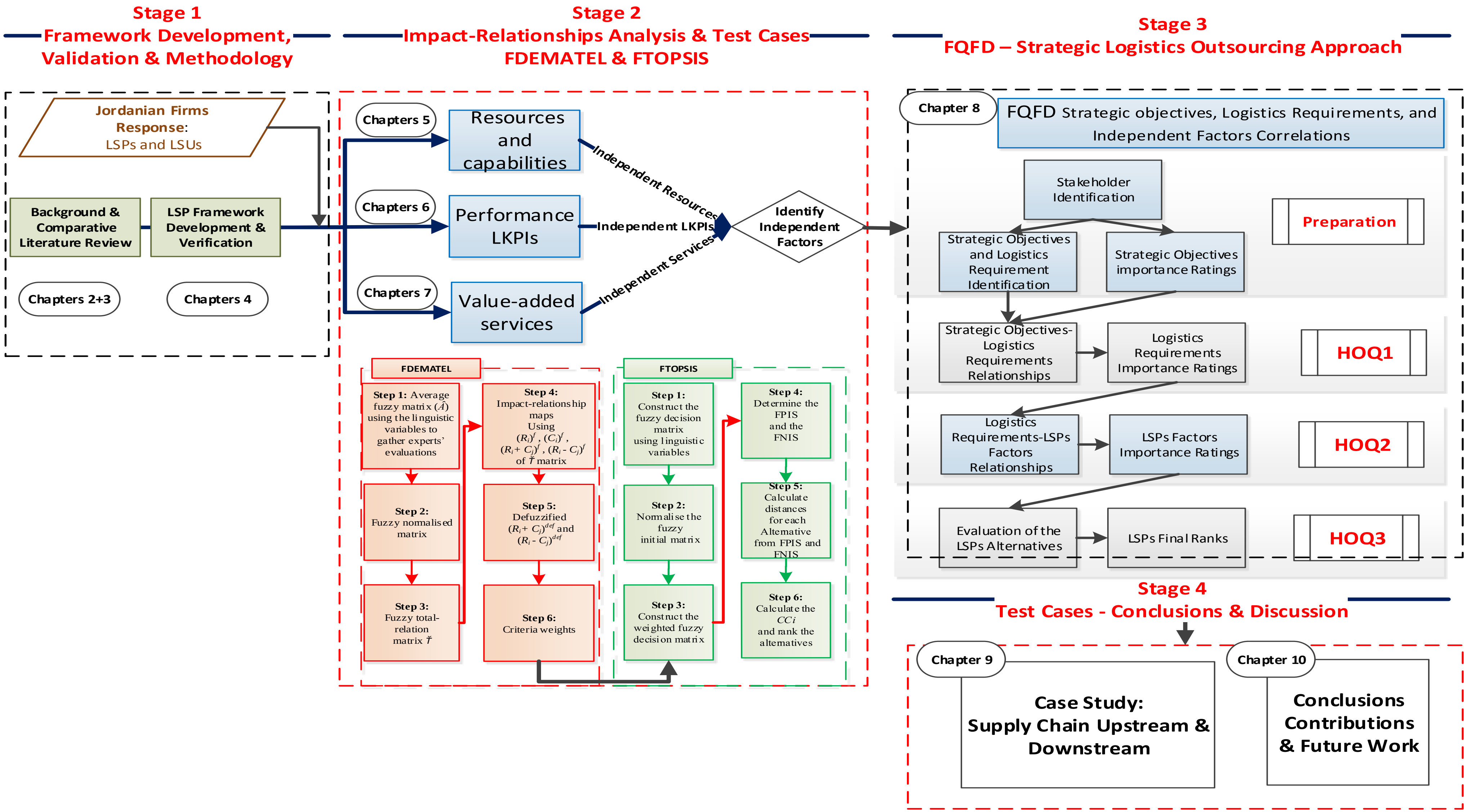

Figure 1-1: Research Flowchart and Thesis Structure

Stage Three: Strategic Logistics Outsourcing Approach.

Chapter 8 uses the ISFs to present a new logistics outsourcing approach. The new approach uses the logic of the FQFD technique to link the strategic objectives, logistics requirements and ISFs with one another. This approach enables DMs to evaluate and rank their strategic objectives, to identify crucial logistics requirements to achieve these strategic objectives and to link these logistics requirement with the ISFs and in turn with the LSP alternatives. **Chapter 7** presents systematic implementation procedures for the new FQFD technique and their equations.

Stage Four: Case Study

Two sets of industrial case-study data were used in **Chapter 9** to demonstrate the new hybrid model effectiveness. The first case study represents the upstream supply chain and the second case study represents the downstream. In each case, a number of DMs (stakeholders) were identified and a number of questionnaires were used to ascertain their responses. The new FQFD approach was used to link strategic objective, logistics requirements and LSPs ISFs for each case study. LSP alternatives were analysed against the weighted ISFs to identify their strength, weakness and strategic complement. Finally, **Chapter 10** summarises the work presented in the thesis, provides thesis overall conclusions and provides some suggestions about a web-based decision support tool (DST). Moreover, this chapter presents some of the research limitations and future works that can expand the research scope to include other dimensions of supply chain management.

Chapter 2: Background and Literature Review

Summary

In this chapter, a logistics outsourcing background is presented. Supply chain management, logistics management and logistics outsourcing were demonstrated. MCDM methods and their uses are presented. Moreover, relevant logistics literature is reviewed. Important literature regarding evaluation and selection processes, criteria and methods are reviewed and compared to identify new trends and gaps.

2.1. Introduction

LSPs evaluation and selection is a core process of the logistics management that is in turn a basic element of the big supply chain management (SCM) process. SCM concerns all processes, activities and resources that are crucial to facilitate the flow of materials, products, information and money between supply chain members in a way that helps the supply chain members to achieve their strategic objectives effectively and efficiently. SCM includes a number of relationship-management processes to create value for supply chain members. A large number of these processes are related to the logistics management, such as demand, orders and return management. This chapter provides more detail regarding the SCM, logistics management and logistics outsourcing processes and their hierarchy.

2.2. Supply Chain Management (SCM)

A supply chain is a system of organizations, people, activities, information and resources that are involved in moving products and/or services from supplier to customers (Leeman, 2010). Stevenson (2011) describes logistics management as the element of the supply chain management that is responsible for all activities related to goods, services and information flows and storage, such as planning, implementing and controlling. These activities include all forward and reverse flows between the point of origin and the point of consumption. Supply chain activities transform resources, raw materials and components into a finished product that is delivered to the end customer. According to the Council of Supply Chain Management Professionals (CSCMP**,** 2013), SCM encompasses the planning and management of all activities involved in sourcing and procurement, conversion and all logistics management. These definitions show the hierarchy of the SCM-logistics management. There are a number of initiative practices trying to improve the SCM processes and increase their effectiveness and efficiencies. Among these initiatives are the Supply Chain Council (SCC) Operations Reference (SCOR©), the Collaborative Planning, Forecasting and Replenishment project (CPFR) and collaborative supply chain grid (CSCG).

2.2.1. Supply Chain Council (SCC)

SCC is a global non-profit organization founded in 1996, initially including 69 voluntary members. The main purpose of this initiative is to provide the methodology, diagnostic and benchmarking tools to help the supply chain members to make improvements to their supply chain processes. The SCC has established the supply chain framework to evaluate and compare supply chain activities and performance (Supply Chain Operations Reference (SCOR) model). SCOR helps firms to determine and compare the performance of supply chain and related operations within their firms or against other firms (SCC, 2013). The SCOR process reference model contains:

- Performance metrics: Standard metrics to measure process performance
- Processes: Standard description of management processes and process relationships
- Practices: Management practices that produce best-in-class performance
- People: Training and skills requirements aligned with processes, best practices and metrics

2.2.2. Collaborative Planning, Forecasting and Replenishment (CPFR)

CPFR is a business initiative practice that combines the intelligence of multiple trading partners in the planning and fulfilment of customer demand (Seifert, 2003). This initiative practice was started in 1995 by Wal-Mart stores as a supply chain collaborative framework to facilitate the flow of information, goods and services. According to the Voluntary Inter-industry Commerce Solutions (VICS, 2013) this project aims to integrate business planning, forecasting and replenishment processes between the supply chain members through different levels of collaborations to fulfil customers' demand. Collaboration levels include collaborative assessment planning, store replenishment collaboration, Distribution Centre (DC) collaboration and retail event collaboration. CPFR aims to improve availability of goods and services and at the same time aims to reduce inventory, transportation and logistics costs by linking sales and marketing best practices. The collaborative practices in this project include four stages: *Analysis, Strategy and Planning, Demand and Supply management and Execution*. Each stage contains a number of planning, forecasting and replenishment practices at different levels. The CPFR project requires the continuous collaboration of all members to ensure the continuity of the project and to get the expected benefits for both suppliers and retailers. Cloud computing technologies can be used to facilitate the developing of such collaboration. Using cloud technologies in SCM leads to a new initiative called: Collaborative Supply Chain Grid (CSCG).

2.2.3. Collaborative Supply Chain Grid (CSCG)

The need to create a kind of computer-collaboration to share information and services was the main motive to develop what is called “grid service” in the early 1990s (Sepehri, 2012). The grid is a middleware between the operating system and the application (Kon et al., 2002) which facilitates the development of new software systems to support various activities. In SCM, collaboration is a critical factor for the SC effectiveness and efficiency. Full supply chain collaboration is not possible without providing the right technology that enables supply chain members to access real-time, dynamic information sharing. Grid technology can provide data management infrastructure to help access distributed resources within a collaboration. Today there are a number of collaborative systems such as Condor©, Globus© and Legion©. In order to define common standards for grid-based applications, the Global Grid Form (GGF) established the Open Grid Service Architecture (OGSA). This technology has been implemented in SCM to coordinate the supply chain practices by providing central entity software named the Collaborative Supply Chain Grid (CSCG) (Sepehri, 2012). The CSCG technology as a supply chain coordinator has three components:

- Monitor and Discover Service (MDS): collect information from supply chain members
- Optimization Module: make necessary calculations to provide decisions and recommendations
- Notification Service: notify supply chain member about the new decisions.

A number of challenges faces these initiatives. Supply chain members must provide skills and IT resources to implement the CSCG. They need to register themselves in the CSCG notification services to get up-to-date decisions and to feed the system with their up-to-date information through the MDS. The SCOR, CPFR, CSCG models require a full level of collaboration, trust and information sharing to work as expected. Advanced IT infrastructure software and hardware technology are needed to ensure real-time information sharing and smooth supply chain flows. Moreover, these models require excellent LSPs to facilitate the supply chain flows and to link the supply chain members, none of these models clarifies how to evaluate and select the best LSP.

2.2.4. Other SCM Models

In addition to the SCOR, CPFR and CSCG models, there are a number of models that have been used to evaluate supply chain performance. These models examined different performance dimensions, used various factors such as productivity, cost, time and flexibility and used a large number of performance measures and indicators. However, these models are not as popular as the aforementioned ones.

- Global supply chain Forum (GSCF): this model is based on three levels of analysis (strategic, tactical and operational) and uses three main performance dimensions (network structure, business processes and management components) to evaluate supply chain performance (Cooper et al. 1997).
- Strategic Profit Model: DuPont Corporation created the DuPont model to help them understand how changes in operations affect shareholders' value (Stapleton et al. 2002). Lambert and Stock (1993) formalised the DuPont model and introduced the strategic profit model. This model formulates to link between strategic and operational levels based on financial ratios calculations. It can be used to trace actions and their impacts on the financial results of the firm, which provide a good guide toward financial efficiency improvement. This model uses inventory, investments in fixed assets, expenses and working capital to build up the key measures of: net income, capital employed and return on capital employed.
- Activity-Based Costing (ABC): initially, it is a costing model use to identify activities and assign their costs according to their real resources consumption (Wang and Li, 2013). This model has been used to evaluate the efficiency of the supply chain performance in order to utilize resources and control costs.
- Economic Value-Added Analysis (EVA): an earned value management model used to measure firms' and projects' performance and progress through combining various costs and time measures. This model helps DMs (managers and stockholders) determine the true physical value of their firms. This model is used to evaluate the supply chain performance based on historical financial data to determine whether the supply chain really generates value or not.

2.3. Logistics Management

2.3.1. Introduction

Logistics is the concept of how to perform the materials, services, cash, information and products movement and storage to achieve the highest level of consumer satisfaction. Although 'Logistics' is a recognised concept, there is a misperception regarding its definition (Langley et al., 2009). This misperception appears because of the different terms that are used to describe logistics activities, such as distribution, physical distribution management, logistics management, material management, marketing logistics and industrial logistics, 'Logistics Management' is the most widely accepted term. In some literature, authors use logistics and supply chain interchangeably, but as indicated in the SCM definition, logistics is a key element of the SCM.

The entire process of logistics that deals with the moving of materials can be divided into three parts. (i) Inbound logistics, which represents the movement and storage of materials received from suppliers. (ii) Materials management, which covers the storage and flows of materials within a firm. (iii) Outbound logistics or physical distribution that describes the movement and storage of products from the final production point to the customer. Transportation flows can take various forms, such as road, rail, air, water, pipeline and digital. Firms can create various combinations of these forms based on the geographical location and/or availability of transportation forms. Regardless of the transportation form, each LSU needs to identify in a balanced way, what activities can be performed 'internally' and what can be outsourced to an LSP. To determine the extent to which outsourcing makes sense, LSUs need to strategically evaluate and select the best LSP. The following section provides more details regarding LSPs.

2.3.2. Logistics Service Provider (LSP)

Survey responses from 1,561 industry executives and managers representing users and non-users of LSP services and also responses from 697 LSPs' executives and managers, confirm that good LSPs continue to provide strategic and operational value, and provide new and innovative ways to improve logistics effectiveness (Langle 2012). LSPs perform logistics activities for other firms, such as in order processing, inventory management, transportation and warehousing management and material handling. LSPs provide desirable features, such as multiple logistics activities, integrated services and creative solutions to logistics/supply chain problems. These features and activities help to clarify the LSP identity.

Therefore, an LSP is a specialised firm providing various activities within the area of logistics management. Transportation, warehousing, picking and packing, light assembly, customisation, labelling and order processing are gaining greater prominence as outsourced activities. Moreover, LSPs can be involved in more customised operations, such as order taking, replenishment, invoicing and showroom management (Daim et al., 2013). More specifically, an LSP is ‘a special type of companies that perform complete or in part logistics services for their customers’ (Koster and Delfmann, 2007**,** pp. 130). The number of logistics services and activities have been significantly increasing and the LSPs offering such services and LSUs that use LSP’s services are expected to increase too (Freight Transport Association, 2013). Some LSPs are small, local actors meanwhile others are international, huge firms such as FedEx©, Ups©, Excel©, Menlo Logistics, Schneider Logistics and UTi© etc.

The concepts of LSP and Third Party Logistics (3PL or TPL) have been interchangeably used in literature. The CSCMP nearly uses the same LSP definition to identify the 3PLs. According to the CSCMP, 3PL is ‘a special firm that performs various integrated or bundle logistics services to be used by their customers’ (He, 2013**,** pp.190). According to Farahani et al. (2011), the 3PL concept emerged in the early 1990s as a special LSP type that offering consolidated services. Then, because of increasing demand for professional advanced logistics services, the (3PL) business developed. Now, 3PL represents the most well-known type of LSPs in supply chains (Andreas et al., 2013). Beyond the concept of 3PL, there are fourth party logistics (4PL), a firm that delivers a comprehensive supply chain solution through assembling and managing the resources, capabilities and technology of its own organization with those of complementary service providers. (Chu et al., 2004, p.131). Based on a comparative literature review, Kasperek (2013) identifies a kind of duality in the 4PL provider definition. Meanwhile some authors deal with the 4PL as a virtual operator using information system and technology to integrate the supply chain ordering process, other authors consider the 4PL providers as a natural evolution process of the 3PL. The 4PL outsourcing is an arrangement in which an LSU outsources some logistical operations to two or more specialist firms (3PLs) and hires another specialist firm (4PL) to coordinate the activities of the 3Pls (Dictionary, 2013). Some scholars classify LSPs into different types; Lu and Su (2002) differentiate between LSPs types:

- 1PL: a small company that executes its own logistics internally
- 2PL: a simple services provider, such as limited storage or transportation services
- 3PL: a logistics operator that offers a wide range of services and management
- 4PL: a single connection between a customer and the logistics operators, responsible for hiring other 3PLs and 2PLs and managing the logistics process.

A fifth level named 5PL represents e-business logistics that manages the supply chain parties using electronic services, it is a SCM conjunction with e-business.

The concept of 'LSP' includes different firms such as freight forwarders and couriers, and other firms integrating and offering subcontracted logistics and transportation services (Mangan et al., 2008). Another classification of the LSPs adds Lead Logistics Provider (LLP), which builds on the foundations of the LSP and additionally delivers a comprehensive supply chain solution with integrated skills just as 4PL. LLPs are not entirely asset free as 4PL, they own assets like 3PL but have the advantage of being capable of integrating the work of other 3PLs by virtue of their larger scale of operations and fleets (Bhatti et al., 2010). Meanwhile, Parashkevova (2007, pp. 32) uses logistics functions to classify LSPs into five types (Carrier companies, Warehousing Operators, Freight Forward/Broker companies, Optimizing services and Software processing programs) Hertz and Alfredsson (2003) used the logistics activities range to classify LSPs into four types:

1. **Standard LSP provider**: is the most basic form of an LSP provider; they would perform basic logistics activities such as pick and pack, warehousing and distribution functions
2. **Service Developer**: this LSP offers customers advanced value-added services such as tracking and tracing, cross-docking, specific packaging, or providing a unique security system. This LSP uses a solid IT foundation and focuses on economies of scale.
3. **The Customer Adapter**: this LSP comes in at the request of the customer and essentially takes over complete control of the company's logistic activities. This LSP improves current logistics activities, but does not develop a new service.
4. **The Customer Developer**: this LSP provider is the highest level that an LSP provider can attain with respect to its processes and activities. This occurs when an LSP provider integrates itself with the customer and takes over their entire logistics functions.

2.3.3. Activities and Services

One of the motivations for firms to outsource logistics activities is to provide a better collection of logistics services for their customers in a professional, effective and efficient way. LSPs offer various services, which vary in type, quality and cost. Some logistics functions can be achieved by SCM solutions, but Vaidyanathan (2005, pp.92) clarifies that LSPs' activities and services are not a substitute for SCM. There are some differences between services logistics and SCM. For example, LSPs are interested in the end-user satisfaction and dealing with just-in-case demand. SCM cares about lower inventory levels and deals with just-in-time demand. Moreover, the flow of links in the SCM is mainly one way and LSPs links flow is multi-direction. SCM stocking strategy is highly centralised and LSPs strategy is highly distributed.

According to Griffis et al. (2007) logistics activities as an element of the supply chain involve an integration of information, transportation, inventory, warehousing, material handling and packaging. Rao and Young (1994) classify a wide range of eight detailed LSP functions, as follows:

1. Planning Functions: Location selection, supplier selection, supplier contracting and scheduling
2. Equipment Functions: Selection, allocation, sequencing, positioning, inventory control, ordering and repairing equipment.
3. Terminal Functions: Gate checks and location control
4. Handling Functions: Pickup, consolidation, distribution, expediting, diversion and Trans loading.
5. Administrative Functions: Order management, document preparation, customs clearance, invoicing, inventory management, performance evaluation, information serves and communications
6. Warehousing Functions: Receiving shipments, inventory control and reshipment activities.
7. Pre/Post, Production Functions: Sequencing, assorting, packaging, postponement and marking.
8. Transportation Functions: modal coordination, line-haul services (moving of cargo between two major cities/ports) and tracking & tracing.

Because of the increasing demands for logistics services, the range of logistics services is broadened to provide more advanced and comprehensive solutions. This broad range motivates LSUs to demand more value-added services and to seek long-term cooperative relationships with LSPs (Wagner and Franklin, 2008). The wide-range of activities highlights the importance of the LSP in the SCM and increases the importance and complexity of the LSP evaluation and selection process. According to Soinio et al. (2012), there is a more strategic and long-term focus between LSUs and LSPs to improve market coverage, improve service level or increase flexibility towards end customers. These changes add a new meaning to the LSU-LSP relationship. In addition to the economic view in terms of cost reduction and economies of scale, relationships with LSPs become a strategic issue that increases the importance and the risk of the Logistics outsourcing process.

2.3.4. Logistics Outsourcing

Outsourcing stands for the transfer of activities that are usually carried out internally to external professional third parties (Smuts et al., 2010). This transfer may include foreign, domestic and/or offshoring contract relations. Outsourcing can take various forms, it can be outsourcing for some components, computer programming, services, tax and accounting services, customer services, transportation and logistics, compensation and human resources activities. Logistics outsourcing is one of the most common outsourcing forms that has attracted the attention of firms, academics and researchers in recent years. According to Erturgut (2012), logistics outsourcing serves five basic purposes: providing the cost leadership, capable to use the basic perfections, providing the competitive edge, harmonising with technology alterations and downsizing. The following section summarises the expected logistics outsourcing advantages and disadvantages.

2.3.5. Advantages and Disadvantages of Logistics Outsourcing

LSPs must differentiate themselves in order to stay competitive and therefore to motivate LSUs to select them. Altlay (2002) classifies the logistics outsourcing motives into four sources: Better focus on core competences, Suppliers' innovations and investments, Convert fixed costs to variable and Cost reduction. Because LSPs are more efficient than LSUs in terms of warehousing and transportation, costs reduction is the major benefit that LSPs offer to LSUs (Deepen 2007). LSP outsourcing directly affects the LSUs cost position through reducing capital investment requirements. Additionally, LSPs help LSUs to avoid any unnecessary investment in workforce and to manage their supply chain at an affordable cost. Another major benefit is the increase in flexibility. LSPs help firms to become more responsive to the customers' requirements. Based on a survey carried out by Accenture (a consulting, technology services and outsourcing company) it was found that the primary reason for outsourcing is the capability to focus on the core competencies, not cost reduction (Wadhwa and Ravindran, 2007). Altlay

2002's classification complements the Wadhawa and Ravindaran (2007) and Accenture survey outcomes that LSUs outsource their logistics activities for different reasons, not only cost. In another study, Rajesh et al. (2012a) found that firms were outsourcing for different purposes, such as:

- To improve management capability and improve reputation.
- Cost savings, increase flexibility, financial stability, consistency, value-added service and IT capability.
- Asset reduction, equipment flexibility, information & experience sharing and service variety.

Close to Rajesh et al. (2012a) and Altlay (2002), Hsu et al. (2012) find that, logistics outsourcing can reduce fixed costs and increase flexibility, allowing greater focus on the core activities, reduce heavy asset investments and improve the quality of service provided. Rajesh et al. (2013) base their views on a survey study in which they asked managers in different industries to indicate the importance of 3PL selection factors. The responses from 3PL users indicate that the most important reasons for logistics outsourcing were to focus on core competencies, followed by improvement in customer services and reduction in logistics costs. Moreover, it was found that operational activities are outsourced more than customer-related activities (such as order processing) and strategic nature activities (such as distribution).The potential benefits of using LSPs include taking advantage of their specialist knowledge, their well-developed information systems and their capability to obtain more favourable shipping rates (Stevenson, 2011). The importance of logistics outsourcing is become more recognised to meet the sustainability and environmental targets such as carbon emission (Kristel et al., 2014). Moreover, LSPs increase global inventory visibility, which helps to set up inventory hubs in key locations that rationalise inventory across the supply chain (Langle, 2012). From another perspective, LSPs have a better response to moving large- and small- sized shipments. To help LSUs in their logistics outsourcing decision, Rushton and Walker (2007) classify the advantages and disadvantages of logistics outsourcing into four groups:

- Organizational: Knowledge, experience, cultural issues and confidentiality of information.
- Financial: Capital, cash flow, fixed and variable costs, scale economies and cost control.
- Customer Services: Flexibility, additional services and delivery frequency.
- Physical: Product related, logistics network.

Meanwhile, Benn and Pearcy (2002) classify outsourcing benefits into three groups: strategic, impact on brand value and financial benefits. The strategic benefits consists of: focus on core competencies, quality of service, recruiting the best, better technology, wider skills pool, agility and employee benefits. Meanwhile the financial benefits include economies of scale, economies of process, cash flow, saving from IT efficiency and risk and gain share. Although some LSUs improve their core business activities and productivity measurements, inventory accuracy and flexible logistics services, other firms face problems because of bad choice and/or loss of control (Tsai et al., 2012). The decision to outsource includes a number of risks related to the loss of control over the logistic process, long-term commitment and the failures of some LSPs in conducting their own business transformation (Farahani et al., 2011). Therefore, the decision to outsource is critical. Effective logistics outsourcing provides good economics and strategic results, meanwhile, ineffective logistics outsourcing causes critical problems and loss of control. LSUs need to evaluate potential benefits/advantages against the potential disadvantages of the logistics outsourcing process. Based on logistics outsourcing literature, Table 2-1 summarises the main advantages and disadvantages of the logistics outsourcing process.

Table 2-1: Expected Advantages and Disadvantages of Logistics Outsourcing

Expected Advantages	**Expected Disadvantages (problems)**
Focus on Core Competences	Loss of control
Increase Management Capabilities	Poor Worker Quality
Saving Costs and Time	Poor Service Levels
Reduce Heavy Assets Investment	Misleading Feedback
Increase Flexibility and Agility	Coordination Problems
Increase Efficiency	Environmental Responsibilities
Value-Added Services and Service Varity	Increase System Complexity
Increase Global Inventory Visibility	More LSU-LSP coordination is needed
Sharing Responsibilities and Reduce Risks	Increase control cost
Economies of Scale	
Sharing Knowledge and Experiences	

In order to gain these advantages and avoid disadvantages, LSUs need to be more careful in their logistic outsourcing decisions. LSPs' evaluation and selection is an important strategic process that provides crucial information to support LSUs in their logistics-based decisions. Moreover, it is a MCDM process. Special skills and techniques are needed to address uncertainty, incomplete data and different quantitative and qualitative measures. Additionally, there are a large number of DMs with various opinions and preferences to satisfy. All these facts increase the importance and complexity of the logistics outsourcing decision. A number of studies provide various techniques and methods to evaluate and select LSPs. These studies use a large number of criteria in fragmented ways. The following sections provide a comparative review of the logistics outsourcing literature.

2.4. Logistics Outsourcing Literature

Evaluation and selection of LSPs is an important element in the logistics outsourcing process. Logistics activities are considered as one of the main activities that no longer need to be managed by firms themselves as they can be outsourced to a professional external party (Ho et al., 2012**;** Ciravegna et al., 2013) and many alternatives now exist for logistics provision. Firms seek to outsource logistics activities in order to avoid high fixed costs and heavy investment requirements associated with logistics and to focus more on their own basic activities. Logistics outsourcing has proven to be an effective strategy helping LSUs to achieve competitive advantages, improve customers' service-levels and reduce overall logistics costs (Boyson et al., 1999).

According to the 2015 19^{th} 3PL study[1], the logistics industry has its own challenges that affect the level and attractiveness of logistics outsourcing. The levels of the global economic activity are driving demand for outsourced logistics services (Capgemini, 2015). However, most of the logistics outsourcing studies are empirical in nature, focus on a specific area or country, are not comparative and are theoretically weak. Therefore, there is a crucial need for a comprehensive comparative study which considers all related criteria to build a comprehensive framework (Aguezzoul 2014).Current business threats, such as the effects of globalisation, economic recession and sustainability issues, increase the levels of uncertainty and motivate firms to rethink the way they evaluate and select their external partners. Additionally, the number of firms specialising in outsourcing has increased in line with the growth of outsourcing as a strategy, thereby making it difficult for LSUs to find appropriate LSPs (Büyüközkan et al., 2008**;** Chen et al., 2011**;** Andreas et al., 2013). This trend of rethinking ways of selecting LSPs has become even more prominent since the economic recession of 2008. Given this new trend, three questions can be raised: (i) To what extent old evaluation/selection criteria and methods still fit with current business priorities? (ii) If they do not, then what are the appropriate criteria and methods? (iii) Based on the most used selection criteria and methods, how can we develop a new LSPs selection framework? Answering these three questions is very important since it helps businesses making better logistics outsourcing decisions and in

[1] 3PL study is an annual study initiated by Dr. C. John Langley in the mid-nineties to follow up the evolution of the 3PL providers and their transition to strategic logistics partners (www.3plstudy.com).

turn to have a better competitive edge. The following literature review sets out to answering the questions by studying a number of LSPs' evaluation and selection papers since 2008 when the economic downturn occurred, identify any possible shift in the way LSPs are evaluated and selected, compare results with previous literature review studies, identify literature problems and gaps and finally propose a new LSPs framework.

2.4.1. Summary of Previous Literatures

Research used different terminologies to refer to external logistics partners such as 3PL, LSPs, supplier and service provider. Although there are different terminologies, the evaluation and selection process, follows the same general approach. The "supplier" and "3PL" or "LSP" concepts have been used interchangeably in studies such as that of Li et al. (2012) and Xiu and Chen (2012). Aguezzoul (2012) conducts a comparative study in terms of criteria and methods between the selection of suppliers of goods and that of suppliers of logistics service providers (such as 3PL). She found that both processes use nearly the same criteria, but the importance order of these criteria is not the same.

In 1966, Dickson et al. provide 23 selection criteria that are used to evaluate and select suppliers (Dickson et al., 1966). A large number of studies have been carried out based on Dickson's selection criteria. After Dickson's (1966) study, a number of literature review studies were conducted: Weber et al. (1991), Degraeve et al. (2000), Boer et al. (2001), Zhang et al. (2004) and Ho et al. (2010). Each study extends the work of others.

Weber et al. (1991) conduct a literature review for the period 1966 -1991 to discover the main criteria used during this period to determine their relevance to supplier selection decisions. After reviewing 74 papers, they found that: Net price, delivery and quality were the most used criteria. Degraeve et al. (2000) provide a systematic approach to compare the relative efficiency of supplier selection models in Dickson (1966), Weber et al. (1991) and other studies in the period 1991-2000. Degraeve et al. (2000) use the concept of Total Cost of Ownership (TCO) as a basis for comparing supplier selection models.

Boer et al. (2001) review the decision methods used in the supplier selection literature. They extended previous reviews by classifying existing models into a framework. They identify several operational research methods, such as Technique for Order of Preference by Similarity to an Ideal Solution (TOPSIS) and distance from target (Hwang and Yoon, 1981), Maxi-min and Linear assignment (Chen and Hwang, 1992), Step Method (STEM) (Vincke 1986) and Even Swaps (Hammond et al., 1998). Based on this analysis, Boer et al (2001) conclude that most of the papers focused on manufacturing firms, most attention was paid to the choice phase more than steps prior to that phase and not all the methods are equally useful in every situation. Except for the identification of some operational research methods, this paper did not add that contribution to the evaluation and selection literature.

Zhang et al. (2004) review supplier selection articles during the period of 1992-2003. Forty-nine articles were analysed to summarise the shared selection criteria. To differentiate their review, Zhang et al. presented a numerical example to illustrate different selection criteria and methods and to compare the advantages and disadvantages of these selection methods. Benyoucef et al. (2003) summarise various problems of supplier selection (such as selection criteria and methods) and the existing methods to solve these problems. They suggest three dimensions to evaluate and select suppliers: Performance, Quality and Business Structure/Manufacturing Capability with a number of sub-criteria under each dimension.

To find the most common methods to evaluate and select external suppliers, Ho et al. (2010) review the literature from 2000 to 2008. This study analysed the approaches used, discussed popular evaluating criteria and categorised MCDM papers into two groups. (1) Individual approaches use one method or technique, such as Data Envelopment Analysis (DEA), Analytic Hierarchy Process (AHP), Analytic Network Process (ANP) and Simple Multi-Attribute Rating Technique (SMART). (2) Integrated approaches integrate two or more models such as Integrated AHP, Integrated Fuzzy Approaches such as FAHP and other approaches, such as integrated ANP with Goal Programming and DEA with SMART. According to this study, DEA was the most popular approach during that period because of its robustness and its capability to handle qualitative and imprecise (fuzzy) data. During that period, most of the integrated approaches adopted an AHP technique. The AHP popularity comes from its simplicity, ease of use and flexibility to be modified according to the DMs' needs and preferences. Additionally, Ho et al. provide a statistical analysis of the most popular evaluation criteria such as quality, delivery and price/cost respectively. Ho et al.'s paper was published in 2010 and covered the period 2000-2008; thus, the findings regarding selection methods provide some indicators regarding the shift in the used methods during that period and highlight the increasing role of MCDM integrated methods. To find how Malaysian manufacturing firms select their suppliers, Sim et al. (2010) review certain literature and classified the criteria into three main groups (i) Qualifying Criteria: Cost, Quality and Delivery. (ii) Selection Criteria: Services, Supplier relationship and management and Organisation. (iii) Additional Criteria: Good Reputation, Financial

Status and Geographical Location. The studies of Weber et al. (1991), Degraeve et al. (2000), Boer et al. (2001), Zhang et al. (2004) and Ho et al. (2010) show some fluctuation in the scope and methods used in the evaluation and selection studies. The later studies reviewed by Ho et al. (2010) are more comprehensive, deal with problems from different points of view and use more relevant criteria. Additionally, later studies apply some of the MCDM methods to address the increasing complexity and uncertainty in the business environment in general and the logistics sector in particular. In contrast, the earlier studies reviewed by Weber et al. (1991) use a large number of selection criteria in a fragmented way.

Some logistics studies use statistical analysis to compare logistics services in two countries (Liu and Lyons, 2011), or investigate the environmental impact of LSPs (Mao 2012) and others are based on the SCOR model to evaluate the logistics effectiveness within supply chains (Lai et al., 2002). Liu and Lyons (2011) analyse the 3PL performance and service provision. This study identified the most important services offered by 3PLs and the most important aspects of 3PL operational performance. Moreover, this research based on statistical analysis to compare the Taiwan and UK 3PLs service providers are based on a long list of performance and service capabilities criteria. They found that, 3PLs with service capabilities that correspond to the key priorities of customers can gain superior financial performance through a better operational performance. Mao (2012) investigates the environmental impact of the UK logistics industry. Fourteen sustainable measures and their interrelationships are used in this investigation. Study findings highlight the importance of cost-effectiveness as a critical factor determining the firms’ sustainability policies. This study provides good data regarding the UK LSPs’ environmental sustainability, through using various environmental measures and environmental solutions, but it takes one sustainability dimension (environmental) and ignores others (social and economic). Mao's study can evaluate some of the LSPs' environmental impacts, but it is not suitable for evaluation and selection process. Based on the SCOR model, Lai et al. (2002) develop a measurement instrument for supply chain performance in transport logistics. A 26-item instrument constructed to reflect the shippers’ services effectiveness. The instrument includes two main processes: the customer facing (the supply chain reliability and flexibility & responsiveness) and internal facing (costs and assets) with a number of performance indicators under each dimension. This instrument focuses on one side of the logistics process (shipping) and uses only operational measures.

From another perspective, Tsai et al. (2012) investigate the dark side of logistics outsourcing. They analysed potential risks that may lead to failure of the 3PLs-customers relationships. They used three main sources of risks: relationship, asset and competence risks and their inter relationships. The results of this study highlight the need for relationship management to moderate the risks in assets and competence. A number of studies propose different models to evaluate and select LSPs. Most of these studies are based on the AHP technique such as (Bhatti et al., 2010**;** Daim et al., 2013**;** Falsini et al 2012**;** Rajesh et al., 2011**;** Xiu and Chen 2012). Bhatti et al.'s (2010) model chooses parameters of 3PL selection in global-lead logistics provider environments. Four main criteria (Vendor status, logistics competence, quality of service and IT-based competence) with 16 sub-criteria were used to build this model. Similar to Bhatti et al.'s study, Daim et al. (2013) apply the AHP method to evaluate and select 3PL providers for international business. Six main criteria (Cost, Service level, Global capabilities, IT capabilities, Expertise/experience and Strong local presence) with their sub-criteria are used to evaluate four 3PL providers. Additionally, they found that a simple ranking of the criteria produced very similar aggregate weights provided the number of experts is high enough. Meanwhile, Falsini et al. (2012) integrate AHP, DEA and Leaner Programming (LP) in one model to evaluate and select LSP. Quality and Reliability, Speed of service, Flexibility, Costs, Equipment, Operators' safety and Environmental safeguard are the main selection criteria used. The purpose of integrating AHP, DEA and LP was to overcome the limitations of the AHP method, but this integration increased the complexity of the model and made it difficult to use. Additionally, the appropriateness and comprehensiveness of criteria is a matter of investigation. Rajesh et al. (2011) integrate AHP with QFD to develop a three-phase "AQUA" model. This model uses five ranked business metrics (cost reduction, financial visibility, risk mitigation, information technology capability and on-time delivery) with seventeen 3PL selection criteria to evaluate and select the 3PL provider. Again, AHP technique has been used here, which affects the novelty of this research. Additionally, some business metrics used in this model are not comprehensive and a large number of logistics requirements are used as business metrics. Xiu and Chen (2012) integrate the AHP and entropy methods to evaluate and select LSPs. Similar to other AHP studies; a limited number of criteria are used (Operational capability, Service level, Price, development potential and Green level). More AHP logistics studies are discussed in the comparative review section (2.4.2.).

Other studies used the ANP technique to try to overcome some of the AHP drawbacks. Alvandi et al. (2012) provide an integrated ANP-DEMATEL MCDM model to rank the LSPs BSC perspectives and the related KPIs under each perspective. This model was used to measure the causal relationship between the perspectives and to the relative weights too. Customer perspective was the most influential factor. Total price of parts, customer satisfaction and lack of parts in production were the most influential KPIs. This performance framework has a limited number of indicators and is designed to fit with spare part suppliers only. In another logistics study, Karia (2011) found the impact of bundling some logistics resources on the LSPs' performance. LSPs' performance was measured in terms of three categories: customer services, innovation and cost, with a number of sub-measures. Jharkharia and Shankar (2007) present a two-stage methodology for LSPs selection: preliminary screening of available LSPs and ANP-based final selection. A number of criteria have been identified and used to construct an ANP model. The compatibility between the user and the provider is the most important determinant that influences the final selection decision. In addition to compatibility, they used cost, quality and reputation. Jharkharia and Shankar's (2007) model is based on three main levels: determinants, dimensions and enablers. Each level consists of a number of sub-elements. The methodology used to select these elements is not clear. Moreover, using ANP in selection problems limits the number of criteria used due to the need to build the super-matrix. Rajesh et al. (2012a) provide a model to choose the best alternative using PROMETHEE technique in an MCDM uncertain environment. Only four main evaluation criteria (Price, Reliability, Flexibility and Economic Conditions) were used.

Other studies provide some logistics models for specific purposes. For example, Chaabouni and Dhiaf (2013) provide a conceptual model to describe the LSU-LSP relationships in order to improve the LSU-LSP interactions and in turn trust. Meanwhile, Chao and Shah (2010) provide a special SMEs logistics outsourcing model. They try to find if the SMEs logistics outsourcing practices differ from the processes suggested in logistics literature or not, in order to determine how SMEs should develop and perform logistics outsourcing process. Bolumole et al. (2007) apply multiple social theoretical perspectives to develop a theoretical logistics outsourcing framework to examine and evaluate the logistics outsourcing strategy. This framework shows that, a number of theories can explain the logic of logistics outsourcing strategy such as General systems theory, Resource-based theory, Channel theory, Transaction-Costs-Economics, Agency theory, the Value-chain concept and network theory. This theoretical framework consists of three perspectives: Cost, Economics and Strategic, with six dimensions to consider: factors influencing logistics outsourcing decision, the supply chain role of the 3PL, reasons for outsourcing, strategic orientation of client firms, the extent of outsourcing and the nature of the client-3PL relationship. Furthermore, Mello et al. (2008), addressed the inconsistency between the logistics outsourcing models that are prescriptive using a top-down, proactive, systematic and strategic-competence process, and the actual reactive, ad-hoc and limit-strategy-driven decision-making process. They presented a descriptive model of logistics outsourcing strategy based on the grounded theory research method. They found that, both cognitive and experiential search & evaluation are crucial in logistics outsourcing decisions. Based on Bolumole et al. and Mello et al.'s theoretical models, LSUs need to integrate between their professional experiences and the 'prescriptive' model to have an effective and efficient logistics outsourcing process. However, a number of questions regarding the logistics outsourcing need/reasons, extent/scope, objectives, contract, performance measurement and LSU-LSP relationship should be answered first.

LSPs must address the increasing uncertainty, cost pressures and supply chains' complexity and at the same time to fulfil continuously changing customer demands. These challenges explain some of the changes that appear in LSP literature. Moreover, the review of aforementioned studies shows that, there is no existing research that actually covers the period from 2008 – until now. This creates an important gap in current research, given that the year 2008, as a turning point when the economic recession started, might have affected the way LSPs are normally evaluated and selected. This study attempts to close this gap by reviewing 56 logistics-related studies during 2008-2013. Over the course of the author's research study, Aguezzoul (2014) review selection criteria and methods that are used in 67 3PL articles during the period 1994-2013. The number of reviewed papers is insufficient to reflect trends and shift during this long period (20 years), only 27 articles for the period 2007-2013 are used.

2.5. A Comparative literature review of the LSPs Evaluation and Selection Studies

At the early stage of this research, a literature review of LSPs evaluation and selection studies during the period 2008-2013 was conducted. An intensive literature review regarding evaluation and selection criteria and methods in the logistics industry has been conducted. A number of related journals from common accessible international databases such as Web of Science, Science Direct (Elsevier), web of knowledge and Emerald have been interrogated in searching for keywords such as: logistics; LSP/3PL; LSPs evaluation and selection; LSPs' selection methods; LSPs' selection criteria; supplier selection; and Fuzzy/MCDM methods. A large number of articles were found. A careful review of the papers' abstract and keywords helped to screen out these articles based on logistics based decision-making and MCDM methods as inclusion criteria. Each article’s title, abstract and key words have been checked against these inclusion criteria. Therefore, fifty-six evaluation and selection articles related to the research questions were selected to be reviewed. Each article has been reviewed with a focus on interest and purpose, evaluation and selection method(s) and evaluation and selection criteria being used. Appendix 2-1 summarises the articles’ purposes, methods and selection criteria.

2.5.1. The Comparative Review Findings and Discussion

2.5.1.1. Studies’ Distributions

Table 2-2 shows the studies’ distribution based on their publication year, Table 2-3 shows the studies’ Journal distribution. The journals Expert Systems with Application and Journal of the Operational Research Society have the highest number of published papers. Meanwhile, year 2012 comes first with total number of published studies. It is expected to have more studies regarding this important issue in the coming years.

Table 2-2: Studies Distribution - Publishing Year

#	Year	# of studies	Studies
1	2008	7	10, 26, 31, 32, 34, 35 and 43.
2	2009	12	9, 11, 19, 21, 33, 36, 37, 42, 44, 45, 47 and 48.
3	2010	10	14, 15, 18, 24, 25, 27, 38, 41, 50 and 55.
4	2011	11	1, 4, 8, 12, 17, 39, 40, 49, 51, 52 and 53.
5	2012	13	2, 3, 5, 6, 13, 16, 20, 22, 23, 28, 29, 46 and 56.
6	2013	3	7, 30 and 54.
	Total	**56**	

Table 2-3: Studies Distribution - Journals

#	Journal	#	Studies
1	*Expert Systems with Applications*	4	8, 19, 23 and 54
2	*Journal of the Operational Research Society*	4	14, 51, 52 and 53
3	*Int. J. of Production Economics*	3	20, 34 and 45
4	*Journal of Manufacturing Technology Management*	3	6, 30 and 46
5	*Benchmarking: An Int. J.*	2	39 and 47
6	*Industrial Marketing Management*	2	37 and 41
7	*Int. J. of Services and Operations Management*	2	4 and 48
8	*Int. J. of Services Technology and Management*	2	36 and 42
9	*Resources, Conservation and Recycling*	2	44 and 56
10	*Applied Mathematical Modelling*	1	40
11	*Asia Pacific Journal of Marketing and Logistics*	1	33
12	*Australian Journal of Basic and Applied Sciences*	1	50
13	*Computers and Industrial Engineering*	1	32
14	*Computers and Operations Research*	1	29
15	*European Journal of Marketing*	1	17
16	*Health Research Policy and Systems*	1	7
17	*Industrial and Engineering Chemistry Research*	1	43
18	*Information Sciences*	1	35
19	*Int. J. for Quality Research*	1	22
20	*Int. J. of Business Information Technology*	1	15
21	*Int. J. of Electronic Business Management*	1	1
22	*Int. J. of Electronic Customer Relationship Management*	1	9
23	*Int. J. of Industrial Engineering Computations*	1	55
24	*Int. J. of Information, Business and Management*	1	13
25	*Int. J. of Innovative Computing, Information and Control*	1	38
26	*Int. J. of Logistics Systems and Management,*	1	11
27	*Int. J. of Management and Enterprise Development*	1	21
28	*Int. J. of Physical Sciences*	1	12
29	*Int. J. of Production Research*	1	3
30	*Int. J. of Uncertainty*, Fuzziness and Knowledge-Based	1	24
31	*Journal of Computers*	1	2
32	*Journal of International Manufacturing*	1	16
33	*Journal of Modelling in Management*	1	25
34	*Journal of Multi-Criteria Decision Analysis*	1	5
35	*Journal of Software*	1	28
36	*Journal of Supply Chain Management*	1	10
37	*Management Decision*	1	18
38	*Marine Policy*	1	31
39	*Supply Chain Management: An Int. J.*	1	27
40	*Transport Policy*	1	49

Based on the work and contribution presented in these papers, they are classified into seven groups:

- LSPs evaluation and selection Case study (specific firm, industry, or country): Studies 1, 6, 13, 14, 17, 18, 25 and 43.
- General LSP evaluation and selection: Studies 2, 3, 4, 5, 9, 10, 11, 19, 21, 22, 24, 26, 28, 29, 30, 32, 33, 36, 47, 48 and 50.
- Integrated models for LSPs evaluation and selection: Studies 1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 16, 19, 21, 23, 24, 26, 29, 30, 32, 33, 34, 36, 38, 40, 42, 43, 44, 45, 46, 47, 49, 51, 52, 54, 55 and 56.
- Strategic logistics outsourcing: Studies 23, 27, 34 and 46.
- Reverse LSPs (RLSPs) evaluation and selection: Studies 20, 39, 41, 42 and 44.
- LSPs evaluation and selection decision under vagueness: Studies 2, 6, 8, 9, 10, 11, 12, 16, 19, 22, 23, 24, 26, 29, 32, 33, 34, 35, 36, 38, 39, 40, 44, 46, 49, 54
- Other logistic-based evaluation and selection decisions: Studies 7, 8, 12, 15, 31, 35, 37, 38, 40, 45, 49, 51, 52, 53, 54, 55 and 56.

The following discussion provides more insights regarding selection methods, logistics sustainability and selection criteria.

2.5.1.2. Evaluation & Selection methods

An analysis of these studies provides a clear picture of current trends in logistics literature: 37 papers out of 56 used integrated models to solve evaluation and selection problems. Twenty-two studies out of the 37 studies integrated MCDM methods with Fuzzy sets in order to address data uncertainty problems. These integrations reflect the complexity and difficulties inherent with these kinds of decisions and the high levels of uncertainties that face DMs.

Returning to Ho et al. (2010) section (2.4.1.), DEA was the most used method during 2003-2008. For the recent period of 2008-2013, however, this research shows that DEA was used only twice. The decreasing in DEA frequency use helps other techniques such as FAHP, FANP, DEMATEL and TOPSIS to have a stronger presence. During the 2008-2013, AHP and ANP are the most used methods (33 studies). Some studies used AHP or ANP alone (Studies 7, 14, 18, 25, 28 and 41) and other studies integrated them with other methods such as DEA, ANN, QFD, DEMATEL and TOPSIS to overcome the interdependency and uncertainty aspects. AHP assumes independency between factors. ANP extends AHP to relax the restrictions of the hierarchical structure that indicates criteria independency. ANP needs complex calculations to handle the super matrix that includes all the factors in one comparison process. In such case, researchers attempt to reduce the number of factors to provide a sense of applicability and to help experts and DMs to build the pairwise comparisons between criteria and alternatives smoothly. DEMATEL and TOPSIS represent a perfect mix to solve complex problems; particularly if they are integrated with Fuzzy sets to reflect the preferences of DMs under uncertainty and vagueness environments (Dalalah et al., 2011 and Baykasoğlu et al., 2013). The DEMATEL technique can represent DMs preferences and reflects the cause-effect relationships of evaluation criteria. This technique was used in the studies 40, 51, 52, 53, 54, 55 and 56. TOPSIS is the most ranking technique integrated with other MCDM methods to evaluate and select LSPs. TOPSIS was used with DEMATEL (study 54), with FAHP (studies 8, 9, 22, 26, 30, 34 and 47) and with ISM (study 44). Meanwhile, there was a limited presence of the PROMETHEE method (studies 6 and 24). Based on the number of studies that used these methods, Figure 2-1 summarises the relative size of the most used methods and their integrations. The size of the circles represents how often these methods were used while circles' overlap represents integrated methods.

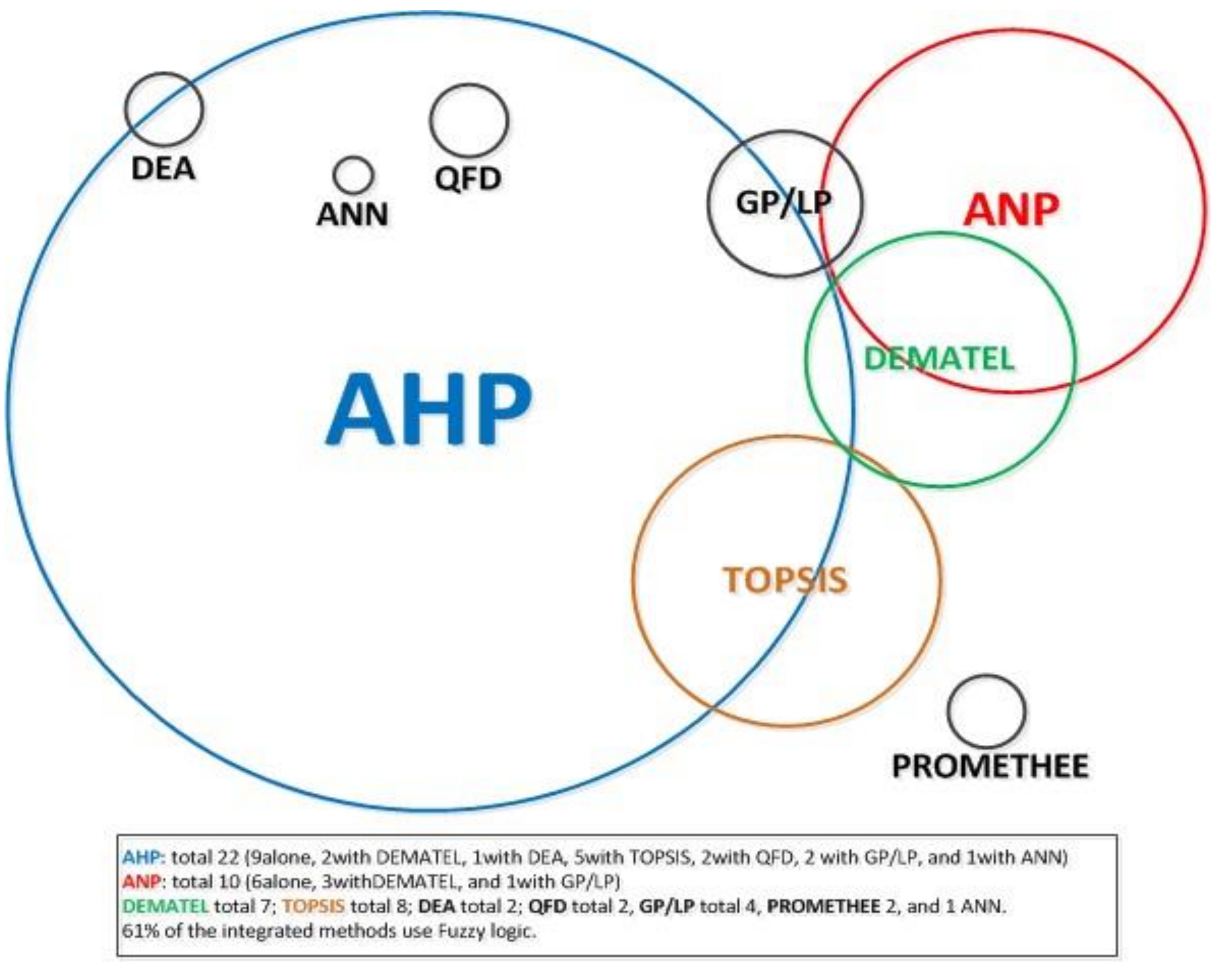

Figure 2-1: Distribution of the Most Used Selection Methods in the 56 Studies

2.5.1.3. Sustainability and Logistics

Sustainability is one of the top global concerns and it has an increasing importance in logistics and SCM fields. The logistics industry includes various activities with different sustainable impacts, such as transportation, inventory and warehousing, packaging, reverse logistics and waste management. According to Mao (2012), transportation has the biggest environmental impact due to huge transport networks, continuous vehicle usage and the disposal of vehicles, oils and parts. The number of logistics and SCM studies that use sustainability and environmental issues is increasing significantly and the call to integrate sustainability within a firm's strategy has increased too. Fifteen studies out of the 56 studies reviewed and analysed within this research used sustainability measures to evaluate and select the appropriate LSP (studies 1, 2, 5, 12, 16, 19, 21, 23, 32, 34, 35, 46, 50, 54 and 56). These measures cover various sustainability issues such as environmental safeguards (CO_2 and waste volume), social measures (social responsibility, health and safety and donations) and economics (best use of resource and resources productivity).

2.5.1.4. Evaluation & Selection criteria

Various evaluation and selection criteria have been used to evaluate and select the best LSP. Based on this literature review, Cost/price in addition to quality, flexibility and services are the most used criteria. Table 2-4 summarises the presence of the most used criteria in the 2008-2013 logistics studies.

Table 2-4: Presence of the Most Used Selection Criteria in 2008-2013 Studies

Criteria	Times used	%	Accumulate %	Rank	Area
Cost/Price	32	16.84	16.84	1	Performance
Quality and Reliability	28	14.74	31.58	2	Performance
Flexibility and compatibility	21	11.05	42.63	3	Performance
Services	21	11.05	53.68	3	Services
Financial measures	16	8.42	62.1	4	Performance
Sustainability measures	15	7.89	69.99	5	Performance
Delivery	13	6.84	76.83	6	Performance
IT	12	6.32	83.15	7	Resources
Management and Organization	10	5.26	88.41	8	Resources
Risk	6	3.16	91.57	9	Services
Geographical Location	5	2.63	94.2	10	Resources
Reputation and status	4	2.11	96.31	11	Resources
Relationship and collaborations	4	2.11	98.42	11	Resources
Global abilities	3	1.58	100	12	Resources
Total	**190**	**100**			

To identify any possible shift in the way LSPs are evaluated and selected, Table 2-5 and Figure 2-2 compare the evaluation and selection criteria during different periods. Due to the difference in the studies' durations and/or the attractiveness of the logistics topic over these periods, there is a significant difference between the paper numbers in each period. Although these studies used various terminologies, the metrics chosen in these studies have been used to measure the same dimensions. For example: net price, price, cost, and cost of service were used to evaluate the service cost dimension. In term of used criteria, there is a clear consensus about cost, quality, flexibility, services, financial measures, sustainability and delivery with a 76.83% accumulated percentage. Other criteria are representing different DMs' preferences and points of views such as the IT, management & organization, risk, geographical location, reputation and status, relationships and global abilities factors with 23% accumulated percentage.

Table 2-5: Percentage of Evaluation and Selection Criteria through Different Periods

#	Criteria	**Weber et al. 1966-1991** (74 Papers = 2.9 papers/year)		**Ho et al. 2000-2008** (78 Papers = 8.6 papers/year)		**This Work 2008-2013** (56 Papers = 9.3 papers/year)	
		#	**%**	**#**	**%**	**#**	**%**
1	Net Price/Cost	61	82	63	81	32	57.1
2	Delivery	44	59	64	82	13	23.2
3	Quality	40	54	68	87	28	50
4	Production facility and capacity	23	31	39	50	0	0
5	Geographical location	16	22	0	0	5	8.9
6	Technical capacity	15	20	25	32	12	21.4
7	Management and Organization	10	14	25	32	10	17.9
8	Reputation and position in industry	8	11	15	19	4	7.1
9	Financial position	7	9	23	29	16	28.6
10	Performance history	7	9	0	0	0	0
11	Repair services	7	9	0	0	0	0
12	Attitude	6	8	0	0	0	0
13	Packaging ability	3	4	0	0	0	0
14	Operational controls	3	4	0	0	0	0
15	Training aids	2	3	0	0	0	0
16	Bidding procedural compliance	2	3	0	0	0	0
17	Labour relations record	2	3	0	0	0	0
18	Communication system	2	3	0	0	0	0
19	Reciprocal arrangements	2	3	0	0	0	0
20	Impression	2	3	0	0	0	0
21	Desire for business	1	1	0	0	0	0
22	Amount of past business	1	1	0	0	0	0
23	Service	0	0	35	45	21	37.5
24	Research and Development (R&D)	0	0	24	31	0	0.00
25	Flexibility	0	0	18	23	21	37.5
26	Relationships	0	0	3	4	4	0.071
27	Risk	0	0	3	4	6	10.7
28	Safety and Environment	0	0	3	4	15	26.8
29	Global abilities	0	0	0	0	3	5.4

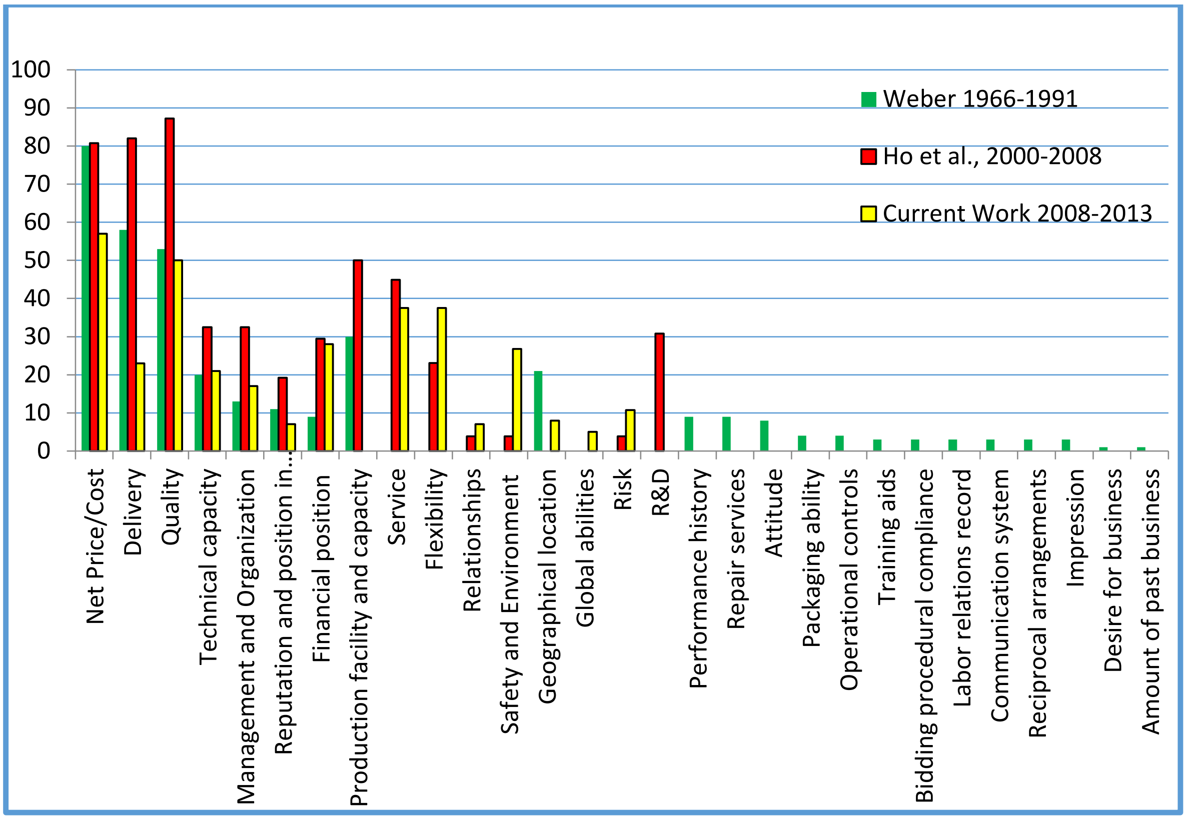

Figure 2-2: Comparative Chart of the Selection Criteria Percentages

These data are related to three independent literature review studies. So, they are not assumed to reflect a normal distribution. Therefore, to test the hypothesis of independence and to confirm the existence of significant difference the Kruskal-Wallis non-parametric test was applied (Corder and Foreman, 2009). Kruskal-Wallis test compares factors' rankings of three or more independent groups. In this case, there are 29 criteria; each criterion has three rankings (87 total rankings). For example, rankings of Net price/cost are 84, 85 and 79 respectively. Based on the Chi-square table, with 28 degrees of freedom (*df*) and 0.05 Alpha, the decision rule for this case is (41.33). The Kruskal-Wallis value (*H*) is calculated based on Equation 2- 1:

Equation 2- 1: Kruskal-Wallis Test

$$\boldsymbol{H = \frac{12}{N(N-1)} * \left(\sum \frac{T_i^{\,2}}{n}\right) - 3(N+1),}$$ (Source: Corder and Foreman, 2009: pp.100)

Where (*N*) is the total number of criteria (87), (*n*) is the number of values from the corresponding ranking sum (3), (T_i) is the sum of the rankings from a particular group, ($df = k-1$) k is the number of criteria in each group (29). In this case, calculated H= 54.364 is greater than the decision rule (41.33), which confirms that, there is a significant difference between the three literature review studies in terms of the 29 criteria [H= 54.364 (28, N=87), p>0.05].

2.5.2. Current problems in the LSPs' literature

The findings of this study clearly highlight a number of problems in the LSPs evaluation and selection literature. Most of the current studies are empirical, not comparative nor comprehensive and theoretically weak. A number of evaluation approaches are unbalanced. There are a large number of criteria and metrics that are presented in fragmented ways, making it difficult to identify the critical success factors (CSFs). Additionally, existing frameworks focus only on costs, financial and/or operational metrics. Moreover, there is an ignorance of logistics sustainability, logistics resources, logistics-outsourcing risks and logistics value-added services factors -this potentially affects the completeness of the evaluation process. So far, there is no analysis on the causal relationships of critical success factors and how they may affect each other. Finally, current investigation of the strategic nature of the logistics outsourcing decision is inadequate.

2.5.3. Literature review conclusions:

Based on the literature review analysis we can arrive at the following conclusions:

1. The work and contribution of the reviewed studies are classified into seven groups: specific LSP case-study, general LSP evaluation and selection, integrated selection models for LSPs evaluation and selection, strategic logistics outsourcing, reverse LSPs, logistics-based decisions under vagueness and other logistics-based decisions.
2. There is increasing importance of the integrated models and fuzzy logic in evaluation and selection studies. Integrated models for evaluating and selecting decisions under vagueness are the most explored areas, while strategic logistics outsourcing and reverse LSPs are the least explored ones.
3. On average, the number of logistics studies per year is increasing during the research periods. Meanwhile, the number of main evaluation criteria/dimensions is decreasing. Earlier studies have a large number of criteria with wide importance levels in a fragmented way. Later studies have a lower number of criteria with relatively close importance levels. This suggests that later studies were more balanced and used more relevant criteria than earlier studies. Some of the low-ranking criteria, -which appeared in less than 10% of the studied articles in Weber et al.'s (1991) study have become some of the main criteria used in the 2008-2013 period. For example, financial position, performance history, amount of past business, operational control, and communication systems are clustered into more holistic and balanced dimensions. Therefore, some of Dickson et al.'s (1966) criteria did not appear in the later literature with the same terminologies. Either they are more relevant to supplier selection than

LSPs selection, or they are clustered into new dimensions such as (i) Performance history, labour relations record and amount of past business can be clustered into the logistics performance dimension. (ii) Packaging abilities and production facilities can be clustered into the logistics service dimension. (iii) Communication systems in addition to some of Weber et al.'s (1991) criteria such as R&D can be clustered into the logistics resources and capabilities dimensions.

4. Cost, Quality, flexibility, services, financial measures, sustainability and delivery represent 76.83% of the criteria used during the 2008-2013. The relative importance of these criteria is not the same during different periods. For example: Cost and Delivery were more important than Quality during the period of 1966 to 1990. Quality became more important during the 1990s through to 2008. After 2008, Cost and Price returned to being the most important criteria, which can be explained by the economic situation in these periods. Moreover, evaluation and selection criteria can be categorised into three main dimensions: Performance (financial, customer and operational), Resources (tangible and intangible) and Services.
5. Based on Tables 2-4 and 2-5, evaluation and selection criteria can be classified into three groups (i) Basic criteria (order-qualifier) such as Cost/Price, Quality, Delivery, Management, Technology and Finance. (ii)Winning criteria (order-winner) such as Flexibility, Sustainability, Innovation, Risk and R&D and (iii) Additional criteria related to special features relevant to a specific firm or industry at a specific point of time.
6. Evaluation criteria can be categorised into three main dimensions: logistics performance (financial, customer and operational), logistics resources (tangible and intangible) and logistics services (breadth, variety and value added of the services). Each dimension is categorised into sub-dimensions and metrics based on the DMs' preferences and/or availability of data.
7. Logistics outsourcing risk is not used in the 1966-1991 reviewed studies and it has a limited existence in the 2000-2008 studies. The importance of logistics outsourcing risk increased in the 2008-2013 studies (9, 23, 35, 46, 47 and 56). Currently, logistics risk (assessment and management) is an important research topic in the logistics literature (Tsai et al., 2012) and it is expected to be one of the important issues in the international logistics agenda.
8. In terms of selection methods, although AHP and ANP are the most used methods, DEMATEL and TOPSIS techniques integrated with Fuzzy logics seems to be a good choice to evaluate, rank and select the best LSPs. Their capability to analyse criteria

impact-relationship, identifying independent factors and to evaluate and select the best LSP effectively and efficiently increase their potential in the logistic-based decisions.

Based on the previous findings, current studies have not yet provided an appropriate, holistic and balanced tool to evaluate and select LSPs. There is a crucial need for a good theoretical, comprehensive and balanced LSPs framework. Chapter 3 provides more detail regarding this framework.

2.6. Chapter Contributions

This chapter provides a brief background of supply chain, logistics management and logistics outsourcing concepts. SCM, logistics management, LSPs and their related issues have been presented in a hierarchical way. Moreover, this chapter reviews related papers to identify most used criteria and methods in logistics literature. Based on a comparative literature review, chapter contributions are summarised by:

- Review LSPs literature during the 2008-2013 period
- Compare results with previous LSPs literature
- Identify most used criteria for various logistics-based decisions
- Identify most used methods to evaluate and select LSPs
- Identify main gaps and literature problems

Chapter 3: LSP Framework and Research Methodology

Summary

In this chapter, a new Three-dimension LSP framework is presented. Each dimension based on a well-known theory to structure the LSP evaluation factors. The second part of this chapter summarises the research methodology. MCDM method, Fuzzy logic and other decision-making techniques that can be used in logistics-based decisions are demonstrated. Additionally, Data collection methods and experts' selection criteria were presented and justified., Finally, a systematic implementation procedure of the integrated FDEMATEL-FTOPSIS approach has been presented.

3.1. LSPs Evaluation and Selection Framework

3.1.1. Introduction

LSPs evaluation and selection is a very important process. By selecting the right LSP, logistics services, suppliers' value and customers' value can be significantly improved (Mentzer et al., 2004**;** Mangan et al., 2012**;** Daim et al., 2013). Given the emergence of new selection/evaluation criteria and a lack of appropriate tools for selecting and evaluating LSPs, there is a crucial need for a new LSPs framework. This study sets out to solve this problem by proposing a new LSPs evaluation and selection framework. This framework aggregates the most relevant and critical factors that have been used fragmentally in logistics studies. Based on the literature review conclusions, this framework covers the main three competitiveness dimensions: (i) Logistics performance, (ii) Logistics resources and capabilities and (iii) Logistics services. This framework based on the idea that the appropriate LSP should have a superior competitive position through providing:

- Excellent performance records (operational, financial and non-financial metrics)
- Distinguished logistics resources and capabilities and
- A wide range of value-added logistics services

The aim of this framework is to provide the basis for new research to develop new LSP evaluation and selection models. The three main dimensions should provide evaluations that are more balanced and reduce the likelihood of selecting inappropriate LSPs. Therefore, it helps DMs to be more confident about their logistics-based decisions. For each dimension, a well-known theory has been used to define the dimension's factors, sub-factors and metrics. The following sections summarise the main factors, sub-factors and metrics that can be used under each dimension.

3.1.2. Logistics Performance

3.1.2.1. Background

LSPs performance is a basic element of any evaluation and selection process. LSUs select LSPs based on their past performance records; assuming that the anticipated future performance is based heavily on past performance results. Historically, a number of approaches have been used to measure and evaluate logistics performance as an element of the supply chain performance, such as: Activity-Based Costing (ABC) (Wang and Li, 2013**;** Chen, 2012**;** and Walton, 1996) and EVA (Sainz et al., 2013**;** Lin and Zhilin, 2008; and Liu and Lyons, 2011). These approaches were not initially designed for SCM or the logistics industry, being based heavily on financial metrics that are driven by historical data and thus present unbalanced approaches. According to Lapide (2000), these financial measures are historically oriented rather than forward-looking; ignorant of the importance of strategic and non-financial performance metrics; and not directly tied to operational effectiveness and efficiency. Additionally, there is a problem in deciding the number of measures/metrics to be used in performance measurement tools. In certain cases, a few effective metrics may be better than a large number of complex measures (Papakiriakopoulos and Pramatari 2010**;** Forslund 2014). Another problem is related to the performance metrics at the strategic, tactical and operational levels. Gunasekaran et al. (2001); Gunasekaran et al. (2004); Stadtler and Kilger (2008); and Halme (2011) provide performance metrics classifications to be used for these three levels. The Balanced Scorecard (BSC) approach is one of the most commonly used approaches to manage and measure firms' performance (Chen et al., 2011**;** Alvandi et al., 2012). BSC helps firms to achieve long-term objectives while keeping in mind the traditional financial measures.

3.1.2.2. Logistics Performance Literature Review

A number of literature reviews have summarised supplier evaluation and selection criteria in general, such as (Weber et al., 1991**;** Degraeve et al., 2000**;** Boer et al., 2001**;** Zhang et al., 2004; and Ho et al., 2010). Meanwhile other studies focus on the logistics industry in particular, such as (Aguezzoul 2014). These literature reviews list a large number of evaluation criteria and methods that have been used in different studies. Additionally, they provide various perspectives of the best criteria/methods to be used in logistics outsourcing processes. Focusing more on the logistics outsourcing decision, Table 3-1 summarises some logistics-based studies.

Table 3- 1: Summary of some Logistics-based Studies and their metrics

Studies	Focus	Main Indicators/metrics
Aguezzoul (2014)	3PL evaluation and selection criteria and methods (1994-2013)	Cost, Relationship, Service, Quality, information equipment, Flexibility, Delivery, Professionalism, Financial position, Location and Reputation
Alvandi et al. (2012)	BSC perspectives Integrating ANP and KPIs	Learning and Growth, Internal Process, Customer and Financial with a number of sub-metrics
Forslund (2012)	Performance management process from LSPs' and users perspective	Similarities: Selecting performance variables, Defining Metrics and Capturing real-time data Differences: Target Setting, Report-Making and in perceiving demand for performance management
Visuddhisat (2009)	Developing measures to assess logistics operational performance	Five main dimensions with 22 metrics: Delivery, Order Quality, In-Storage Handling, Personal Quality and Flexibility
Hamdan and Rogers (2008)	Performance Measurements (items picked in terms of lines, broken case, full case and pallet)	Labour (hours), Space (sq. ft.), Capital ($) and Broken-Cases
Griffis et al. (2007)	Aligning Logistics performance measures to the real needs of the firms	Fourteen logistics KPIs are suggested such as on-time delivery, logistics costs and days order late. Most of the 14 KPIs are operational ones and their contribution to achieve the firm's objectives is not clear
Knemeyer and Murphy (2006)	Evaluating LSP performance from a Marketing Perspective	Seventeen items used to measure LSP performance: 10 for Logistics Operations Performance, 5 for Marketing Channel Performance and 2 for Asset Reduction
Lohman et al. (2004) and Krakovics et al. (2008)	Use performance indicators to represent the Efficiency achieved by a process or part of it compared to a goal	**Internal Client:** Operational Efficiency, Inventory Accuracy, Internal Operational Product Damage **External Client:** External Operation Product Damage, Distribution Efficiency **Finance:** Distribution Cost, Moving and Storage Costs, **External Impact:** Information Quality for Planning, Demand Availability
Turner (1999)	Indicators to evaluate firms competitiveness	Cost, Productivity, Quality and Time

The Griffis et al. (2007) literature review suggests a list of 14 logistics KPIs: On-time delivery; Logistics costs as a percentage of sales; Days order late; Inventory turnover; Complete order fill rate; Average order cycle time; Order cycle time variability; Items picked per person per hour; Average line item fill rate; Weeks of supply; Average backorder fill time; Sales lost due to stock-out; Percentage error pick rate; and Logistics costs per unit. Most of these suggested KPIs are operational ones and their contribution to achieve the firm's objectives is not clear. More financial, customer and learning and growth KPIs are needed.

In another study, Visuddhisat (2009) developed measures to assess logistics operational performance. Based on responses from 207 logistics managers, she categorised the measures into five main dimensions with 22 metrics:

1. Delivery: Delivery to correct destination, On-time delivery, Delivery of complete order, Cargo space confirmation and Order cycle time.
2. Order Quality: Thefts during transit, Accurate inventory reports, accurate inventory records, accurate data entry, correct order, On-time pick up and damage due to transportation.
3. In-Storage Handling: Accurate order picking, Accurate put away, accurate storage location and dock-to-stock time.
4. Personal Quality: Staff training, prompt response to enquiries and staff education, skills and experience.
5. Flexibility: Additional manpower at short notice, Prompt reaction to special request and Expedite urgent shipment.

The review of existing literature shows that there is no clear consensus regarding a specific approach that can organise all of these indicators in one holistic balanced model. Moreover, there is no clear consensus regarding the critical/key indicators to use. However, comparing the literature review results (Table 2-5) with the aforementioned studies shows that, there is a certain consensus about some logistics performance indicators, such as cost, quality, flexibility and delivery. Meanwhile, some indicators represent various preferences and points of views, such as services, technology, financial stability, environment, culture and strategy. The following indicators are the most commonly used:

- Costs: LSP efficiency is a basic performance indicator that reflects an LSP's capability to control processes within acceptable limits to give a firm the main competence to support its competitive advantage.
- Quality: this performance indicator measures an LSP's capability to provide goods and services that meet and exceed customer expectations; this includes internal and external customers.
- Flexibility: this performance indicator measures an LSP's capability to address market, customer, local and global changes that affect its performance in an effective and efficient way.
- Financial status/strength: this performance indicator measures an LSP's profitability (net profit), financial position (in term of cash flow), returns (such as return on assets and return on investment), cost of returns and its financial leadership (market share).

- Sustainability: this performance indicator measures an LSP's efforts and actions to be more sustainable, within its three levels (economic, social and environmental); sustainability has become a basic performance indicator used in nearly all sectors.
- Delivery: this performance indicator is at the heart of the main logistics processes. Delivery speed and accuracy include a number of measures and indicators used to ensure delivery of an order in the right time, location, procedures and conditions are a basic LSP performance dimension.

Different measures/metrics can be used under each performance indicator. A special approach is needed to structure indicators and their metrics in one holistic framework and therefore, to link the structure with the LSU's strategic objectives.

3.1.2.3. Current work:

This literature review shows that the selection of the best measures depends on the circumstances. This study does not aim to determine specific measures to be used by LSUs and LSPs under all situations. Instead, it aims to assist logistics researchers and DMs to select measures that fit with their situations and match their preferences. To serve this purpose, sustainable balanced scorecard (SBSC) and LKPIs have been used to develop the LSPs performance dimension. The new framework has been developed to link LSUs' strategic objectives, evaluation and selection dimensions (SBSC perspectives) and LKPIs in a hierarchical structure to facilitate the decision-making process. To make this determination, the BSC perspectives have been revisited to fit LSPs case, as follows:

- **Financial strength perspective**: represents the financial performance levels (costs and revenues) that an LSP needs to provide to support the achievement of the customers' strategic objectives. **LKPIs are**: Profitability, Return and cash, Costs and Flexibility.
- **Customer satisfaction perspective**: represents the performance indicators that satisfy the LSPs' customers. **LKPIs are**: Service quality and reliability, Service flexibility and Customer sustainability.
- **Logistics processes perspective**: represents the internal performance indicators that support the strategic objectives for both LSPs and their customers. **LKPIs are**: Logistics quality, Logistics productivity, Timeliness and Process sustainability.
- **Learning and growth perspective**: represents the sustainability, learning, growth and improvement indicators that support other BSC perspectives and help LSPs to achieve their strategic objectives. **LKPIs are**: Human talent, Innovation and development and Resources sustainability.

Based on the level of the analysis and/or availability of the data, for each LKPI under each perspective, different performance measures can be used. Figure 3-1 summarises the hierarchy of the LSPs performance.

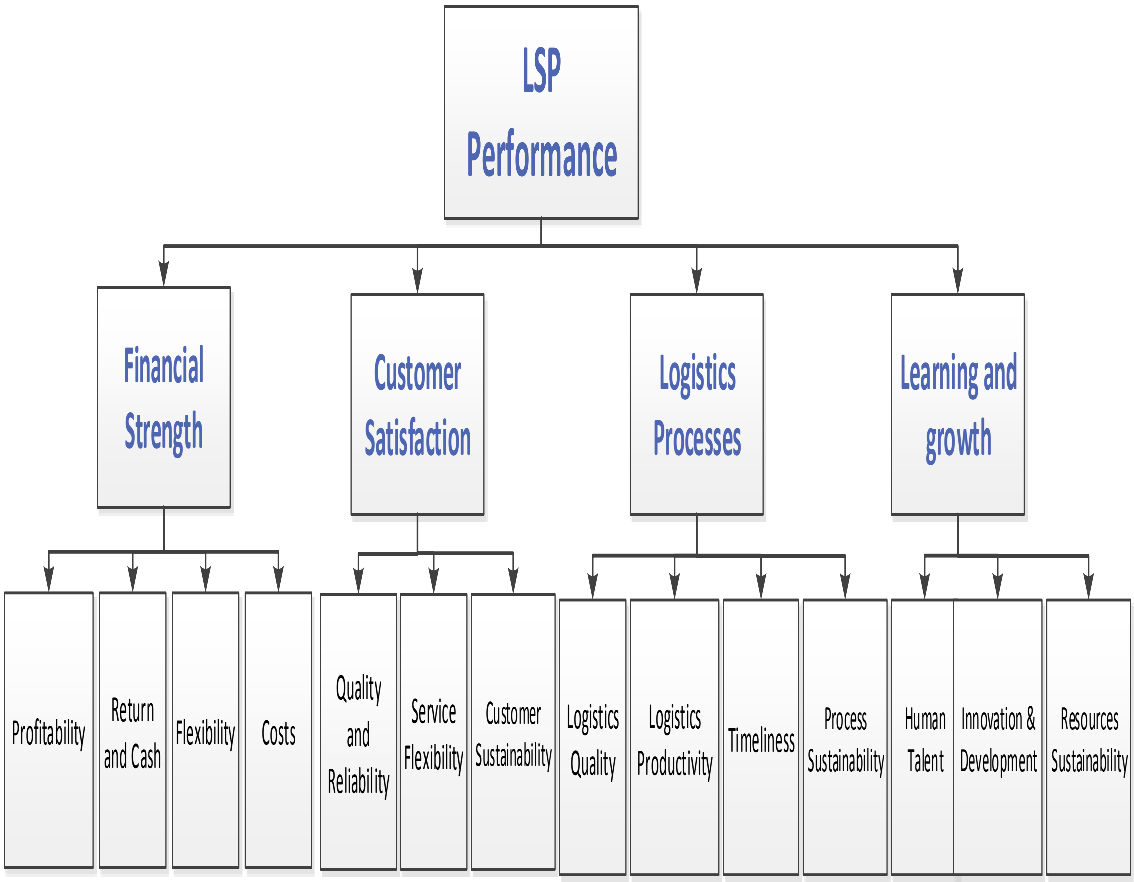

Figure 3- 1: LSPs performance

3.1.3. Logistics Resources & Capabilities

3.1.3.1. Background

Differentiate logistics resources and capabilities are important core competences that support the LSPs competitiveness. According to Karia and Wong (2013), LSPs must gain the right capabilities to transform their logistics resources into superior logistics performance levels. Historically, Mentzer et al. (2004) divide logistics resources into tangible and intangible resources. Logistics resources, either tangible or intangible must be managed in the right way to gain distinctive logistics capabilities, which in turn help to build and sustain strong logistics competitive advantages. Karia and Wong's (2013) study is based on Mentzer et al. (2004) and the resources-based view (RBV) theory to develop the resources-based logistics (RBL) theory, which argues that logistics resources and capabilities are the determinants of the LSPs performance.

3.1.3.2. Logistics Resources Literature Review

A number of studies have identified the strategic resources of LSPs and their effects on LSP performance from various perspectives. During the 1990s, a limited number of studies investigated LSPs' resources and capabilities and analysed the relationship between LSPs' resources and capabilities and to their performance (Chiu 1995**;** Kahn and Mentzer 1998; and Larson and Kulchitsky 1999). Other studies, such as that of Novack and Wells (1992), investigated the strategic aspects of LSPs' resources and capabilities in terms of creating competitive advantage. Dramatic changes in the number and types of LSPs had occurred by the late 1990s, which in turn affected the number, nature and scope of logistics studies. The increasing demand for, and number of, LSPs augmented the number of studies of the logistics sector in general and of LSP evaluation and selection in particular.

Hunt (2001) analysed the effect of the availability of tangible and intangible resources on a firm's capability to produce efficiently and effectively, classifying resources into financial, physical, human, organisational, informational and relational resources. Lai et al. (2008) found that logistics resources and capabilities have a significant positive relationship to firm performance and affect LSPs' competitiveness. Hartmann and Grahl (2011) studied the flexibility of LSPs using RBV to measure the impact of this flexibility on customer loyalty. Karia and Wong (2013) used the RBV theory to develop the resource-based logistics (RBL) theory, which argues that logistics resources and capabilities are the determinants of LSP performance.

In addition to financial measures, a number of non-financial measures have been used to analyse the relationship between LSPs' resources and capabilities and a firm's performance. Ryoo and Kim (2015) analyse the impact of the knowledge complementarities on the supply chain performance. They use two supplier and buyer samples to test the knowledge complementarities, inter-firm knowledge exchange and supply chain performance. Positive and significant relationships were found between knowledge exchange and supply chain performance. Ramanathan et al. (2014) analyse the impact of the RFID usability features in the UK LSPs adoption of this technology. A positive influence of the RFID usability over the adoption level has been found. Meanwhile, Vlachos (2014) evaluates the impact of RFID practices on supply chain performance. He found that the implementation of RFID practices significantly affected the supply chain performance in different areas such as supplier, inventory, distribution, sales and forecasting**.** Knemeyer and Murphy (2006) focused on LSPs' relationships as the main logistics resources that affect firm performance. Min et al. (2005) used a similar approach to investigate the collaboration between LSPs and users and the effects of the collaboration on performance indicators, such as effectiveness, efficiency and profitability. Other studies used the RBV theory to list and analyse logistics resources and capabilities and to investigate the effects of these resources and capabilities on firm performance. The RBV theory allowed researchers to see the entire picture by including large numbers of resources and capabilities (Lowson 2003 and Aldin et al., 2004). Shang and Marlow (2005) found that logistics performance is related to IT and information-sharing resources. Similar to Shang and Marlow (2005), Wu and Huang (2007) and Huang et al. (2006) used RBV to investigate the effects of logistics IT capabilities on firm performance. Wu et al. studied supply chain IT capabilities and Huang et al. studied an individual logistics firm. In addition to the financial indicators, Wu and Huang (2007) used market indicators, such as market share and competitor rankings, to analyse the effect of supply chain IT alignment and advancement on firm performance.

There is a strong relationship between LSPs' resources and capabilities and their performance. Despite this strong relationship, logistics resources and capabilities have not been used to evaluate and select LSPs. This finding provides a valid base for using logistics resources and capabilities to evaluate and select the most appropriate LSP. This study is one the first studies that models the logistics outsourcing process to provide a hybrid model to evaluate and select the best LSP based on the tangible and intangible resources of the LSP. The FDEMATEL and FTOPSIS techniques were combined into one hybrid model in this study. The following sections provide a systematic description of the main components of this hybrid model.

3.1.3.3. Current work

This study uses the general Mentzer et al.'s (2004) resource classification and the RBL theory to establish the resources and capabilities dimension in the LSPs evaluation and selection framework.

Under tangible resources, there are two main categories: physical and technology resources. Physical resources represent the LSP's capability to acquire, use and maintain logistics vehicles, machines, tools and facilities. RBL classified physical logistics resources into two general dimensions (facilities and equipment and warehousing and transportation). This study, however, classifies physical logistics resources into four categorises based on the logistics activities: Warehousing (storage area, handling equipment, cranes and winch, etc.); Transportation (trucks, trains, planes, ships, etc.), Production and packaging and Improvements to and maintenance of these resources. Technology resources (IT-based resources) cover the infrastructure components such as computers, communication tools, databases, etc. This study classifies IT resources into three categories: Physical IT resources, Communication tools and databases, IS and internet-based technology. Intangible resources represent all valuable, unique, inimitable non-physical assets that enable LSPs to use and optimise their tangible assets and perform their activities and logistics operations in an effective and efficient way. RBL classified intangible logistics resources into three categories (management expertise, relational and organisational resources). This study uses the intellectual capital concept to classify intangible logistics resources and capabilities. Intellectual capital is the amount by which the market value of an LSP exceeds its tangible (physical and financial) assets less liabilities (Mehri et al., 2013).

Normally, intellectual capital is classified into three main categories: human, structural and relational. Therefore, intangible logistics resources and capabilities sub-dimension consists of:

1- Human Resources: the value that the LSP's employees provide through the application of skills, knowledge and expertise. Human capital covers how effectively an LSP uses its human resources. Logistics human resources consist of education and training, knowledge and experience and skills.

2- Structural Resources: includes all the supportive non-physical assets, such as; non-physical infrastructure, processes, procedures and databases of an LSP that enable human capital to perform various functions. It is close to the physical IT tangible resources. This dimension covers the software side while physical IT covers the hardware side. Logistics structural resources consist of databases and software, processes, image and reputation and LSP's culture.

3- Relational Resources: includes all relations with customers, suppliers and other LSPs that help and support the LSPs to perform various logistics activities. Logistics relational resources consist of collaboration, long-term relationships and information sharing.

Figure 3-2 clarifies the hierarchy of the tangible and intangible logistics resources. Various quantitative and qualitative measures can be used to evaluate each resource's dimension.

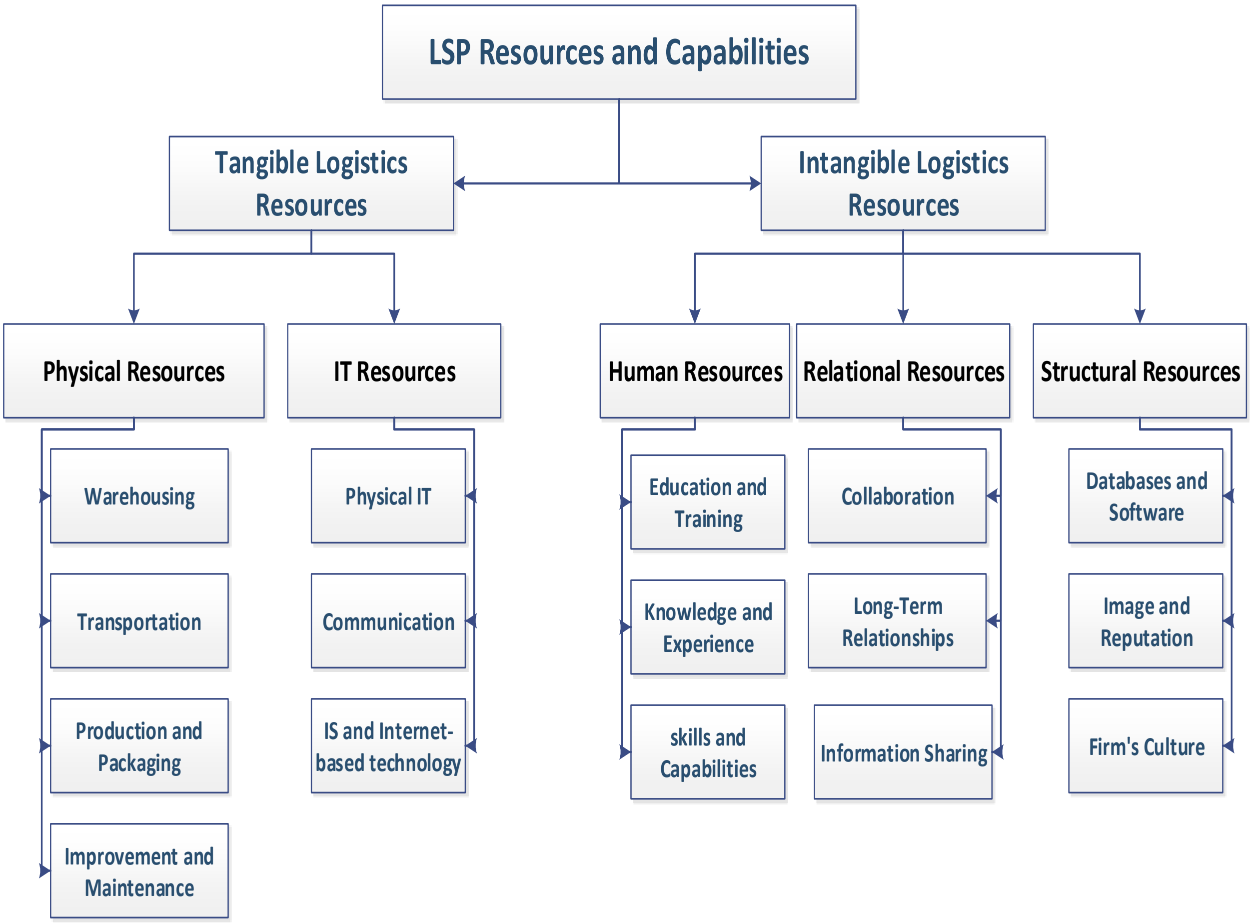

Figure 3- 2: LSPs resources and capabilities

3.1.4. Logistics Services

3.1.4.1. Background

Due to the increasing demand for logistics services, there is a big opportunity for LSPs to develop a full range of logistics services that satisfy customers' needs. Adding the logistics services dimension to the LSPs evaluation and selection framework improves the evaluation quality. Historically, Hsiao et al. (2010) classify logistics services into four groups: inventory and logistics services, warehousing services, transportation services and customer services with a large number of logistics services and activities. Sink and Langley (1997) and Rajesh et al. (2011) classify them into: Inventory and Warehousing Services, Transportation Services, Production and Packaging Services and Customer Services. Mangan et al. (2012) and Daim et al. (2013) present various logistics services and functions where Logistics services are classified into main four groups: inventory and logistics services, warehousing services, transportation services and customer services. However, this classification underestimates the potential of e-commerce and does not offer the full range of services required by online business, which has shown a fast growth in the logistics sector.

3.1.4.2. Logistics Services Literature Review

One of the main motivations for firms to outsource logistics services is to provide a better collection of logistics services for their customers in a professional, effective and efficient way. With a growing number of LSPs and the emerging demand of advanced logistics services, LSPs must differentiate themselves and search for innovative approaches to improve their services and/or provide new logistics services. To make this determination, LSPs acquire new resources, provide new logistics services and adopt new logistics technology, which increase the importance of IT's role in the logistics industry. LSPs offer various services varying in type, level of quality and definitely cost. Vaidyanathan (2005) clarified that, LSP's activities and services are not a substitute for SCM. Due to the differences between logistics services and SCM, logistics functions cannot be achieved by SCM solutions. For example, LSPs are interested in end-user satisfaction and dealing with just-in-case demand, while SCM focuses on lower inventory levels and deals with just-in-time demand. According to Wagner and Franklin (2008), LSPs broaden their logistics services range, which in turn motivate firms to ask for more and increase the level of completion between LSPs. The European logistics report (COLLIERS, 2012) found that current market situations present a good opportunity for 3PL companies to develop a full range of tailored logistics services, and for developers who in turn can provide suitable warehouse centres. Meanwhile, Soinio et al. (2012) see that, there is a more strategic and long-term focus between firms and logistics services providers to improve market coverage, improve service level or increase flexibility towards end customers. Therefore, the LSU-LSP relationship receives a new meaning beyond the economic view that focuses on cost reduction and economics of scale, to a more strategic and value-added one. This new strategic view increases the importance and the risk of LSP evaluation and selection process. A limited number of logistics studies investigate logistics services. For example, Bottani and Rizzi (2006) used fuzzy TOPSIS for order preference of 3PLs, Govindan and Murugesan (2011) used fuzzy extent analysis for 3PL selection in the supply chain. Kumar and Singh (2012) used an integrated approach of fuzzy analytical hierarchy process (fuzzy AHP) and TOPSIS in evaluating the performance of global third-party logistics service providers for effective supply chain management. Some of these studies use logistics service an evaluation criterion in their evaluation models. This study is one of the first studies investigating the logistics services impact-relationships and their effect on the LSPs evaluation and selection.

3.1.4.3. Current work:

Previous classifications on the one hand underestimate the importance of electronic logistics services and logistics risks as main trends in today's logistics industry and literature. On the other hand, they used a large number of logistics services and activities in a fragmented way. This study sets out to solve this problem by using six main logistics services dimensions: inventory & warehousing, transportation, postponement, customer services, e-logistics services and Safety & security, as shown in Figure 3-3.

Electronic logistics services support all other logistics services and help LSPs to ensure the highest levels of real-time collaboration between supply chain members. This dimension consists of global visibility and tracing, real-time information sharing, real-time collaboration & decision-making and e-logistics training services. Meanwhile, the Safety & security dimension consists of risk assessment, shipment & equipment security and people safety & security. Logistics services and activities under each dimension have been clustered into sub-groups to facilitate the evaluation and selection processes. For each cluster, a number of logistics services and activities can be used to evaluate the LSP capability to provide value-added services-packages.

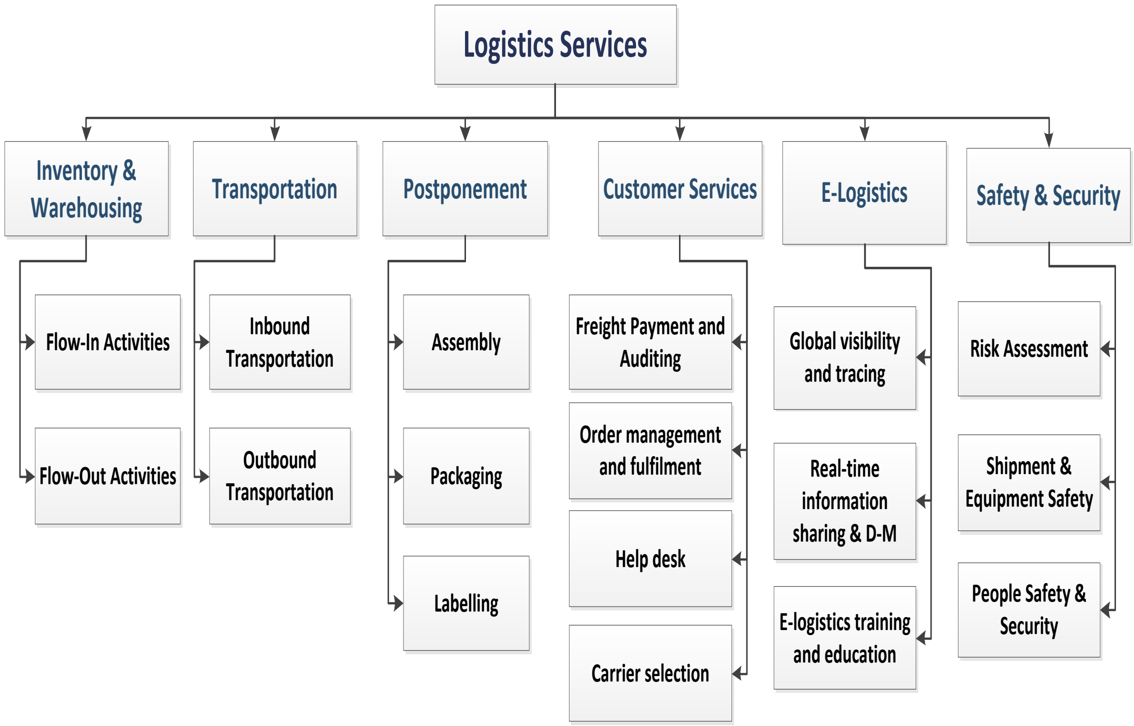

Figure 3- 3: LSPs services

3.1.5. Integrating the three dimensions:

The LSPs evaluation and selection process is multi-dimensional. This study is one of the first studies that integrates the logistics services with logistics performance and logistics resources in one evaluation and selection framework.. This integration enables managers and DMs to be more confident about their decisions and to reduce the risk of selecting inappropriate LSPs by providing more holistic and balanced evaluations. Integrating the performance, resources and services dimensions helps to identify crucial logistics information that can be used for different purposes. In addition to LSP evaluation/selection, this logistics information can be used in various logistics-based decisions and processes, such as logistics performance management, logistics improvement and development and benchmarking. Figure 3-4 shows the overall hierarchy of the integrated framework.

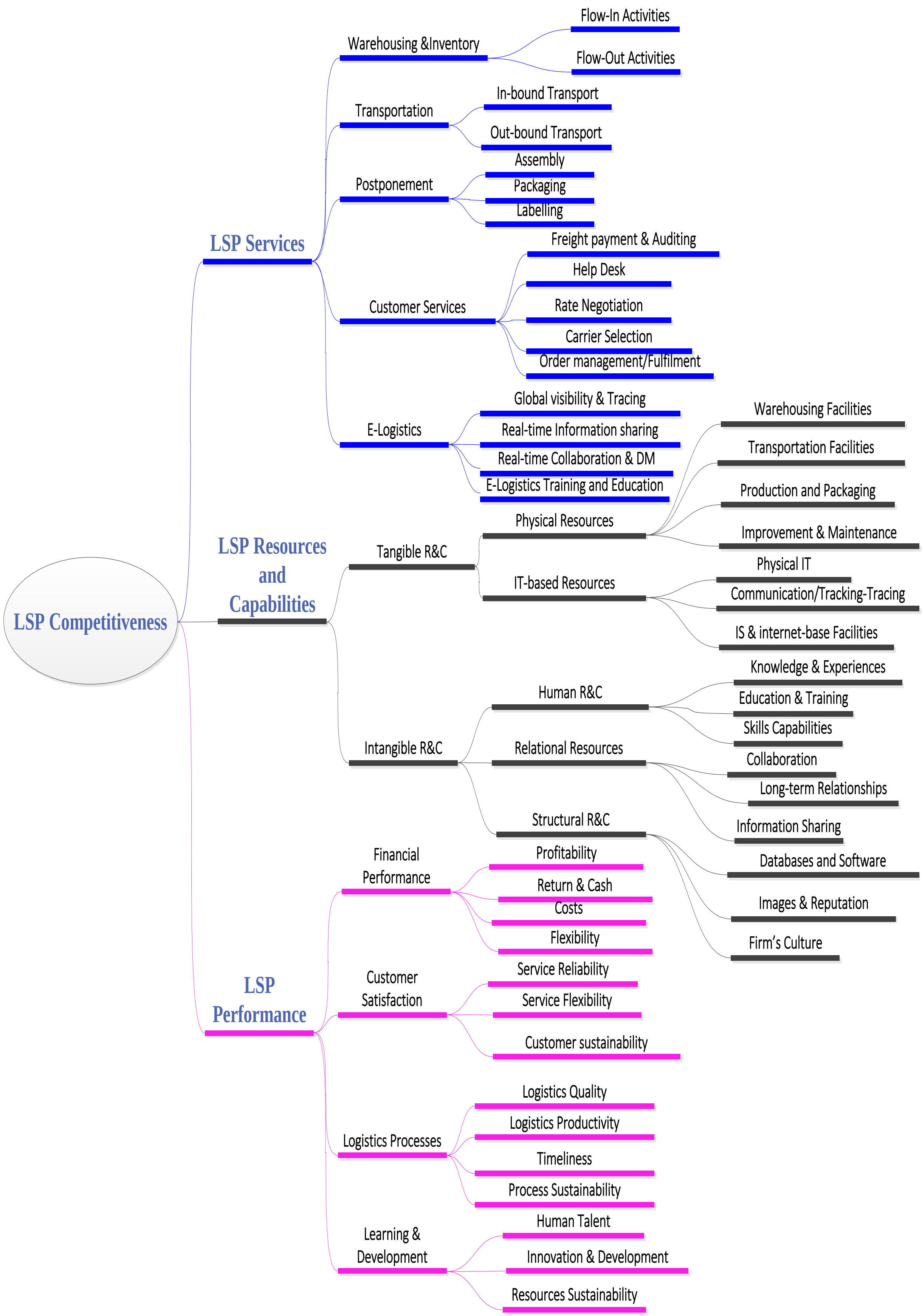

Figure 3- 4: LSPs Evaluation and Selection Framework

3.2. Research Methodology

After introducing the general LSPs' framework (section 3.1.) this section presents various research methods and designs that may be used in MCDM research sittings, and justifies the use of specific techniques in this study.

3.2.1. MCDM Methods

The LSPs' evaluation and selection process is multi-dimensional. The DMs' subjective evaluations and feelings toward evaluation dimensions/criteria directly affect the process. Therefore, a number of evaluation and selection studies deal with this problem by using various Fuzzy-MCDM integrated methods.

3.2.1.1. MCDM Methods and Logistics Literature

Boer et al. (2001) wrote one of the earliest papers that suggested some MCDM methods for use in logistics studies. They clustered evaluation and selection methods into three main groups: First, methods for problem definition and formulation of criteria such as the interpretative structural model (ISM). Second, methods for alternatives pre-qualification such as categorical methods, DEA analysis, cluster analysis (CA) and case-based-reasoning (CBR). Third, models for the final choice phase, such as linear weighting models, total cost of ownership (TCO), mathematical programming models, statistical models and artificial intelligence (AI)-based models. Years later and through historical reviews, Liou and Tzeng (2012) and Zavadskas and Turskis (2011) presented the main MCDM methods and illustrated their primary steps. Zavadskas and Turskis summarised the most important results and applications over the last five years. Liou and Tzeng (2012) addressed the importance of new methods and current trends in the MCDM methods. For example, Chen et al. (2011) and Ho et al. (2012) proposed a new Hybrid Dynamic Multiple Criteria Decision-Making (HDMCDM) method for problem solving in interdependent and feedback situations. Tzeng and Huang (2011) developed a DEMATEL based on ANP (DANP) method that can generate an Influential Network Relation Map (INRM) to analyse degrees of influence. Yuksel and Deviren (2010) applied FANP, and Momeni et al. (2010) applied FDEA to evaluate firms' performance under high uncertainty. Yang et al. (2009) proposed a new technique obtained from The VlseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR), based on DEMATEL Influential relation maps to reduce gaps between current performance and Aspiration Level. As a result, the MCDM approach is shifting to performance management and improvement methods, rather than just ranking and selection ones. These points complement the findings of Ho et al. (2010), which argued that there is a clear trend to apply integrated hybrid methods to obtain the advantages of each individual technique.

The benefit of such hybrid methods is that they can be customised according to the problem's features and/or research requirements.

3.2.1.2. Potential Logistics Outsourcing Decision-Making Techniques

Research and studies regarding logistics as a supportive industry has increased its importance. One important topic in this area is 'Logistics outsourcing' to select the appropriate LSP that helps firms to gain competitive advantages.

Various types of techniques and methods can be used to evaluate and select LSPs. According to Benyoucef et al (2003), these methods can be classified into three principal categories:

Elimination Methods: At each level of comparison, eliminate some of the alternatives (LSP) from the alternatives list if they do not satisfy the selection rule, beginning with the most important rule.

Optimisation Methods: Optimise an Objective Function (Goal) which is subject to a set of constraints.

1 Optimisation Methods Without Constraints:
   - A single criterion such as Cost or Services.
   - A multi-criteria situation, the most common methods in literature.

2 Subject to a set of Constraints: the idea is to maximize an objective function (goal) subject to a set of constraints related basically to the alternative and/or the firm.

Probabilistic Methods: Provide several future scenarios to see the probability of selecting the right LSP and its consequences and the probability of selecting the wrong LSP and its consequences.

Various MCDM methods have been used in logistics studies. These methods have different features and provide different implementations and usages. Table 3-2 provides a brief descriptive summary of selective MCDM methods with good potential in logistics studies.

Table 3-2: Some MCDM Methods used In Logistics Literature

#	Method	Author	Description
1	Analytic Hierarchy Process (AHP)	Saaty (1977); (1980)	AHP models the subjective decision-making processes based on multiple attributes in a hierarchical system
2	Analytic Network Process (ANP)	Saaty (1996)	An extension of the AHP method to release the restrictions of the hierarchical structure which indicates that the criteria are independent from each other
3	Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)	Hwang and Yoon (1981)	The concept of the compromise solution to choose the best alternative nearest to the positive ideal solution and farthest from the negative ideal solution
4	The VlseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR)	Serafim (1979), Lucien and Opricovic (1980)	Ranks alternatives and determines the solution, named compromise that is the closest to the ideal.
5	ELimination Et Choice Translating REality (ELECTRE) I, II, III	Roy (1968) and Benayoun et al. (1966)	This technique is developed to find a core solution or to rank the order of alternatives based on the degree of significance of the criteria and the preferential information (weights, concordance index, discordance index, veto effect).
6	Preference Ranking Organisation METHods for Enrichment Evaluations (PROMETHEE)	Brans et al. (1982, 1985), extended by Brans and Vincke (1985)	A decision support system dealing with the evaluation and selection problems based on the objective of identifying the pros and cons of the alternatives and obtaining their rankings based on these pros and cons.
7	Decision-making trial and evaluation laboratory (DEMATEL),	Battelle Memorial Institute of Geneva 1972-1976, (Gabus and Fontela**,** 1973)	A modelling technique to solve problems visually. It can: model the structure of the cause-effect relationships between the elements of complex systems; divide multiple criteria into cause group and effect group; show interdependency relation between elements and can be converted into a visible model (impact relation maps)
8	Evidential Reasoning (ER)	Yang and Singh (1994), Xu and Yang (2005)	A generic evidence-based on MCDM approach for dealing with problems having both quantitative and qualitative criteria under various uncertainties. It is an evidential reasoning algorithm based on an evaluation analysis model and the Dempster–Shafer (D–S) theory of evidence.

Sources: Tzeng and Huang (**2011**); Kahraman (**2008**); Rao (**2007**); and Xu and Yang (**2001**).

MCDM methods have been integrated to study SCM efficiency and effectiveness, LSPs evaluation and selection, supply chain collaboration and integration and logistics performance. In addition to the MCDM methods, there are a number of other methods used to evaluate firms' performance such as balanced scorecards (BSC), total quality management (TQM), activity based costing (ABC) and EVA analysis. BSC is recognised as the most comprehensive, commonly used approach in most sectors (Alvandi et al., 2012). BSC has been integrated with MCDM methods to provide different hybrid models. Wu et al. (2011), Tseng (2010) and Jassbi et al. (2011) integrated the BSC with DEMATEL, ANP and/or VIKOR in performance studies. Huang et al. (2011) and Huang (2009) used the AHP method with the BSC concept to measure the firms' strategic performance. These findings support what was mentioned earlier regarding the growing use of integrated MCDM methods in logistics studies in general and for LSPs evaluation and selection in particular. In order to make use of the MCDM advantages in logistics outsourcing decisions, it is preferable to integrate these methods with Fuzzy logic.

3.2.1.3. Fuzzy Logic

MCDM methods are integrated with fuzzy logic to help managers and DMs in their decision-making processes under high uncertain environments. Since it was introduced by Lotfi Zadeh in 1965, Fuzzy logic received a wide range of discussion regarding its validity, applicability and its capability to handle uncertainties.

Fuzzy Theory and Membership Function: Both Probability theory and Fuzzy theory deal with uncertainties and are used to represent subjective facts or opinions, but they differ in terms of how they deal with uncertainty. Fuzzy logic uses fuzzy sets to see how much a variable is in a set, while probability theory measures the likelihood or how probable it is for that variable to be in a set. Fuzzy logic deals with reasoning that is 'Approximate' rather than 'Fixed' or 'Crisp' exact values. Most people use binary sets when they describe specific variables, but there are many situations where crisp values do not reflect the exact opinion, particularly when we use linguistic variables such as good, bad, agree and disagree. These linguistics variables may take different values for different individuals and for the same individual under different situations. Fuzzy logic can help by using linguistic variables that facilitate the expression of facts. A Fuzzy Set is a set of objectives in which there is no clear cut or predefined boundary between the objects that are or are not members of the set (Bevilacqua et al. 2006). That means each object in the set is associated with a value to indicate the extent to which the object (element) is a member of that set. This value ranges from (0) to (1), where (0) is the minimum degree of membership and (1) is the maximum degree of membership. That means all the values between (0) and (1) represent various degrees of membership or what is called 'Partial membership'. Each object can be represented by a triangular fuzzy number (TFN) which includes the lower and upper limits and the closest fit, e.g. Y= (X^L, X^M, X^U), where X^L is the lower limit, X^M is the closest fit and X^U is the upper limit. This technique is widely used to quantify linguistic data, where each linguistic variable such as "high" or "low" has a TFN which reflects how much this variable is relevant to the fuzzy set. In order to translate linguistics into fuzzy numbers we need to define an appropriate fitness function. Based on the fuzzy calculation principle the "weights" of each linguistic are aggregated according to the purpose of the decision-making process. Based on Zadeh's (1965) notations, Cheng and Lim (2002) provided some important definitions of fuzzy set theory (Mavi et al., 2013). Let *X* be the universe of discourse $X=\{x_1, x_2, x_3, \ldots, x_n\}$. Then, a fuzzy number is a subset in the universe of discourse *X* that is not convex (curved) but also normal. A fuzzy set $\tilde{A}$ of the universe of discourse *X* is a set of order pairs:

$\left\{\left(x_1, f\tilde{A}(x_1)\right), \left(x_2, f\tilde{A}(x_2)\right), \ldots, \left(x_n, f\tilde{A}(x_n)\right)\right\}$ where $f\tilde{A} \rightarrow [0,1]$ is the membership function of Ã, and $f\tilde{A}(x_i)$ stands for the membership degree of x_i. If a TFN is defined as triple (a_1, a_2, a_3), then, the membership function of the fuzzy number is defined as (Zadeh 1965; Cheng and Lim, 2002; Mavi et al., 2013):

$$f_{\tilde{A}}(X) = \begin{cases} 0, & x > a_3 \\ \frac{(x-a_1)}{(a_2-a_1)}, & a_1 \leq x \leq a_2 \\ \frac{(a_3-x)}{(a_3-a_2)}, & a_2 \leq x \leq a_3 \\ 0, & x < a_1 \end{cases}$$

Let Ã and Ñ be two TFNs (a_1, a_2, a_3) and (n_1, n_2, n_3) respectively, then the operational lows of these two TFNs are:

$\tilde{A} + \tilde{N} = (a_1, a_2, a_3) + (n_1, n_2, n_3) = (a_1 + n_1, a_2 + n_2, a_3 + n_3)$

$\tilde{A} - \tilde{N} = (a_1, a_2, a_3) - (n_1, n_2, n_3) = (a_1 - n_1, a_2 - n_2, a_3 - n_3)$

$\tilde{A} \times \tilde{N} = (a_1, a_2, a_3) \times (n_1, n_2, n_3) = (a_1 \times n_1, a_2 \times n_2, a_3 \times n_3)$

$\tilde{A} / \tilde{N} = (a_1, a_2, a_3) / (n_1, n_2, n_3) = (a_1 / n_3, a_2 / n_2, a_3 / n_1)$

Because of uncertainty, lack of information and ambiguity in logistics, experts are able to provide only criteria importance ranking using linguistic expressions rather than giving crisp values. As is shown in Chapter 2 (Figure 2-2), DEMATEL and TOPSIS techniques have good potential in logistics studies. Integrating Fuzzy logic with the DEMATEL and TOPSIS techniques can help address these uncertainties and therefore, to achieve research objectives.

3.2.2. DEMATEL

Background and unique capabilities

The Battelle Memorial Institute of Geneva Research Centre was the first place to introduce the DEMATEL technique (Fontela and Gabus, 1976). DEMATEL was applied to solve complicated multi-criteria problems in different areas: energy, environment and economics, etc. DEMATEL has the capability to convert the qualitative designs into quantitative analysis through analysing the component structure of each criterion and determining the direction and intensity of all direct and indirect relationships **(**Lee et al., 2011). DEMATEL helps to find which components are central in the complex system and which components affect one another and themselves. It converts the relationships between factors into an easy to understand model to facilitate the decision-making process. The visual impact-relationship map (IRM) provides better understanding of the components causal relationship. When using DEMATEL, DMs must specify both the direction of the relative importance of the criteria and the degree of relativity. This is a challenge for DMs. Due to uncertainty, information leaks and ambiguity; experts cannot provide crisp values of the criteria importance ranking. In this case, integrating Fuzzy logic into DEMATEL can help address the uncertain side of the decision making process. The modified FDEMATEL model is an extended crisp DEMATEL technique that follows the same logic and steps, except that it uses linguistic terms with TFNs rather than (0,1,2,3,4) crisp values (Hosseini and Tarohk, 2013**;** Felix and Devadoss, 2013**;** and Lin, 2013; Tadić et al., 2014; Abdollahi et al. 2015). Table 3-3 summarises these linguistic terms and their values.

Table 3-3: FDEMATEL Linguistic Terms and their TFN Values

Linguistic Terms	TFN
Very high Influence (VH)	(0.75, 1.0, 1.0)
High Influence (H)	(0.5, 0.75, 1.0)
Low Influence (L)	(0.25, 0.5, 0.75)
Very Low Influence (VL)	(0.0, 0.25, 0.5)
No Influence (NO)	(0.0, 0.0, 0.25)

Appendix 3-1 provides a systematic description of the DEMATEL technique. The DEMATEL technique consists of the following steps:

1. Find the average matrix ***(A)***, the initial direct-relation matrix
2. Calculate the normalised initial direct-relation matrix ***(X)***
3. Compute the total-relationship matrix ***(T)***.

4. Identify the Cause and Effect Groups.
5. Set a threshold value and obtain the IRM.
6. Find the criteria importance and weights. Figure 3-5 summarises the DEMATEL technique procedures:

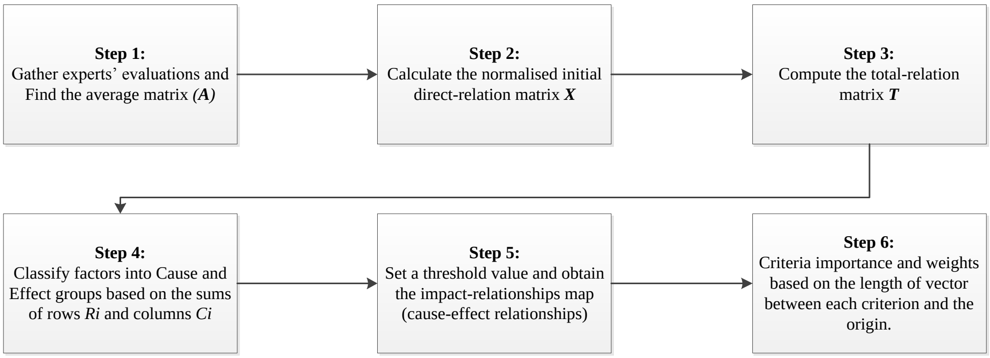

Figure 3- 5: The DEMATEL Technique Procedures

3.2.3. TOPSIS

Background and unique capabilities

The TOPSIS technique introduced by Hwang and Yoon (1981) and improved by Yoon (1987) and Hwang et al. (1993) is the most frequently used ranking technique in the decision-making literature. The advantages of TOPSIS lie in its capability to identify the best alternative quickly and in its capability to integrate with a number of weighted techniques, such as DEMATEL. A compensatory aggregation technique allows managers and DMs to trade-off between the criteria of alternatives where the good scores of some criteria compensate for the bad scores of other criteria. This trade-off helps managers and DMs select the best alternative that should have the shortest geometric distance to the positive ideal solution (PIS) and the longest geometric distance from the negative ideal solution (NIS). To handle data uncertainty problems, a number of studies used an extension of the TOPSIS technique in a fuzzy situation (FTOPSIS) with TFNs (Chen, 2000**;** Chen et al., 2006; and Büyüközkan et al., 2008). Table 3-4 represents the linguistic rating variables that have been defined to evaluate LSPs' alternatives with respect to each criterion.

Table 3-4: FTOPSIS Linguistic Terms and their TFN Values

Linguistic Terms	TFN
Very Good (VG)	(0.75, 1.0, 1.0)
Good (G)	(0.5, 0.75, 1.0)
Fair (F)	(0.25, 0.5, 0.75)
Poor (P)	(0.0, 0.25, 0.5)
Very Poor (VP)	(0.0, 0.0, 0.25)

Appendix 3-1 provides a systematic description of the TOPSIS technique. TOPSIS is a compensatory aggregation technique which allows managers and DMs to trade-off between the criteria of alternatives where the good scores of some criteria compensate for the bad scores of other criteria. The advantages of TOPSIS lie in its ability to identify the best alternative quickly and in its capability to integrate with a number of weighted techniques, such as DEMATEL. The TOPSIS technique is divided into the following steps:

1. Create an evaluation matrix consisting of *m* alternatives and *n* criteria.

2. Normalise the evaluation matrix using the normalisation method.

3. Calculate the weighted normalised decision matrix (***T)*** by multiplying each criterion column by its weight.

4. Determine the Positive Ideal Solution (PIS) and the Negative Ideal Solution (NIS).

5. Calculate the distance between the target alternative *(i)* and the NIS (*d*-) and the distance between the alternative *(i)* and the PIS (*d+)*.

6. Calculate the **Closeness Coefficient (*CC*)** by dividing (d^-) by the sum of (d^+) and (d^-) and rank the alternatives according to their CC_i values. An alternative to the highest value is the best value (the longest distance from the NIS and shortest distance to the PIS). Figure 3-6 summarises the procedures for the TOPSIS technique:

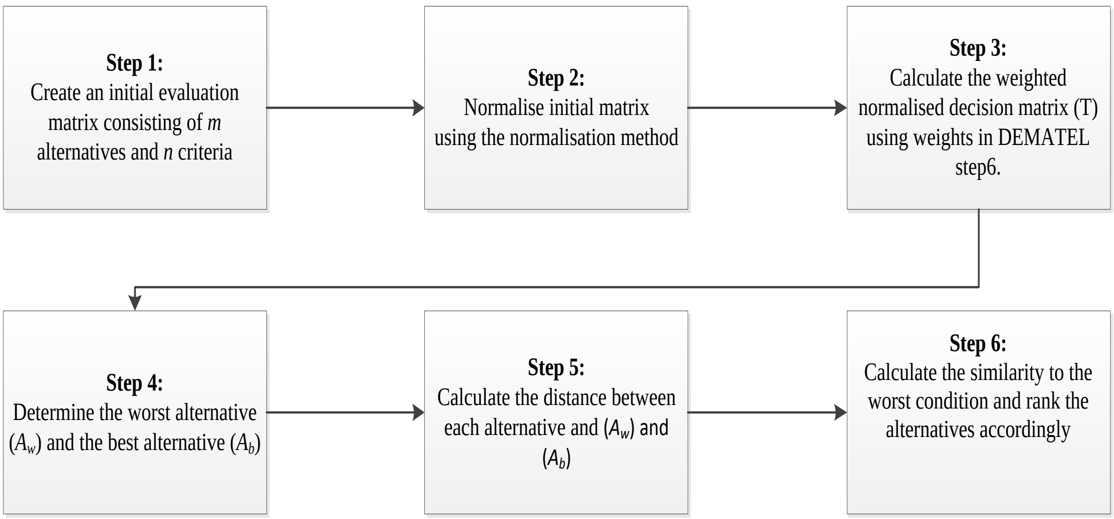

Figure 3- 6: TOPSIS Technique Procedures

3.2.4. Implementation Procedures

Evaluating and selecting the appropriate LSP is an issue for all logistics service users. The selection of an inappropriate LSP directly affects logistics service users' capability to perform their core activities, satisfy their customers and achieve their strategic objectives. This study helps firms evaluate and select their appropriate LSP through a number of integrated approaches of fuzzy DEMATEL and TOPSIS techniques. This study uses the FDEMATEL-FTOPSIS integrated approach for evaluating logistics factors (resources & capabilities, performance and services) impact-relationship, identify independent factors and in turn to have an effective logistics outsourcing process. The procedures for developing these integrated models required various types of information at various stages. Three questionnaires were developed and used: (i) An information sheet to collect LSPs' information (secrtion 3.2.2.), (ii) a FDEMATEL questionnaire to collect experts' evaluations of the LSPs' factors impact-relationship and (iii) a FTOPSIS questionnaire to collect experts' evaluations of the LSP alternatives against the weighted Factors. Figure 3-5 clarifies the hybrid model procedures.

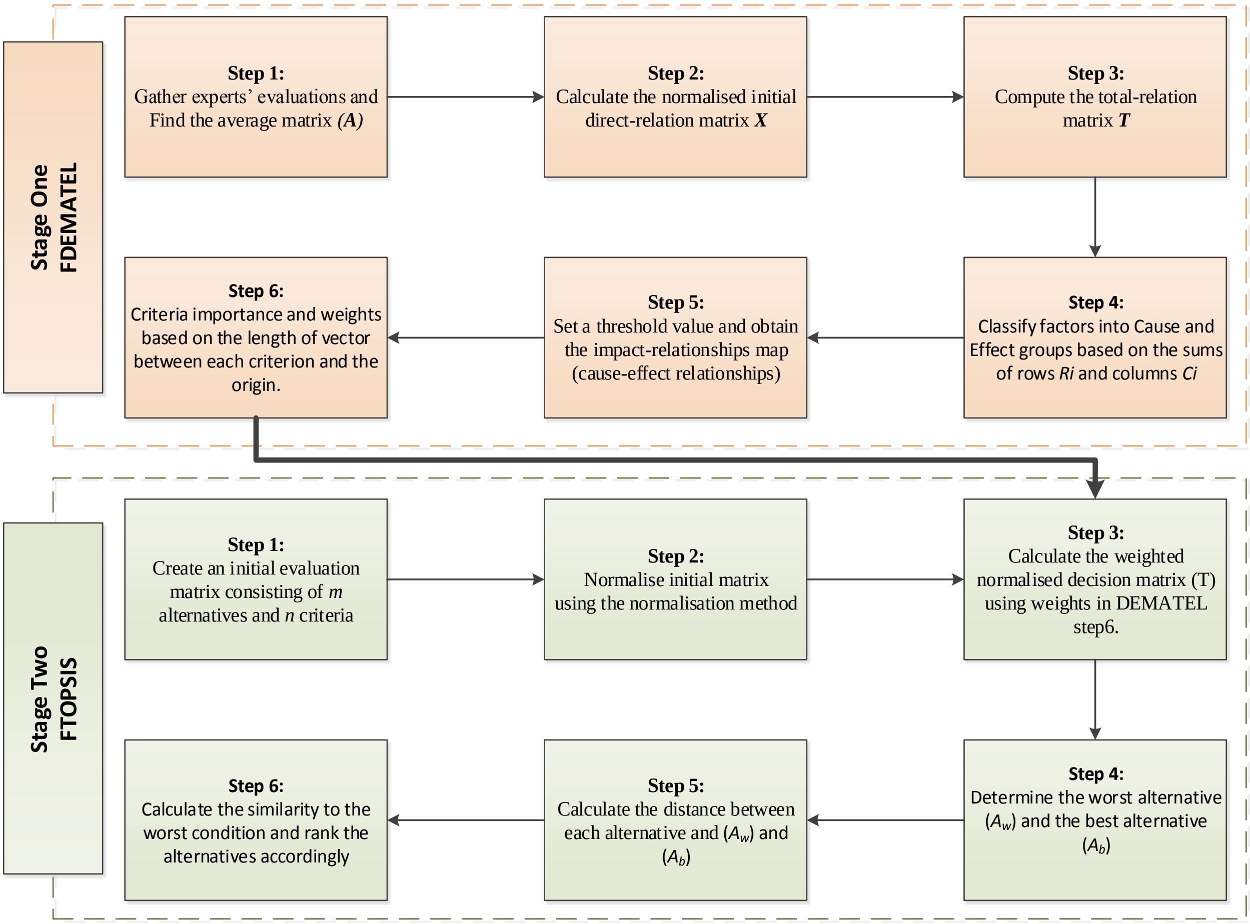

Figure 3-7: The FDEMATEL-FTOPSIS Hybrid Model Procedures

3.2.5. Data Collection methods

The choice of data collection method should be in line with the research aim. This research aims to maximise the logistics outsourcing benefits through developing a number of integrated models under high uncertainty. Different data are needed for identifying, analysing and developing such models, and therefore to integrate them into one strategic logistics approach. The data collection method adopted namely experts' judgements, in which different survey questionnaires - mainly in the form of a comparison matrix – ware given to logistics experts as discrete object of enquiry to ascertain their expert opinions. These questionnaires use qualitative linguistics variables to help logistics experts to express their judgements easily under uncertain environments. Then, the obtained linguistics variables were transformed into quantitative data (in the form of TFNs) to be used in the implementation procedures (section 3.2.4.).

The procedures for developing these integrated models required various types of data in various stages. Therefore, a number of questionnaires were developed and used. For the first stage (Framework development), in addition to the primary data (section 4.2.1.) two questioner were developed and used to collect the needed data. The first questionnaire was used to collect the needed data regarding the Jordanian logistics sector with special emphasis on the Jordanian LSPs. The second questionnaire aims to verify the LSPs' framework elements, measure their relative importance and degree of use based on both the LSPs and LSUs' perspectives. For the second stage, (FDEMATEL and FTOPSIS) six new questionnaires were developed and used. Three different questionnaires were used to analyse the impact-relationships among decision factors in Chapters 5, 6 and 7. Meanwhile, another three questionnaires were developed and used to evaluate and select the best LSP against the weighted decision factors in each chapter. For the third and the fourth stages (FQFD and case studies) another three questionnaires were developed and used to help DMs perform the new strategic approach for logistics outsourcing. The first questionnaire links the firm's weighted strategic objectives with logistics requirements, the second one links the weighted logistics requirements with the ISFs, while the third one evaluates the LSP alternatives against the weighted ISFs. More information about these questionnaires summarised in Table 3-5. Appendix 3-2 provides some examples of used questionnaires.

Table 3- 5: Data Collection Methods

Data Collection Tool	Directed To	Number of Questionnaire	
		Distributed	Use
1- The Jordanian logistics sector (Ch. 4)	Jordanian LSPs	35	7
2- Relative importance and degree of use (Ch. 4)	Jordanian LSPs & LSUs	158	16
3- FDEMATEL – Logistics Resources (Ch. 5)	Logistics Experts	7	4
4- TOPSIS – Logistics Resources (Ch. 5)	Final year PhD students Business and Logistics	3	3
5- FDEMATEL – Logistics Performance (Ch. 6)	Logistics Experts	7	4
6- TOPSIS – Logistics Performance (Ch. 6)	Final year PhD students Business and Logistics	5	5
7- FDEMATEL – Logistics Services (Ch. 7)	Logistics Experts	7	4
8- TOPSIS – Logistics Services (Ch. 7)	Final year PhD students Business and Logistics	6	6
9- Strategic Objectives – Logistics Requirements	Managers/ DMs	1st Case 5 DMs 2nd Case 4 DMs	
10-Logistics Requirements – ISFs	Managers/ DMs		
11-ISFs – LSP alternatives	Managers/ DMs		

3.2.6. Experts Selection

The development of such integrated models requires different knowledge to be obtained from experts who are knowledgeable and working their related fields. Several experts from different backgrounds have been approached for their expert opinions. Filed of specialisation and years of experience are the main inclusion criteria. Several logistics experts with more than ten years of administrative and/or academic logistics experience were contacted. Table 3-6 lists the approached experts with their qualifications.

Table 3- 6: List of Experts

	Qualifications
1	A Vice President of Business Development/Logistics, Logistics Company/Freight management services with more than 30 years of experience in logistics and supply chain management
2	A Logistics Director, Logistics International Freight Services with more than 35 years of experience in logistics and supply chains
3	A Logistics and supply chain academic/researcher with more than 10 years of experience and more than 30 published works
4	A president of an academic institution with more than 32 published papers and more than 43 years academic and administrative experiences
5	A vice president of an academic institution with more than 52 publications, an editorial board and more than 20 years academic and administrative experience
6	Logistics academic and researcher with more than 12 years of experience, 20 published papers and 9 conferences
7	Senior executive/Logistics and Procurement Company and academic lecturer – faculty of business management with more than 16 years of experience, 2 published papers, 6 PhD students and 7 international conferences
8	Logistics and IT manager and logistics academic with more than 8 years of experience, 6 published papers and 10 conferences

3.3. Chapter Contributions

This Chapter presents the LSPs evaluation and selection framework and the research methodology implement to achieve research objectives. This chapter presented various data collections and MCDM techniques in an effort to lay down the basics of the research. The reasons behind the selection of the research and data collection methods have been explained in details. Chapter contributions are summarised by:

- Propose a new LSPs framework as a base for new LSP evaluation an selection models
- Propose three new models to evaluate and select LSP based on three different theories
- Present and explain research methodology in terms of data collection tools, experts selection criteria, impact relationships and ranking techniques (MCDM)

Chapter 4: LSP Framework Verification - Jordan Logistics Case

Summary

In this chapter, the first Jordanian logistics study is presented. Both primary and secondary data are used. Moreover, JLSPs and JLSUs perspectives are used to verify the LSP framework dimensions/elements. Additionally, this chapter provides the conceptual definitions of the LSP evaluation and selection framework.

4.1. Introduction

The importance and complexity of the LSP evaluation and selection process increases in developing economies and emerging markets. The need for professional LSPs capable of helping and supporting developing economies in their development process is crucial. However, the absence of logistics reports, statistics and measures and the lack of research about developing logistics sectors increase the complexity of this process. This chapter presents the first Jordanian logistics study based on the JLSPs and JLSUs perspectives using primary and secondary data. Moreover, this chapter aims to verify the proposed LSP framework (Chapter 3), to test its appropriateness and relatedness to these developing economies before analysing impact-relationship and developing the logistics outsourcing approach.

4.1.1. Case-study: Country Selection

A number of developing economies are currently attracting attention worldwide. The Middle East region has two major attributes that increase its importance over others, natural resources (particularly oil) and location. Although there is an absence of oil in Jordan, its strategic location at the heart of the Middle East makes it a link between three continents (Asia, Europe and Africa) and represents a gateway to the Middle East and North Africa. At the same time, this strategic location represents a good trade centre to link countries in the Americas with East Asia and vice versa. In addition to location, Jordan has a market-oriented economy, where the competitiveness of the location is supported by financial and economic legislation. Jordan has undertaken a wide range of financial and economic legislation to improve its economic competitiveness. In addition to the Arab countries, Jordan has free trade access to major international markets such as the USA and Europe. In 1997, Jordan and the EU signed a partnership agreement to establish a free trade area between Jordan and the EU over twelve years. This agreement attracts more European investments. In 1999, Jordan joined the World Trade Organisation (WTO). In 2000, Jordan and the USA signed a free trade agreement, which attracts more foreign investments. In addition to these agreements, the attractive investment environment helps Jordan to offer a wide-range of opportunities, the investment environment includes:

- The Jordan Investment Board: responsible for promoting investment in Jordan and supporting investors from the reception at the airport to the opening of the factory or establishment.
- The Qualifying Industrial Zones (QIZ): attract various investments through providing duty-free access to the USA markets for the goods produced within the zones.
- Aqaba Special Economic Zone (ASEZ): an ideal opportunity for doing business in a competitive location with attractive legislation.
- Competitively priced and skilful Human Resources: Jordan has one of the highest literacy rates in the region (89%) with a large number of highly-qualified intellectual and professional workers.

All these points put more pressure on Jordan to provide an excellent logistics sector capable of gaining the benefit of these opportunities and securing the advantages of the unique geographical and economic features of the country. However, there is a scarcity in the Jordanian logistics data and research increases the importance of this study and supports the selection of Jordan as a case study. Here, a number of questions can be raised (i) what are the main features of the Jordanian logistics sector? (ii) What are the main factors that are used by the Jordanian firms to take their logistics-based decisions? (iii) what is the relative importance of these factors from LSPs' and LSUs' perspectives? This chapter aims to provide one of the first studies of the Jordanian logistics sector, analyse the importance and usage level of the logistics factors and in turn to validate the LSP framework's (Figure 2-7) appropriateness and suggest further improvements.

4.1.2. Jordan as a Case-Study in the Logistics Literature

There is scarcity of studies regarding the Jordanian logistics sector, whether the aggregate or individual logistics performance. For example, Dalalah et al. (2011) provide a multi-criteria model for evaluating and selecting suppliers in manufacturing industry, while Karasneh (2012) provides a route optimisation technique for Aqaba seaport to test the optimality of the existing actual costs of the major Jordanian exports and imports. Devlin and Yee (2005) mentioned the Jordanian logistics sector through two cases in their study with some suggestions to improve the efficiency of trade logistics in the Middle East and North Africa (MNA) region. Six transport cases from different MNA countries were used to identify improvement areas to improve the logistics efficiency of the MNA countries. More specifically, the Jordanian two cases show that: expensive airfreight, infrequent service and long shipping time to Aqaba, port processing (clearance, loading, unloading, etc.) are the areas in the Jordanian logistics chain that need most improvement.

4.2. Jordan Logistics Sector

The 2013-transport intelligence report regarded the Jordanian logistics market as one of the fastest growing markets in the Middle East region. Different logistics operations developed over the last fifteen years in line with economic developments and the evolving needs of customers (Transport Intelligence, 2013). The continued growth in the logistics market, good relations with neighbours and the continuous maintenance of the political and economic legislations, along with recent infrastructure improvements, increase the attractiveness of the Jordanian logistics sector. Therefore, many international logistics companies invest in the country. Although the Jordanian logistics sector is important for domestic, regional and international trade, there is no specific logistics database of the sector's elements and measurements. Most of the formal Jordanian statistics are trade statistics with some export and import classifications. The following sections use two data sets to provide the first Jordanian logistics study. Section 3.2.1 summarises the formal secondary data gathered from the formal Jordanian bodies. Meanwhile, Section 3.2.2 is based on an information sheet that was developed and used to provide the primary data collected directly from the Jordanian LSPs (JLSPs).

4.2.1. Jordanian Formal Logistics Data and Statistics

This section summarises the Jordanian secondary logistics data and statistics. A number of formal bodies' websites have been reached to collect the data (trade, logistics investments, logistics association and the logistics sector structure data).

4.2.1.1. Jordanian Trade Statistics

According to the Jordan Trade and Investment Information System (TIIS)[2], in 2012 the total amount of Jordanian trade was more than JD20 billion in general. JD8.5billion trade was in the service sector, more than JD2 billion was in transport and freight trade

[2] TIIS is a system designed to automatically compile, standardise and publish some of the most updated Jordanian statistics on trade and investment. This system is furnished and periodically updated by eight participating government entities that generate primary data on trade and/or investment in Jordan; they are: Department of Statistics, Ministry of Industry and Trade, Companies' Controller Department, Central Bank of Jordan, Jordan Industrial Estates Corporation, Amman Chamber of Industry and Jordan Investment Board.

(JD 1,404,700,000 transport trade and JD 682,200,000 freight trade) (Table 4-1, Table 4-2). These statistics show the importance of the logistics sector in the developing economies.

Table 4- 1: Value of Jordan Trade Statistics during the Period 2008-2012 (Million JD)

Year	Total Export	National Export	Re-Export	Imports	Total Trade
2008	5,667.6	4,456.1	1,211.5	12,180.6	**17,848.2**
2009	4,598.3	3,611.9	986.4	10,096.9	**14,695.3**
2010	7,143.7	6,380.8	762.9	10,957.2	**18,100.9**
2011	5,213.1	4,350.2	862.9	10,672.1	**15,885.1**
2012	5,598.7	4,750.5	848.2	14,690.7	**20,289.4**

Table 4- 2: Trade in Service Sector during the Period 2008-2012 (Million JD)

Year	All Service Trade	Transport Trade	Freight Trade
2008	14,087.3	2,182.8	1,113.4
2009	13,524.3	1,945.3	941.4
2010	16,738.1	2,450.2	1,239.7
2011	15,441.4	2,469.9	1,210.4
2012	8,414.4	1,404.7	682,.2

4.2.1.2. Investments in the Logistics Industry

In 2008, the Jordanian transport and freight firms invested JD 405,804,308 in the land, water, air and other supportive transport activities. With about 16000 Trucks & Tractors and other 16,254 Semi-Trailers (Table 4-3), the Jordanian land transport sector is considered one of the main logistics actors in the Middle-East region. Now, due to the crisis and wars in Syria and Iraq, the Jordanian logistics sector faces critical challenges in terms of boarder closing; security and safety of people, equipment, trucks and shipments; increasing logistics and insurance costs; increasing demand for military, crisis and refuge logistics.

Table 4- 3: Trucks and Semi-Trailers Registered in Jordan at 2010

Vehicle	#	Average Age	Company Ownership	Individuals Ownership
Truck/Tractor	15,874	13.73 year	59.2%	40.8%
Semi-Trailers	16,254			

Source: adapted from the land transport regulatory commission website: www.ltrc.gov.jo

4.2.1.3. Jordan Logistics Associations (JLA)

In 2007, Jordanian logistics firms established the Jordanian Logistics Association (JLA) to organise the logistics sector and to create an official entity representing the logistics industry. JLA cooperates with other official entities such as Jordan's Ministry of Transport and the International Federation of Freight Forwarding Associations (FIATA) to help and support the JLSPs. There are more than 85 registered members with various logistics specialisations: transportation (air, land and maritime), inventory & warehousing, shipping & clearance and other logistics services. According to the JLA website (accessed Jan-2014), there are 88 listed members representing various Jordanian and international LSPs working in Jordan. Sixty members out of the 88 provide 'Air' services, 57 members provide 'Land' services, 74 members perform 'Ocean' services, 11 members perform 'Clearance' services, 15 members perform 'logistics' services and 9 members provide a full range of these services (Figure 4-1).

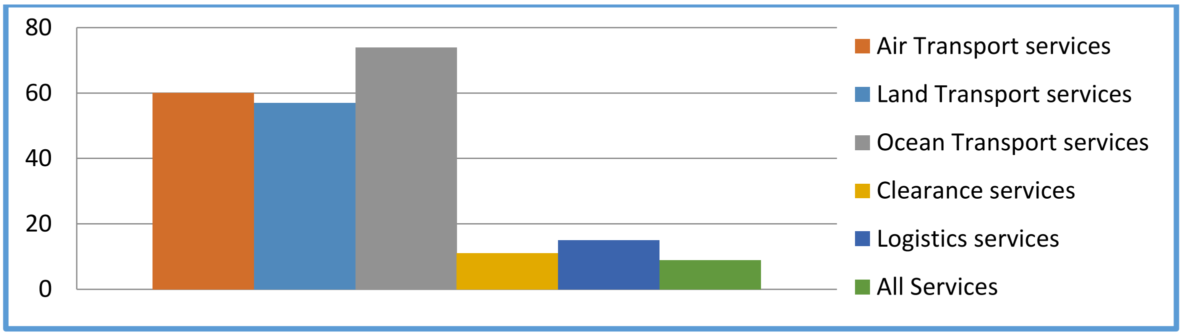

Figure 4- 1: Range of Services of the JLA Members

4.2.1.4. The Structure of the Jordanian Logistics Sector

The Jordanian transport network is based on a number of sea and airports. There is only one seaport (Aqaba seaport) and three main airports: Queen Alia and King Hussein international airports and Amman civil airport. In addition to these ports, there are a number of QIZs managed by the Jordanian Free-Zones Corporation.

Sea Ports: Aqaba Port Authority was established in 1952 and took its present name (Aqaba Ports Corporation, APC) in 1979 (APC 2014). APC is a governmental body with an independent character responsible for establishing, developing, maintaining and operating port activities (receiving of ships, handling and storing cargo). In 2004, Aqaba Development Corporation on behalf of Aqaba Special Economic Zone Authority signed a contract for a partnership agreement with APM terminals for management and operations of Aqaba container terminal for a period of 25 years. APM terminal – a part of the A.P MOLLER –MAERSK group- took over the management and operation of the Aqaba terminal. There are more than 35 main shipping lines calling at Aqaba port. The Aqaba Container Terminal (ACT) started a project in 2010 to build a new port in the southern

Jordan city of Aqaba; the new project includes a 460-metre extension of the quay to improve annual container capacity.

Airports: There are three civil airports in Jordan (i) Queen Alia international airport (QAIA) was opened in 1983; with three passenger terminals, it hosts about 5.5 million passengers each year. Over 35 airlines provide flights to Europe, the Middle East and Southeast Asia. (ii) King Hussein international airport (KHIA) is located 9 km north of Aqaba city. It was officially opened in May 1972 and has now expanded to address the increasing demand. (iii) Amman civil airport is a one-terminal airport situated at Marka in East Amman. It was the national flag carrier until Queen Alia International Airport was opened in 1983. Now it is a regional airport servicing domestic and nearby international routes.

Aqaba Logistics Village (ALV): is a special logistics corporation located in the ASEZ. The main purpose of ALV is to improve the ASEZ capabilities through providing excellent logistics services. With more than 430,000m^2 of land and more than US$ 60 million investment, ALV contributes to the ASEZ's logistics capabilities and supports various industrial, commercial and public sectors in Jordan and the region in general. ALV acquires advanced supporting facilities to provide cargo-handling and warehousing services. Logistics services provided by the ALV range from simple cargo handling and trade facilitation services, to 3PL warehousing and distribution centre set-up (ALV, 2015).

4.2.2. Primary Data

In order to determine the Jordanian logistics sector's quantitative and qualitative metrics, a data-collection tool has been developed with the input and advice of academic and logistics professionals. This tool has been developed to obtain more relevant and accurate logistics data. The information sheet includes questions regarding the three main evaluation dimensions used in the LSPs framework (logistics resources and capabilities, logistics performance and logistics services) with their sub-levels. Two e-mail-based sessions supported by telephone calls were used in distributing the information sheets to 95 Jordanian LSPs. However, due to the sensitivity of the required information, a low response rate was achieved. Therefore, personal networks have been used to circulate a paper-based information sheet to convince logistics managers in some JLSPs to complete the sheets. Thirty-five information sheets were distributed in Amman and ALV. Eight information sheets were collected. One of the collected sheets is for a new, small logistics agent where most of information is not available and/or not applicable. Five LSPs provided most of the information except for the financial metrics.

4.2.2.1. Logistics Resources and Capabilities of the Jordanian Logistics Sector

With an average of 68.5 employees, JD 400,000 total fixed assets and 5917m^2 storage areas, JLSPs are considered small to medium-sized firms. In term of tangible resources, JLSPs focus on the warehousing and transportation resources more than other logistics resources. Seventy-five percent of these firms provide warehousing and transportation facilities, which is in line with the transportation services results (Figure 4-2 b). Cars, vans, small and big trucks are the most used resources. With an average of 5-years old and 30 vehicles per firm, JLSPs are considered good in terms of vehicle age, but they are not that good in terms of vehicle numbers if they are compared with other countries in the same region. For example, according to the Turkish Statistical Institute (Turkstat 2014), by the end of December 2013, there were about 3 million small registered trucks and 1.5 million registered trucks with an average age of 8.8 and 14.2 years respectively. This explains the formal statistics (section 4.2.1.2**)** where 13,108 individual-owned trucks are used to support the JLSPs trucks shortage. To retain these vehicles in good condition, JLSPs use various improvement and maintenance activities. Eighty-eight percent of these firms provide scheduled truck maintenance (weekly or monthly), meanwhile, 12% carry out maintenance as it is needed. In addition to the internal communication systems, JLSPs have good external communication systems that connect them with trucks and drivers throughout the country (e.g. EXPIDITIORS© tracking, TRACKYOURLIVE© system, MAGAYA©, ZAIN© tracking and ORBIT©). Although, most of the JLSPs use emails and telephone calls to communicate with customers, less than 50% of the JLSPs have simple websites and/or use cloud systems and few of the JLSPs provide a full-service website.

In terms of intangible resources, 37.7% of the JLSPs' employees have diploma certificates, 32.3% bachelor’s degree and 4% graduate degrees. Out of the total number, 43% have obtained logistics certificates and have the capability to use various logistics technologies to improve the regional JLSPs’ competitiveness. In terms of experience, 46% of the JLSPs’ employees have less than 5 years of experience and 33% of them have 5 to 10 years, this is in line with the Jordanian youth demographics. JLSPs’ young employees need more training courses to support their limited experience and improve their logistics performance. On average, JLSPs provide five training courses per year. In addition to training courses, logistics employees need more authority to take decisions and share information with customers, suppliers and other LSPs as required. In terms of decision-making and authority delegation, only 7% of the employees have the authority to take decisions and only 20% of them have the right to share information with others.

These percentages explain why it was so difficult to obtain this data. In terms of relational resources, in general JLSPs have good relationships with customers and suppliers. Sixty-five percent of the JLSPs' customers and suppliers are 'loyal' and have dealt with the same LSP for more than 2 years. Meanwhile, integration and cooperation within the JLSPs are limited to a narrow circle of 13 LSPs on average for a limited time and/or specific project. Although the JLSPs' average age is 13.75 year, a limited number of them have trademarks and/or trade names (such as UPS, EXPIDITOR, DIONEX and DHL). The JLSPs resources and capabilities data are used in Chapter 4 case study to validate the new LSPs resources and capabilities model.

4.2.2.2. Logistics Performance of the Jordanian Logistics Sector

The efficiency of logistics activities is measured in terms of resources used to perform these activities from order-to-delivery (Devlin and Yee, 2005). For example, logistics costs consist of transport and non-transport costs such as ordering, loading unloading and storage. These metrics are importance to measure the LSPs' performance and to improve their efficiency. Therefore, due to the sensitivity of the logistics performance metrics, most of the JLSPs did not agree to disclose the financial metrics. However, they did estimate some of the logistics processes metrics. The following section summarises the JLSPs' performance metrics based on the collected information sheets.

Customer Satisfaction Metrics: With almost 100% delivery to the correct destination and orders with the right price calculation; 97% on-time delivery; 2% of units damaged during transportation; 5.8% customer complaints/year and 0.75% thefts during transportation, JLSPs have very good '**Service Quality and Reliability**' metrics. Meanwhile, average order delivery time varies based on the nature of the delivery, for example, domestic deliveries range from 'less than 24hours to 48hours' while industrial orders take 4 to 8 days. In terms of '**Service Flexibility**', most of the JLSPs can add workers as needed, provide special cargo services and handle urgent shipments. Moreover, 62.5% can increase/decrease delivery volume and 75% can increase/decrease shipments volume based on the customers' needs. Additionally, 87.5% of them provide consolidation services. These flexibility metrics measure the JLSPs' capability to satisfy their customers through providing logistics services that meet the LSUs' needs and requirements. The JLSPs have various results in terms of the '**Customers' sustainability**' dimension. Most of the JLSPs have zero rates of customer accidents, but not all of them perform well in terms of customer growth. Some of the JLSPs have a good customer growth rate (can reach 10%) whilst others are facing a 20% decrease in customer numbers. On average, the JLSPs have about 2% customer growth/year.

Logistics Processes Metrics: 'Logistics Processes' has been measured through four main sub-dimensions: **logistics quality, logistics productivity, timeliness and processes sustainability**. With 99% complete order delivery and less than 1% internal inventory damage and inventory record errors, the JLSPs have high-quality logistics processes. Additionally, the JLSPs' capability to handle serious deliveries and a 3% delay rate increase the quality of these processes. However, some of the JLSPs need to improve their delivery rate to cope with the average of the sector, particularly in sea transportation. Due to the differences in size, the JLSPs have various productivity indicators. Regardless of the order size, about 50% of the JLSPs deal with less than 1,000 orders/year, about 25% of them deal with more than 1,000 to10,000 orders/year, the rest (about 25%) deal with more than 10,000 up to 50,000 orders/year. These orders come with 99% faultless delivery and complete order fill rate. In order to obtain the best use of resources, the JLSPs need to improve their warehousing and truck space utilisation (the current rates are 77.8% and 81.4% respectively). Although most of the JLSPs have a 'daily' order response-time and 'same day' response-time for customer complaints, more attention for 'Timeliness' metrics is needed, particularly the 'average order cycle time' which varies from 3 up to 22 working days and on-time pick-up (90% of total orders). In terms of processes' sustainability, most of the JLSPs did not have any records regarding their greenhouse gases, waste volume or any other environmental impact metrics, which makes it difficult to evaluate processes' sustainability levels. Meanwhile, 4% of total workers have had an internal accident and there is a 6.75% employee turnover rate; these figures need to be taken more seriously by the JLSPs.

Learning and Growth Metrics: As mentioned earlier, 43% of the JLSPs' employees have logistics certificates and/or are capable of using the logistics technologies. This means 57% of the employees need more training, education and development. On average, the JLSPs arranged about 5 training courses per year and about 13 employees (19%) attend these courses. These training courses cover various topics (70% logistics, 19% administrative and 11% others). Additionally, about 50% of the JLSPs did not have specific training budgets, they provide training courses 'as is needed', 25% of the JLSPs allocate about JD 3,000/year and 25% allocate about JD 25,000/year for training purposes. These numbers reflect the crucial need for more investment in human resources, training and development. Moreover, JLSPs need to rethink their priorities regarding learning and growth metrics. The same results are noticed in terms of the ‘Innovation and development’ metric where the investment in R&D is not announced and data regarding ‘innovation rate of new products/services’, ‘sales of new products/services’ and its profits are not available either. Two of the JLSPs estimated some ‘resource sustainability’ metrics, such as resources productivity and energy consumption.

Financial Metrics: There are 13 transportation firms listed in the Amman stock exchange (ASE), most of them specialise in tourism and passenger transportation (such as TRUST©, RUM©, JETT©, ALIA©, etc.). Although the financial results of these firms are available in the ASE, these firms did not participate in this study. Table 4-4 summarises the financial data collected from two JLSPs. The first one is an industrial JLSP dealing with manufacturers and mainly deals with full truckload (FTL) freight. The second firm provides logistics services, dealing with commercial firms and mainly operates less than truckload (LTL). Additionally, the first firm provides a flexible billing system to customise logistics bills based on the customers’ needs and quantity and time discounts to motivate early full load orders. The JLSPs performance data used in Chapter 5 case study to validate the new LSPs LKPIs model.

Table 4- 4: Financial metrics of two JLSPs

Metric	JLSP1	JLSP2	Metric	JLSP1	JLSP2
Total return	450,000 JD	N/A	**Transport cost**	500JD/orde	15JD/unit
ROA	5%	N/A	**Packaging cost**	Avg. 100JD	8JD/unit
EVA	N/A	10%	**Inventory cost**	Avg. 100JD	1JD/unit/month
Net profit	400,000JD	N/A	**Handling cost**	Avg. 150JD	0.10JD/Kg
Book value	350,000JD	N/A	**Waste handling**	N/A	5% of product cost
Market value	1millionJD	1million JD	**Total salaries/year**	364,000JD	360,000JD

ROA: return on assets, EVA: economic value-added, N/A: not available or not announced, JD Jordanian Dinar.

4.2.2.3. Logistics Services in the Jordanian Logistics Sector

The Jordanian logistics sector provides a wide range of logistics services. Basically, JLSPs can provide various ‘Inventory and warehousing’ services, whether through their own warehousing facilities or through cooperation with other LSPs. Eighty-eight percent of the JLSPs can provide most of the inventory and warehousing activities (see Figure 4-2 a). About 50% of the JLSPs can provide refrigerated warehousing. In terms of ‘Transport services’, most of the JLSPs focus on ‘Land transport’ (88%) and ‘Air transport’ (75%) followed by ‘Sea transport’ (50%) see Figure 4-2 b). In terms of ‘Production and packaging’ services, JLSPs provide packaging, labelling and geographical postponement activities more than ‘Production postponement’ services (Figure 4-2 c). ‘Customer services’ is a main element of the logistics services that are provided by the JLSPs (Figure 4-2 d). All the conducted JLSPs provide ‘Order fulfilment’ and ‘Carrier selection’ services. Meanwhile, about 63% of them are capable of providing e-logistics services such as cloud system technology and real-time internet-based services.

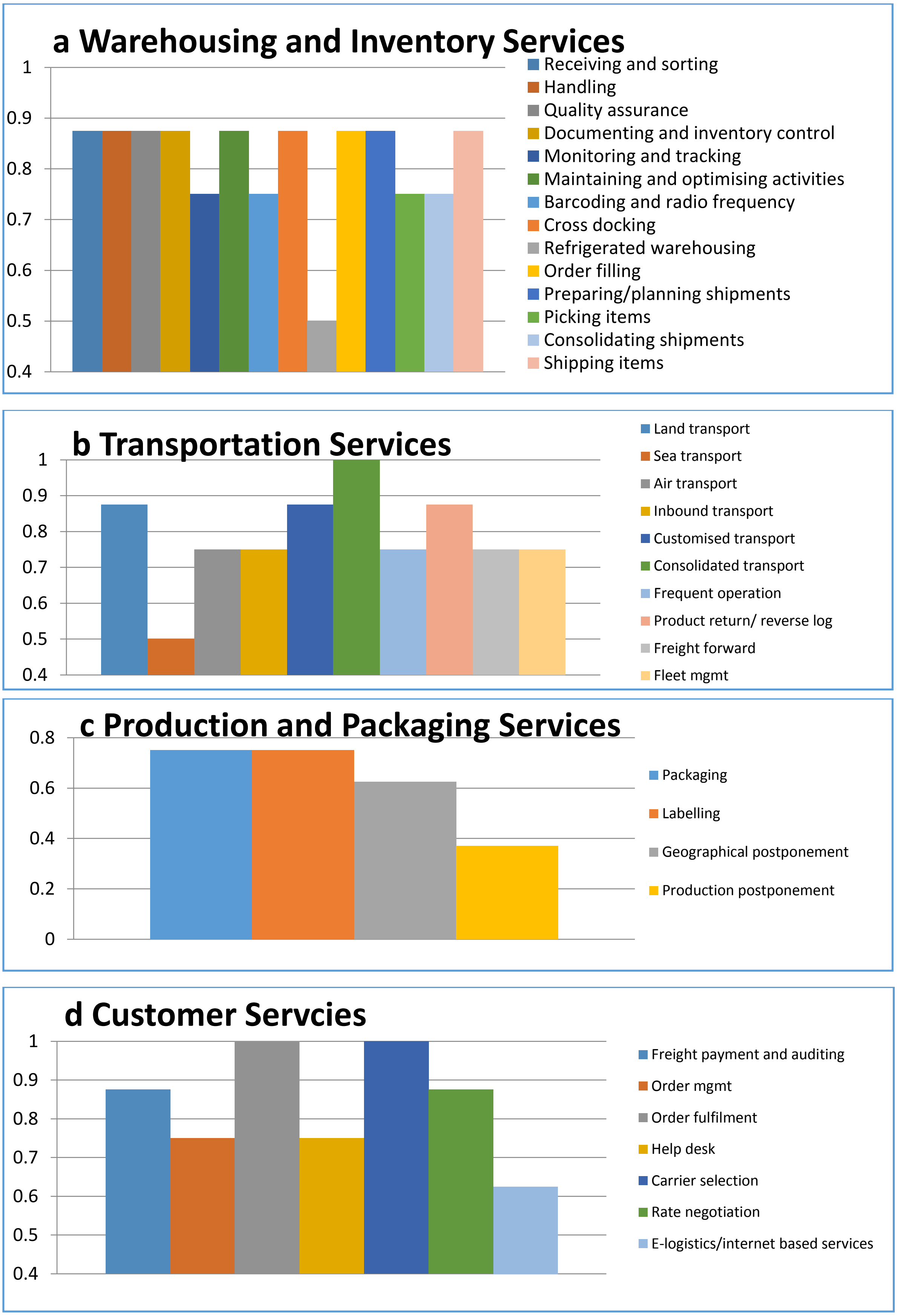

Figure 4- 2: Logistics Services Provide by the JLSPs

4.3. Developing Economies LSPs' Framework - Case of Jordan

4.3.1. Data Collection

Jordan has a competitive logistic position in the Middle-East region (Arvis et al., 2014). A questionnaire has been developed to ascertain the Jordanian LSPs and LSUs evaluations of the LSP Framework elements. Two scales have been used to evaluate level of importance and degree of use for each element. A list of 210 Jordanian LSUs and LSPs out of 289 registered firms in the ASE (Amman stock exchange) was selected. Fifty-two firms cannot be contacted by email, so 158 questionnaires were distributed. With twenty-one questionnaires collected and five incomplete questionnaires subsequently removed, 13.3% is the response rate. Factors/metrics with importance levels ≥ 4 and/or usage rate ≥ 50% were selected to be used in the new hybrid model. Based on these thresholds, LSPs framework indicators/metrics are classified into 3 groups: highly important and used, not highly important but used and not highly important and not used.

4.3.2. Importance Levels and Usage Rates

Appendices (4-1, 4-2 and 4-3) summarise the level of importance and usage rate of the logistics resources, performance and services factors respectively. Figure 4-3 shows the factors' distribution under each evaluation dimension.

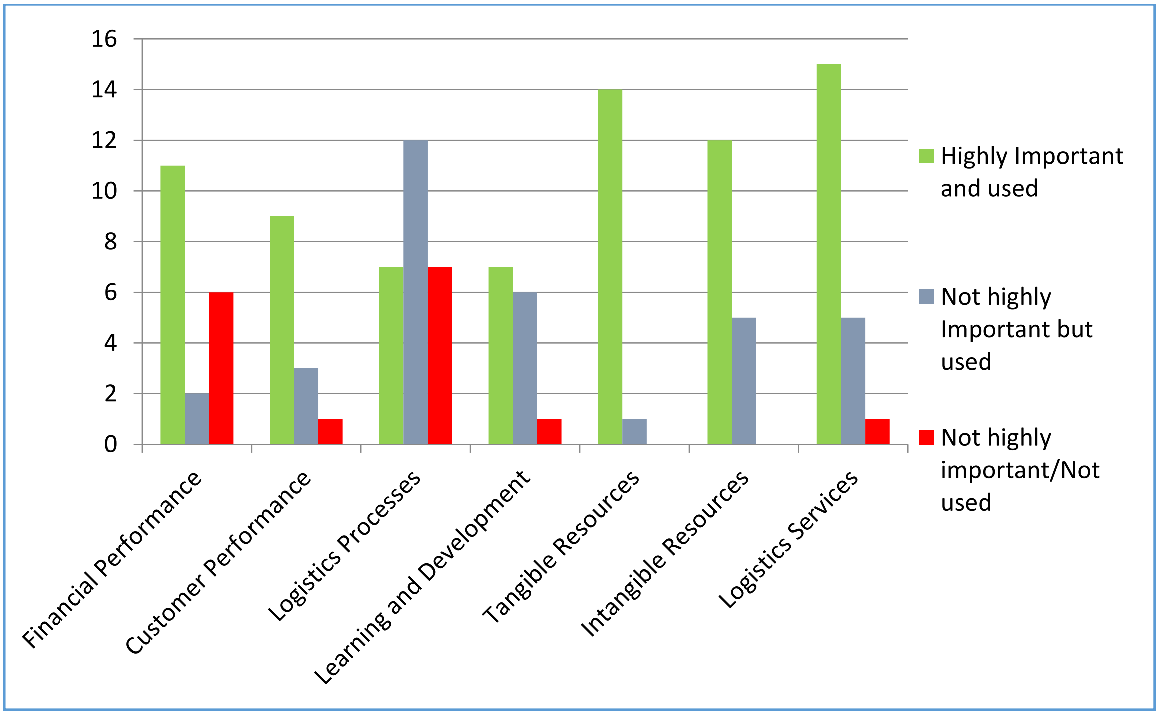

Figure 4- 3: Number of Metrics Used under each LSP Evaluation Dimension

4.3.3. Study Findings

4.3.3.1. Logistics Resources and Capabilities

Based on the Jordanian LSUs/LSPs evaluations, all the logistics resources and capabilities factors (Appendix 4-1) are important and used. Both JLSPs and JLSUs agree upon the importance of logistics resources in any logistics-based decision and they use them to evaluate and select LSPs. For example, ‘Improvement logistics facilities and technology usage’ and ‘focus on customers’ requirements’ are the most important factors. Followed by ‘Logistics facilities and equipment’, ‘Periodic maintenance’ and ‘Continuous improvement’ which reflect the importance of continuous improvement and development in logistics resources and therefore, for LSPs competitiveness. Meanwhile, ‘Management experience’, ‘Coordination and collaboration’, ‘Skilled and educated workers’ and ‘Web-based information systems’ are the most important intangible logistics resources.

Based on these results, the ‘Logistics resources and capabilities’ dimension of the developing economies framework can maintain the same sub-dimensions. Appendix 5-1 (Chapter 5) summarises the operational definitions of logistics resources and capabilities metrics with some supportive references.

4.3.3.2. Logistics performance

Based on the SBSC approach, logistics performance is classified into four main perspectives, under each perspective, a number of LKPIs. For each LKPI a number of indicators/metrics can be used (Appendix 4-2). Based on the JLSPs/JLSUs, the following are the most important indicators/metrics.

Logistics financial perspective: ‘Operational profit’ and ‘Total revenue’ are the most important metrics followed by ‘Profit margin’, ‘Logistics costs’, return on equity ‘ROE’ and return on investment ‘ROI’. In term of costs, the most important metrics are ‘Warehousing cost’, ‘Transportation cost’, ‘Handling cost’ and ‘Logistics fixed costs’. Meanwhile, there are a number of logistics financial metrics with importance level less than (4) that are used by the Jordanian firms to support their logistics-based decisions, such as ‘ROA’.

Customer satisfaction perspective: Delivery is the most important factor to satisfy customers. ‘Deliver to correct destination’, ‘On-time delivery’ and ‘Delivery time’ having the highest importance scores. ‘Quality of employee’, ‘Order response time’, ‘Days of order’ and ‘Complete order fill rate’ come next.

Logistics processes perspective: None of the environmental performance metrics are important or used by the Jordanian firms to evaluate and select their LSP partner, such as 'Vehicles' ages', 'Greenhouse gases', 'Green design', 'Green purchasing', 'Waste volume' and 'Corporate sustainability report'. These evaluations reflect low awareness of logistics process sustainability and environmental issues of these firms. Important logistics process metrics are related to processes Productivity, Quality and Reliability such as 'Order fulfilment', 'On-time Pick-up', 'Inventory accuracy', 'Damage due transportation', 'Delay rate', 'Health/Safety of employees' and 'Internal accident rate'. Additionally, there are a number of metrics with importance level less than (4) that are used by the Jordanian firms to support their logistics-based decisions. Some of these metrics are related to quality and reliability ('Delivery complete order', 'Internal damage', 'Serious (risky) deliveries', 'Thefts during transportation'), timeliness ('Short lead-time') and flexibility ('Expedite urgent shipment', 'Increase/Decrease delivery volume', 'Increase/Decrease shipment volume' and 'Addition of manpower at short notice').

Learning and Development perspective: Employees' talents are the most important and most used metric by the Jordanian firms to evaluate and select their logistics partner. In addition to employees' talents, 'Employees' satisfaction, Skills, Knowledge, Training, Education, Safety and Health' comes in the first ranking. Then resource sustainability ('Rate of costs reduction' and 'Avoiding employee discrimination') followed by TQM certificates in the second level. In addition to these metrics, Jordanian firms use a number of relatively moderate important metrics such as 'Training budget', 'Intellectual capital' and 'Profit from new products/Services'. Although the Jordanian firms did not use 'R&D budget' in their logistics-based decisions, it still has a relatively high score (3.94), which makes it an important factor to support other important/used metrics such as 'Cost reduction', 'TQM', 'Profit from new products/services' and 'Intellectual capital'. Some of the environmental metrics such as 'Greening Costs' are neither important nor used, while other environmental and security metrics have been used regardless of their moderate importance levels such as 'ISO28000' and 'ISO14000' certificates. Appendix 6-1 (Chapter 6) summarises the operational definitions of performance metrics for each LKPI under each SBSC perspective with some supportive references.

4.3.3.3. Logistics Services

As it shows in Appendix 4-3, 'Product making' is the only factor that is neither important nor used by the Jordanian firms. Some manufacturing and industrial firms prefer to control their logistics processes by themselves and prefer to perform their logistics activities internally (such as Phosphate and potassium industries). Additionally, most of the traded goods that pass through Jordan are finished, packaged and labelled. Although most of the logistics services factors have been used in logistics-based decisions, five of these factors are not highly important. Three out of these factors (packaging, labelling and product return) are related to the manufacturing sector as 'Product making'. Therefore, the production/postponement sub-dimensions are rearranged to be a sub-dimension as long as they are not important and not used by JLSPs in their logistics-based decisions. Moreover, some used factors with importance level less than 4, such as packaging, labelling, cross-docking, product return and rate negotiation can be added to the 'Customer services' dimension. In addition to the 'E-logistics' and 'Logistics Risk: Safety & Security' services that are added in the late stage of this research, 'Logistics Services' consists of the following dimensions: Inventory and Warehousing, Transportation, Postponement and Customer services. Appendix 7-1 (Chapter 7) summarises the operational definitions of logistics resources and capabilities metrics.

4.3.4. Conclusions and Recommendations

This section aims to provide data about the Jordanian logistics sector. Due to the scarcity of studies and statistics regarding the Jordanian logistics industry, a number of questionnaires have been used to collect primary data from the JLSPs and LSUs. In addition to these primary data, a number of secondary data sources have been conducted (Section 4.2.1.). In the case of the Jordanian logistics sector, a number of actions are needed to improve the efficiency and effectiveness of this sector. The findings of this study are used to verify the LSPs' evaluation and selection framework and therefore, to develop the logistics outsourcing approach. The following observations have significant implications for the competitiveness of the Jordanian logistics industry.

- For both LSPs and LSUs, logistics resources and capabilities are very important factors and crucial element in the LSPs' evaluation and selection process and any other logistics-based decisions. Therefore, JLSPs need to gain the appropriate understanding of logistics resources and capabilities to provide superior performance records.

- Both, tangible and intangible logistics resources are important in any strategic logistics-based decision.
- Continuous improvement and maintenance of these resources and capabilities are as important the resources themselves. Therefore, JLSPs need to provide continuous improvement and maintenance-scheduled activities, not ‘as is needed’.
- Renewal and updating of transportation resources, information and communication technologies to improve the trucking sector is a priority for the Jordanian logistics industry in particular and for the developing economies in general.
- ‘Management experience’, ‘Coordination and collaboration’ and ‘Skills and education’ are the most important intangible logistics resources and capabilities. More attention to improve human talents in the Jordanian logistics industry is highly needed to support the ‘young logistics employees’ and to compensate their lower experience levels.
- In terms of logistics services, most global shipping lines and supply chain networks consider this region as a transit station rather than a final destination. Therefore, JLSPs need to focus more on transportation, customer services and temporary warehousing services.
- Time and resources management, summarising important logistics services in which Jordan needs to excel to improve the JLSPs’ efficiency and competitiveness.
- In terms of logistics performance, financial indicators (profit, revenue and cash) are the most important and the most used ones, followed by logistics processes indicators that have the biggest indicators number. JLSPs and LSUs need to rethink their evaluation and selection criteria to make it more balanced and more comprehensive.
- To take a strategic logistics-based decision, LSUs need to pay more attention to customers, sustainability and learning and growth indicators, and should be considered equal to the financial and processes indicators. Satisfied customers, more sustainability and continuous improvement and development are important factors to have good financial and processes performance.
- Most of the studied JLSPs have similar delivery records, therefore, delivery performance can be considered as an ‘order qualifier’ factor. JLSPs need to analyse their value chain to find their core value-added activities, enhance core competences and strengthen their competitiveness position. Quality of service, flexibility, cost saving, efficiency and sustainable logistics activities are one of the most value-added factors.

The next stage is to evaluate the framework impact-relationships and to identify independent factors to be used in the final approach. The following section provides more information regarding MCDM methods and logistics decision-making techniques.

4.4. Chapter Contributions

This chapter provides one of the first studies regarding the Jordanian logistics sector. Both primary and secondary data are used. Both, JLSPs and JLSUs perspectives are used to verify the LSPs framework elements. MCDM method, Fuzzy logic and other decision-making techniques that are used in logistics-based decisions have been introduced. Chapter contributions can be summarised as follow:

- The first comprehensive study of the Jordanian logistics sector
- Both, primary and secondary logistics data are used to describe Jordanian logistics, its strengths and weaknesses and areas of development.
- Both, JLSPs and JLSUs' perspectives are used to verify and validate the importance of the LSPs framework elements.
- LSPs and LSUs feedback clarifies the new LSPs framework importance and its crucial role in any strategic logistics outsourcing process.
- MCDM methods, Fuzzy logic and other potential decision-making techniques that are used in logistics-based decisions have been introduced
- More specific, FDEMATEL and FTOPSIS integrated approach and its implementation procedures are presented too.

Chapter 5: A novel technique for Evaluating and Selecting LSPs based on the Logistics Resource View

Summary

This chapter proposes an integrated logistics outsourcing approach for evaluating and selecting LSPs based on their logistics resources and capabilities. This approach combines a FDEMATEL and FTOPSIS methods. The new MCDM model addresses the impact-relationship between decision criteria and ranks LSP alternatives against weighted resources and capabilities. The effectiveness of this approach is demonstrated through a case study and a two-phase sensitivity analysis confirms its robustness.

5.2. Introduction

The growing demand for logistics outsourcing and the increase in the number and type of LSPs highlight the increasing importance of the LSP evaluation and selection process. Firms use various approaches to analyse, evaluate and select their LSP partners. The complexity of the decision and the large number of criteria involved increase the attractiveness of the MCDM approaches. LSP performance is a vital dimension in the evaluation process and many firms use LSPs' past performance records to select appropriate LSPs (Straight, 1999; Lai et al., 2002; Liu and Lyons, 2011; Rezaei et al., 2014; Du et al., 2015; Moghaddam 2015). However, using past performance records alone is insufficient for performing a comprehensive evaluation. There is no guarantee that an LSP can replicate its past performance, particularly if the LSP encounters unfamiliar work conditions. In many cases, the availability, accessibility and accuracy of performance measures should be investigated. Therefore, using LSPs' past performance as a single evaluation dimension is insufficient particularly under high uncertainty decision-making environments. Moreover, many studies of LSP evaluation and selection have failed to address the inherent uncertainty in data and the interdependencies of the LSPs' evaluation and selection criteria – an area that has not been extensively studied. Moreover, the importance and complexity of the LSP evaluation and selection process increases in developing economies and emerging markets where the need for professional LSPs which can help and support these economies in their development process is crucial. Lack of research regarding developing logistics sectors increases the importance of this study. To overcome the aforementioned shortcomings, this study uses LSPs' logistics resources and capabilities to model the logistics outsourcing process and therefore, to evaluate and select the most appropriate LSP in developing economies. Based on comprehensive reviews of related literature, this study provides a fuzzy-based logistics outsourcing model that uses logistics resources and capabilities rather than performance metrics to evaluate and select LSPs under high uncertainty. Moreover, it is one of the first studies to analyse the logistics resources impact-relationship and in turn to identify independent resources. In addition, it analyses the logistics outsourcing decision based on the LSPs' resources and capabilities in the developing economies (Case of Jordan).

Firms' resources and capabilities and their effect on firms' performance have been extensively studied using the Resource-Based View (RBV) theory. The RBV theory (Wernerfelt 1984 and Barney 1991) states that firms' performance and competitive advantage are highly affected by firms' unique and valuable resources. Therefore, LSPs acquire various logistics resources and capabilities to generate the flexibility necessary to provide logistics services that meet customer needs. This study uses logistics resources and capabilities to develop an advanced hybrid LSP evaluation and selection model. This model uses the DEMATEL technique to evaluate and construct interdependency relationships between logistics resources and capabilities, identify independent resources and determine their weights. The TOPSIS technique is used to evaluate, rank and select an appropriate LSP. However, data uncertainty problems make it difficult for experts and DMs to provide a crisp value of criteria weights and to quantify the precise rankings of LSPs. Therefore, the concept of fuzzy sets is integrated with the DEMATEL and TOPSIS techniques to handle the uncertainty of the data. Fuzzy sets help DMs express their preferences using TFNs through applications of specific linguistic expressions.

5.3. Background

Logistics outsourcing has attracted the attention of firms, academics and researchers. Logistics outsourcing is an important strategic process. It has been proven that, logistics outsourcing is an effective way to achieve a competitive advantage, improve customer services and reduce logistics costs (Boyson et al., 1999; Jonsson 2008; Aguezzoul 2014). Logistics outsourcing can reduce fixed costs and increase flexibility, allowing for a greater focus on a firm's core activities, a reduction of heavy asset investments and an improvement of service quality (Hsu et al., 2012). At the same time, the decision to outsource includes a number of risks related to the loss of control, long-term commitment and the failures of some LSPs to perform their duties (Farahani et al., 2011; Wang et al., 2014; Soeanu et al., 2015). Therefore, LSUs need to be sure of the way they evaluate and select their logistics partner. LSPs' resources and capabilities and their effect on logistics performance have been studied before using the RBV theory. A number of studies have identified logistics resources and their effects on a firm's performance (Hunt 2001; Lai et al., 2008; Hartmann and Grahl 2011; and Karia and Wong 2013).

5.3.1. Resource-Based View (RBV) and LSPs' Performance

Resources and capabilities are one of the strategic choices that firms use to achieve a competitive advantage. According to Mentzer et al. (2004), logistics resources can be divided into tangible and intangible resources. These resources must be correctly managed to gain distinctive logistics capabilities, which in turn helps build and sustain strong competitive logistics advantages. Logistics resources include all of the tangible and intangible components that are acquired and used to perform a firm's activities. Capabilities are a firm's ability to use these resources in a unique way to create competitive advantage (Lai 2004). Lai et al. (2008) and Karia and Wong (2013) suggest using RBV theory to examine the impact of resources and capabilities on LSPs' performance. Based on the RBV theory, Karia and Wong (2013) developed a theoretical model of logistics resources and capabilities. They called it resource-based logistics (RBL). The RBL constructs logistics resources into tangible and intangible groups. The tangible resources group consists of technology and physical resources. The intangible resources group consists of management expertise, relational and structure resources. According to RBL, these logistics resources and capabilities determine an LSP's performance. Therefore, logistics resources and capabilities are valid factors for evaluating and selecting the best LSP.

5.4. The Hybrid Model

This study uses Mentzer et al.'s (2004) general resource classification and the RBL theory to develop an LSP resource and capabilities model. According to the RBL**,** tangible and intangible logistics resources and capabilities are the base of the new hybrid model to evaluate and select LSPs. Jordan is selected as a case study. Based on the Jordanian LSPs and LSUs responses (Chapter 3), only factors/metrics with importance levels ≥ 4 and/or usage rate $\geq 50\%$ were selected to be used in the new hybrid model. Logistics resources and capabilities factors are classified into three groups: highly important and used, not highly important but used and not highly important and not used. Figure 5-1 summarises the numbers of metrics under each evaluation dimension.

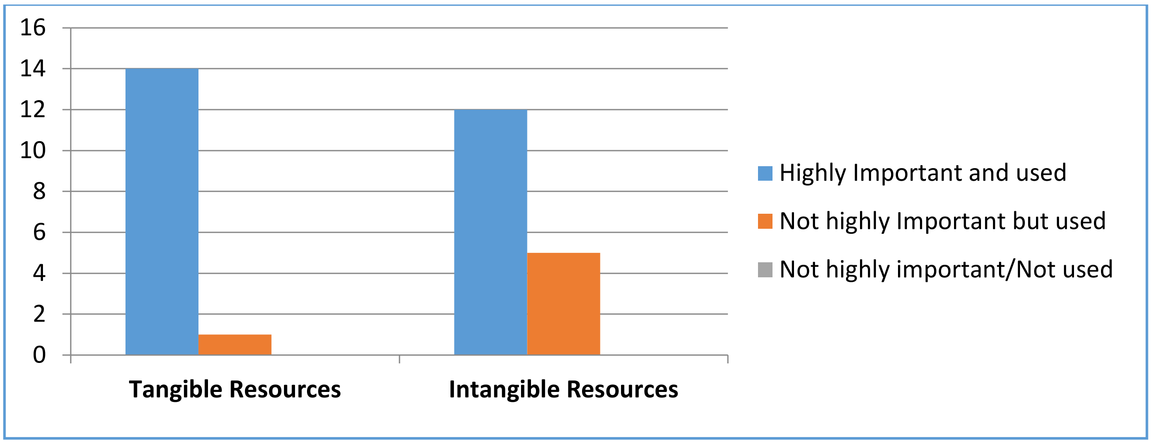

Figure 5- 1: Logistics Resources and Capabilities Metrics

5.4.1. Tangible Logistics Resources and Capabilities

Tangible resources include two main categories: physical and technological resources. Physical resources represent an LSP's capability to acquire, use and maintain logistics vehicles, machines, tools and facilities. Based on logistics activities, this study classifies physical logistics resources into four categories:

- Warehousing (storage area, handling equipment, cranes and winches, etc.)
- Transportation (trucks, trains, planes, ships, etc.)
- Production and packaging
- Improvements to and maintenance of these resources

Availability and quality of physical logistics resources are basic requirements to perform logistics activities effectively and perfectly satisfy LSUs needs and requirements. LSPs need to acquire the right quantity and quality of physical logistics resources to facilitate and support all the internal and external logistics operations.

Technology resources (IT-based resources) cover the infrastructure components such as computers, communication tools, databases, etc. Technological logistics resources represent an LSP's capability to acquire, use and maintain advanced logistics technologies for use with other physical resources to perform logistics activities effectively and efficiently. Technological resources help LSPs manage, control, monitor and improve logistics operations. This study classifies IT resources into three categories: Physical-IT resources, Communication tools and databases, Information Systems (IS) and internet-based technology (Appendix 5-1).

5.4.2. Intangible Logistics Resources and Capabilities

RBL classifies intangible logistics resources into three categories (management expertise, relational and organisational). To provide a more holistic view, this study uses the intellectual capital concept to classify intangible logistics resources and capabilities. Intellectual capital is the amount by which the market value of an LSP exceeds its tangible (physical and financial) assets minus its liabilities (Mehri et al., 2013). Normally, intellectual capital is classified into three main categories: human, structural and relational capital. Therefore, intangible logistics resources and capabilities consist of:

1- Human Resources: is the value that the LSP employees provide through the application of skills, knowledge and expertise. Human capital covers how effectively an LSP uses its human resources. Human capital resources consist of education and training, knowledge and experience and skills.

2- Structural Resources: includes all the supportive non-physical assets, such as; non-physical infrastructure, processes, procedures and databases of a LSP that enable human capital to perform various functions. Structural resources are close to the physical-IT tangible resources, but this dimension covers the software side of IT and physical-IT covers the hardware side. Structural capital resources consist of databases and software, processes, image and reputation and LSP's culture.

3- Relational Resources: includes all relations with customers, suppliers and other LSPs that help and support the LSPs to perform various logistics activities. This dimension consists of collaboration, long-term relationships and information sharing. Appendix 5-1 conceptualises tangible and intangible logistics resources by providing a brief description and classifications, measures and supportive studies.

Integrating tangible and intangible logistics resources into one hybrid model helps create a more comprehensive and balanced LSP evaluation and selection process. Figure 2-5 clarifies the hierarchy of the tangible and intangible logistics resources. The five resource dimensions allow DMs to choose between LSPs based on their tangible and intangible logistics resources. Rather than using one or two limited dimensions, this balance trade-off provides a more realistic picture by compensating for some low-score resources with high-score resources. Figure 5-2 summarises this trade-off.

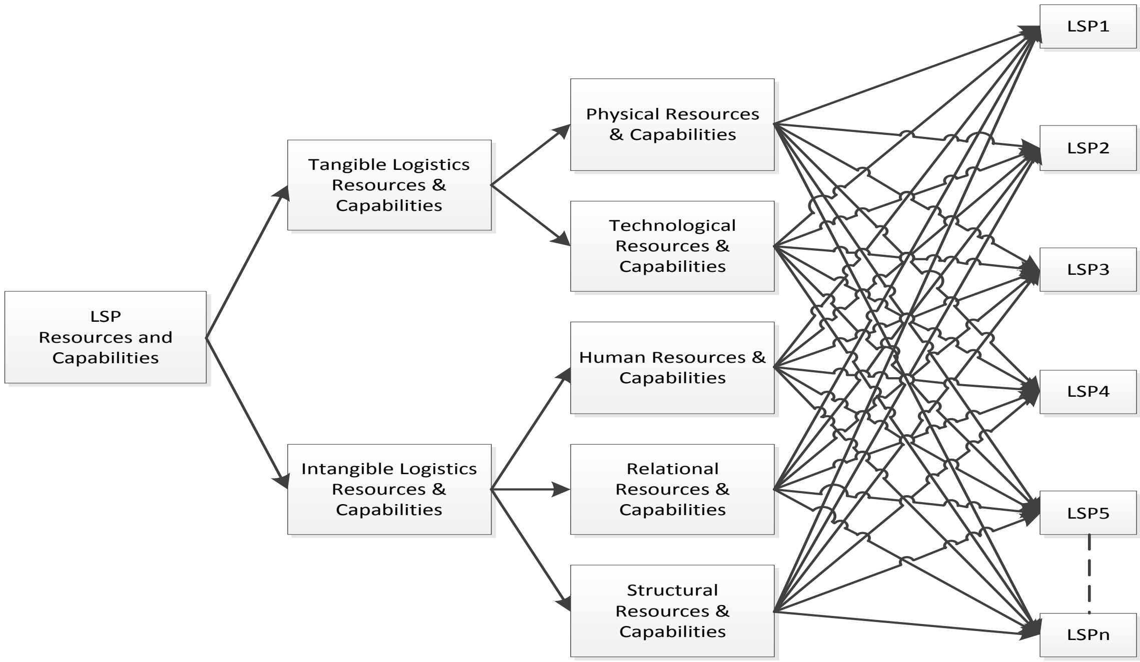

Figure 5- 2: LSPs' Trade-off Model Based on their Resources and Capabilities

5.4.3. Implementation Procedures

Evaluating and selecting the appropriate LSP is an issue for all LSUS. The selection of an inappropriate LSP directly affects LSUs' capability to perform their core activities, satisfy their customers and achieve their strategic objectives. This study helps firms evaluate and select their appropriate LSP through an integrated approach of fuzzy DEMATEL and TOPSIS techniques (Appendix 3-1). This study uses the FDEMATEL-FTOPSIS integrated approach to evaluate logistics resources impact-relationship and in turn to evaluate and select appropriate LSPs. Figure 3-7 clarifies the hybrid model procedures. Three questionnaires were developed and used. (i) Information sheet to collect LSPs' information (Chapter 4). (ii) FDEMATEL questionnaire to collect experts' evaluations of the LSPs' resources and capabilities impact-relationship. (iii) FTOPSIS questionnaire to collect experts' evaluations of the LSP alternatives against the weighted resources and capabilities.

5.5. Results

5.5.1. FDEMATEL

Several logistics experts were approached for their opinions and a questionnaire was used to ascertain those opinions. Seven logistics experts with more than ten years of logistics experience were contacted. Four experts completed the entire questionnaire. The experts who provided full responses were: (i) A Vice President of Business Development/Logistics, Logistics Company/Freight management services with more than 30 years of experience in logistics and supply chain management. (ii) A Logistics Director, Logistics International Freight Services with more than 35 years of experience in logistics and supply chains. (iii) A Logistics and supply chain academic/researcher with more than 10 years experience and more than 30 published works. Beginning with the first level of the logistics resources and capabilities framework (Figure 5-2), the logistics experts were asked to evaluate the extent to which they believe that factor *i* influences factor *j* by using linguistic variables defined in Table 3-3. The average matrix at the first level was obtained using Equation 3-4. The same procedures were repeated for each portion of the framework. A Physical Resources and Facilities factor was used to demonstrate the FDEMATEL procedures. Table 5-1 summarises the experts' evaluations regarding the degrees of influence between the Physical Resources and Facilities factors. Table 5-2 is the initial fuzzy average matrix (A^{fuz}) (direct-relations matrix).

Table 5- 1: Experts' Evaluations of the Physical Resources Impact-Relationship

Experts	W-T	W-P	W-Im	T-W	T-P	T-Im	P-W	P-T	P-Im	Im-W	Im-T	Im-P
Exp1	H	V.L	L	L	No	V.L	V.H	H	L	L	V.L	V.L
Exp2	No	V.L	V.L	No	No	H	V.L	No	L	V.L	V.L	L
Exp3	H	V.H	L	H	L	L	L	V.H	L	H	H	H
Exp4	H	L	H	H	V.L	V.L	L	L	V.L	V.L	V.L	V.L

W: warehousing, **T**: transportation, **P**: production & packaging and **Im**: improvement and maintenance.

Table 5- 2: Physical Resources and Capabilities Afuz Matrix

A^{fuz} matrix	Warehousing	Transportation	Production/ Packaging	Improvement & maintenance
Warehousing	(0.00, 0.00, 0.00)	(0.375, 0.563, 0.813)	(0.250, 0.500, 0.688)	(0.250, 0.500, 0.750)
Transportation	(0.313, 0.500, 0.750)	(0.00, 0.00, 0.00)	(0.063, 0.188, 0.438)	(0.188, 0.438, 0.688)
Production	(0.313, 0.563, 0.750)	(0.375, 0.563, 0.750)	(0.00, 0.00, 0.00)	(0.188, 0.438, 0.688)
Improvement	(0.188, 0.438, 0.688)	(0.125, 0.375, 0.625)	(0.188, 0.438, 0.688)	(0.00, 0.00, 0.00)

Each fuzzy number in Table 5-2 is the average of the experts' evaluations of the degree of influence between two factors. For example, on average, the Transportation Resources influence over Warehousing Resources equals $(0.313, 0.500, 0.750)$:

$$\frac{1}{4}(L + No + H + H) = \frac{1}{4}\big((0.25, 0.50, 0.75) + (0.0, 0.0, 0.25) + 2(0.50, 0.75, 1.0)\big)$$

The normalised fuzzy direct relation matrix (X^{fuz}) was obtained using Equations (3-5, 3-6 and 3-7). Table 5-3 summarises the X^{fuz} matrix of Physical Resources and Facilities.

Table 5- 3: Normalised Xfuz Matrix

X^{fuz} matrix	Warehousing	Transportation	Production/ Packaging	Improvement & maintenance
Warehousing	(0.00, 0.00, 0.00)	(0.167, 0.250, 0.361)	(0.111, 0.222, 0.306)	(0.111, 0.222, 0.333)
Transportation	(0.139, 0.222, 0.333)	(0.00, 0.00, 0.00)	(0.028, 0.083, 0.194)	(0.083, 0.194, 0.306)
Production	(0.139, 0.250, 0.333)	(0.167, 0.250, 0.333)	(0.00, 0.00, 0.00)	(0.083, 0.194, 0.306)
Improvement	(0.083, 0.194, 0.306)	(0.056, 0.167, 0.278)	(0.083, 0.194, 0.306)	(0.00, 0.00, 0.00)

Normalising the fuzzy direct relation matrix transforms the various criteria scales into a comparable scale. The fuzzy total-relation matrix is obtained using Equations (3-8, 3-9 and 3-10), as shown in Table 5-4.

Table 5- 4: Tfuz matrix

T^{fuz} matrix	Warehousing	Transportation	Production/ Packaging	Improvement & maintenance
Warehousing	(0.060, 0.313, 3.075)	(0.207, 0.514, 3.342)	(0.136, 0.427, 2.892)	(0.146, 0.475, 3.263)
Transportation	(0.162, 0.417, 2.928)	(0.042, 0.236, 2.680)	(0.056, 0.271, 2.484)	(0.109, 0.386, 2.859)
Production	(0.184, 0.515, 3.269)	(0.210, 0.517, 3.270)	(0.037, 0.247, 2.610)	(0.124, 0.457, 3.192)
Improvement	(0.113, 0.425, 3.057)	(0.093, 0.407, 3.043)	(0.101, 0.371, 2.677)	(0.029, 0.246, 2.767)

Table 5-4 summarises the experts' overall influence ratings of Physical Resources and Capabilities. Each FTN is the total direct and indirect fuzzy influence of each criterion *i* over criterion *j*. For example, the total direct and indirect fuzzy influence of the Warehousing criterion over the Transportation criterion is (0.207, 0.514, 3.342). The sum of the Warehousing row (R_i^{fuz}) (0.549, 1.730, 12.573) is the total direct and indirect fuzzy influence that the Warehousing criterion has over the system. Meanwhile, the sum of the 'Warehousing' column (C_i^{fuz}) (0.518, 1.671, 12.330) is the total direct and indirect influence of the system over the 'Warehousing' criterion, as shown in Table 5-5 that summarises the R_i^{fuz}, C_i^{fuz}, R_i^{def}, C_j^{def}, $(R_i+C_i)^{def}$, $(R_i-C_i)^{def}$ values and the factor type.

Table 5- 5: Physical Resources and Capabilities Importance, Relations and Types

Factors	R_i^{fuz}	C_i^{fuz}	R_i^{def}	C_i^{def}	$(R_i+C_i)^{def}$	$(R_i-C_i)^{def}$	Type
Warehousing	(0.549, 1.730, 12.573)	(0.518, 1.671, 12.330)	4.499	4.396	8.895	0.103	Cause
Transportation	(0.370, 1.311, 10.951)	(0.553, 1.674, 12.335)	3.809	4.410	8.219	-0.601	Effect
Production	(0.555, 1.736, 12.341)	(0.329, 1.315, 10.663)	4.436	3.713	8.149	0.722	Cause
Improvement	(0.335, 1.448, 11.544)	(0.409, 1.564, 12.082)	4.022	4.247	8.268	-0.225	Effect

Using Equation 3-11 to defuzzify (R_i^{fuz}) and (C_i^{fuz}) provides the values of R_i^{def} and C_i^{def} (Table 5-5). These defuzzified values are used to provide $(R_i+C_i)^{def}$ and $(R_i-C_i)^{def}$ values which in turn are used to acquire the IRM. Equation 3-11 is used to defuzzify the T^{fuz} matrix. Only factors with effects greater than the threshold value should be chosen and in turn shown in an IRM (visual diagram). The average value of the T^{def} matrix is defined as the Threshold in this hybrid model (Tzeng et al., 2007; Wu 2008; Shieh et al. 2010). The average value of the T^{def} is (1.048). Therefore, only shaded cells in Table 5-6 were represented in the IRM (Figure 5-3).

Table 5- 6: Tdef Matrix

T matrix	Warehousing	Transportation	Production	Improvement
Warehousing	1.035	1.237	1.049	1.179
Transportation	1.065	0.885	0.845	1.015
Production	1.208	1.218	0.866	1.144
Improvement	1.089	1.071	0.953	0.909

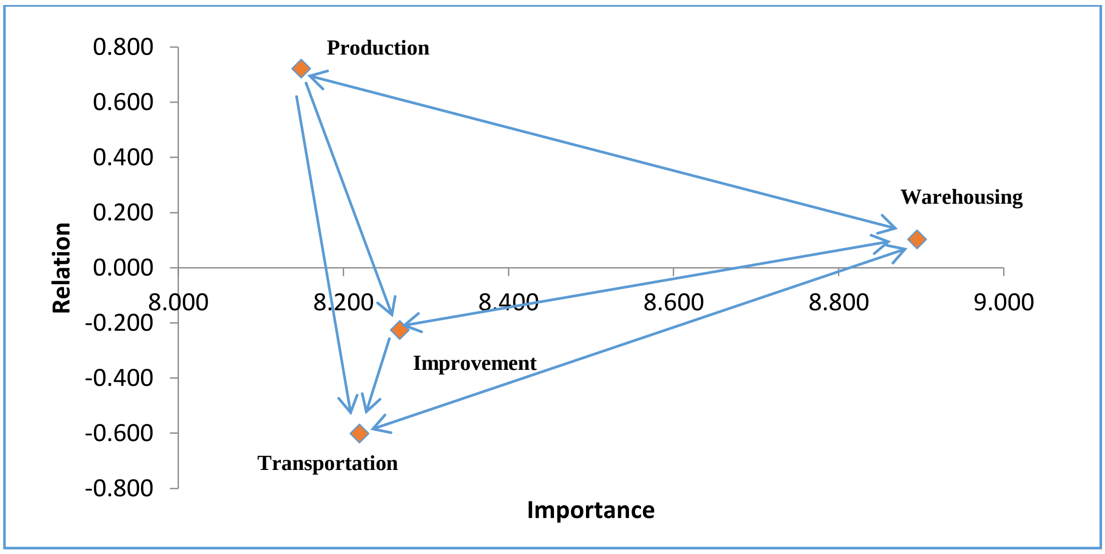

Figure 5- 3: Physical logistics resources IRM

In the IRM, the horizontal axis ($R_i + C_j$) provides an index representing the total effects both given and received by factor *i*. ($R_i + C_j$) shows the degree of importance that factor *i* plays in the system. Meanwhile, the vertical axis ($R_i - C_j$) shows the net effect that factor *i* contributes to the system. When ($R_i - C_j$) is positive, factor *i* is a *net causer* and belongs to the '*Cause Group*' e.g. production and warehousing (Figure 5-3). If ($R_i - C_j$) is negative, factor *i* is a *net receiver* and belongs to the '*Effect Group*' e.g. improvement and transportation (Dalalah et al. 2011**;** Tzeng et al. 2007**;** Tamura et al., 2002).

The same procedures were used to evaluate the cause-and-effect relationships, relative importance and relative weights for all of the criteria. Table 5-7 summarises the $(R_i+C_i)^{def}$, $(R_i\text{-}C_i)^{def}$, criterion type, relative importance and relative weight (global and local) for all of the criteria in the LSP resources and capabilities framework. The local and global weights of each criterion in this group can be obtained using Equations 3-1 and 3-2. The global weight of any criterion is the result of multiplying its local weight by the global weight of the cluster or group where it belongs. For example, the local weight of Physical logistics resources is (0.500). This cluster is under the 'Tangible resources' dimension. The global weight of Tangible resources is (0.500). Therefore, the global weight of Physical logistics resources is (0.500×0.500), which equals (0.250).

Table 5- 7: FDEMATEL Outputs

Factor	R_i+C_i ^{def}	R_i-C_i ^{def}	Type	Relative Importance	Local Weight	Global Weight
(A) Tangible R&C	6.027	0.604	Cause	6.057	0.500	**0.500**
Physical R&C	5.841	-0.705	Effect	5.883	0.500	0.250
Warehousing	8.895	0.103	Cause	8.896	0.265	0.066
Transportation	8.219	-0.601	Effect	8.241	0.245	0.061
Production and packaging	8.149	0.722	Cause	8.181	0.244	0.061
Improvement and maintenance	8.268	-0.225	Effect	8.271	0.246	0.062
IT-based R&C	5.841	0.705	Cause	5.883	0.500	0.250
Physical-IT	9.808	0.569	Cause	9.824	0.330	0.083
Communication Tracking	9.759	-0.148	Effect	9.760	0.328	0.082
IS and internet based systems	10.155	-0.420	Effect	10.164	0.342	0.085
(B) Intangible R & C	6.027	-0.604	Effect	6.057	0.500	**0.500**
Human R&C	6.306	0.328	Cause	6.315	0.357	0.178
Education	5.438	0.375	Cause	5.451	0.362	0.065
Knowledge	4.716	-0.278	Effect	4.725	0.313	0.056
Skills	4.899	-0.097	Effect	4.900	0.325	0.058
Relational R&C	6.069	-0.323	Effect	6.078	0.344	0.172
Collaboration	15.117	-1.094	Effect	15.157	0.345	0.059
Long-term relationships	14.552	-1.039	Effect	14.589	0.332	0.057
Information sharing	14.079	2.133	Cause	14.239	0.324	0.056
Structural R&C	5.298	-0.005	Effect	5.298	0.299	0.150
Databases and Software	3.273	0.846	Cause	3.380	0.345	0.052
Image & Reputation	3.123	-0.466	Effect	3.157	0.322	0.048
Cultural & mgmt.	3.249	-0.380	Effect	3.271	0.333	0.050

In order to find the most suitable metrics to be used under each factor in the lower level of this hybrid model, logistics experts were asked to rank a number of relative metrics after each session of DEMATEL evaluation. These metrics include the most used metrics in the logistics literature. The purpose here is to provide a weighted list of suitable metrics to help managers and DMs in their logistics-based decision-making processes. Appendix 5-2 summarises the relative importance of these metrics.

5.5.2. Impact-relationship

This study is one of the first to develop logistics resources IRM using FDEMATEL outputs. These maps help clarify how logistics resources and capabilities affect one another and themselves and identify resources that are central to the LSP evaluation and selection problem.

5.6.2.1. Tangible-intangible Logistics Resources Impact-relationship

Logistics resources and capabilities have been classified into two main groups: Tangible logistics resources and capabilities consist of the physical and IT-based logistics resources and Intangible logistics resources and capabilities consist of human, relational and cultural logistics resources and capabilities. Tangible and intangible logistics resources are equally important in the logistics-based decision making processes (50%), as shown in Table 5-7. According to the Tangible-Intangible IRM (Figure 5-4), tangible logistics resources and capabilities are 'Cause factors' which affect intangible logistics resources and capabilities, which are classified as 'effect factors'. Tangible logistics resources and capabilities significantly affect intangible resources and capabilities. LSP can build a good reputation, attract qualified logistics employees, build and sustain healthy relationships with other LSPs and customers and create and sustain a strong firm culture by obtaining and maintaining appropriate tangible logistics resources and capabilities.

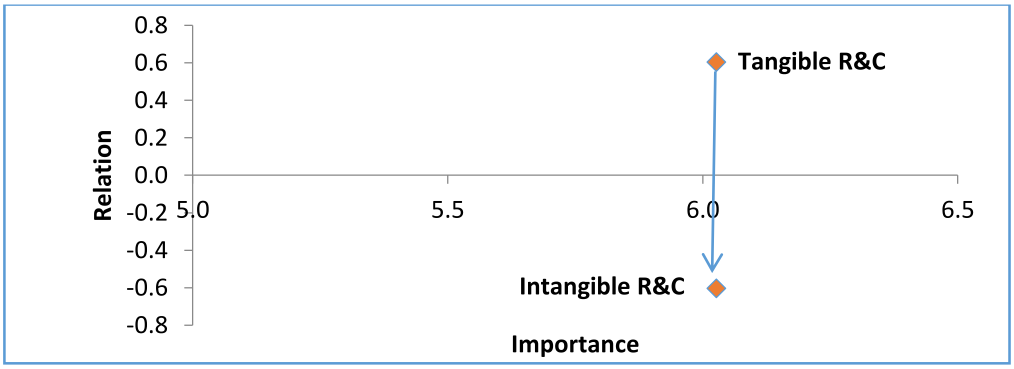

Figure 5- 4: Tangible-Intangible IRM

5.6.2.2. Tangible Logistics Resources Impact-relationship

Both Physical and IT-based logistics resources are important in logistics-based decisions (50% each). In terms of causal relationships (Figure 5-5), IT-based resources and capabilities significantly influence physical resources and capabilities. Good IT Facilities, Communication Systems and IS & Internet-based Facilities support other Warehousing & Inventory', Transportation, Production and Improvement physical resources. An LSP that obtains advanced IT-based resources has better warehousing and inventory management and is more capable of using its physical resources and transportation capacity and of providing an outstanding delivery performance. As shown in Table 5-7, IS and Internet-based systems and facilities are the most important elements of IT-based resources. LSPs with advanced websites will be able to create real-time decision-making, information sharing, order tracking and shipment processes. These technologies enable LSPs to provide better logistics services, which support both LSPs and logistics service users in their daily processes and help them achieve their strategic objectives.

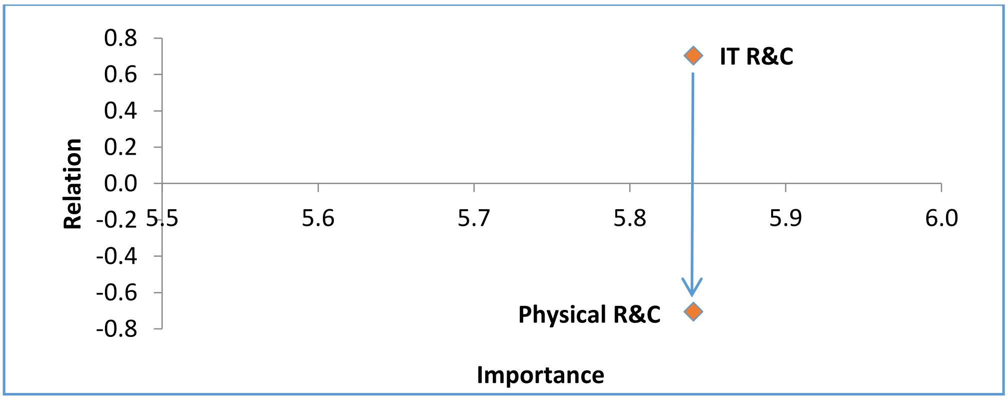

Figure 5- 5: Tangible Logistics Resources IRM

Physical logistics resources

Figure 5-3 summarises the impact-relationship between the 'Physical resources': warehousing, transportation, production and improvement & maintenance. These four groups did not have the same relative importance and affect each other in various ways. 'Warehousing' and 'production' resources and facilities have significant influence over 'transportation' and 'maintenance' resources. Based on the experts' evaluations (Table 5-7), 'warehousing and inventory' resources and facilities are the most important one. LSUs try to take off the heavy load of logistics fixed investment through outsourcing logistics activities. Improvement and maintenance of these physical resources comes in the second level of importance. This good rank reflects the importance of continuous improvement and scheduled maintenance in the logistics industry.

IT-based resources (Technological)

'IS & internet-based systems' is the most important element in the IT-based resources (Table 5-10). It is correct that it is an 'effect factor' but its mutual relationships with other IT-based elements increase its importance (Figure 5-5). 'IS & internet-based systems' has a mutual impact-relationship with 'Communication systems' and is influenced by the quality and availability of the 'Physical IT' resources. In addition to its mutual impact-relationship with 'IS and internet systems', the 'Communication systems' factor is influenced by the quality and availability of the 'Physical IT-based' resources. In this case, LSPs need to provide the right quantity and quality of the physical IT-based resources that enable them to provide high quality 'IS' and internet services and at the same time provide reliable communication systems.

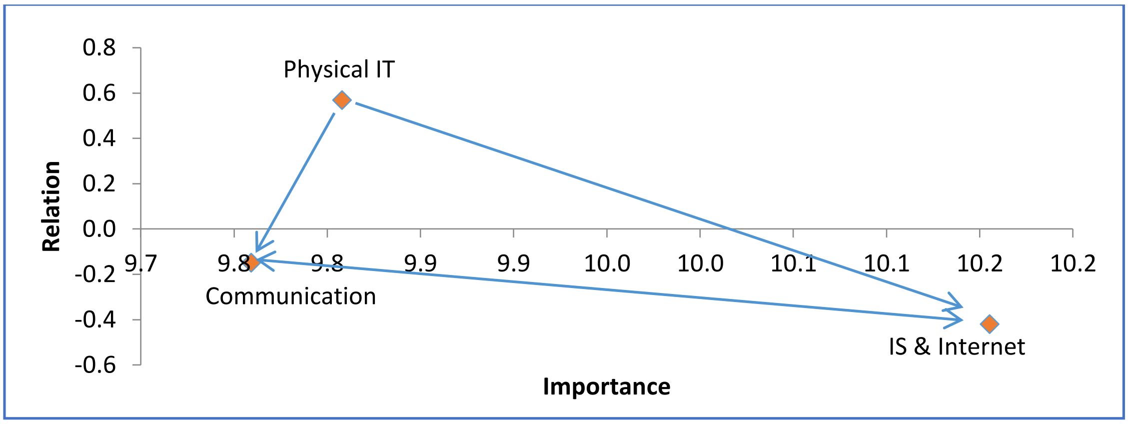

Figure 5- 6: IT-based Resources IRM

5.6.2.3. Intangible Logistics Resources and Capabilities Impact-relationship

Human Resources are the most important intangible resources and capabilities (Table 5-7). Human resources have the strongest influence over other intangible resources, both relational and structural. Based on the IRM (Figure 5-7), we see that: (i) Human resources and capabilities are the most important intangible logistics resources and capabilities. (ii) Human resources have a direct impact-relationship with structural resources and a mutual impact-relationship with relational logistics resources. (iii) Qualified human resources help build and sustain healthy long-term relationships with customers, suppliers and other LSPs. (iv) Healthy long-term networks of relationships help LSPs attract, obtain and retain highly qualified human resources. (v) LSPs that obtain the right qualified human resources are more capable of creating the right mix of structural resources (databases, software, departments, management and firm culture). In general, firms prefer to address LSPs with similar cultural and managerial features. Therefore, the mix of structural resources affects LSPs' capability to build healthy long-term relationships with customers and other LSPs.

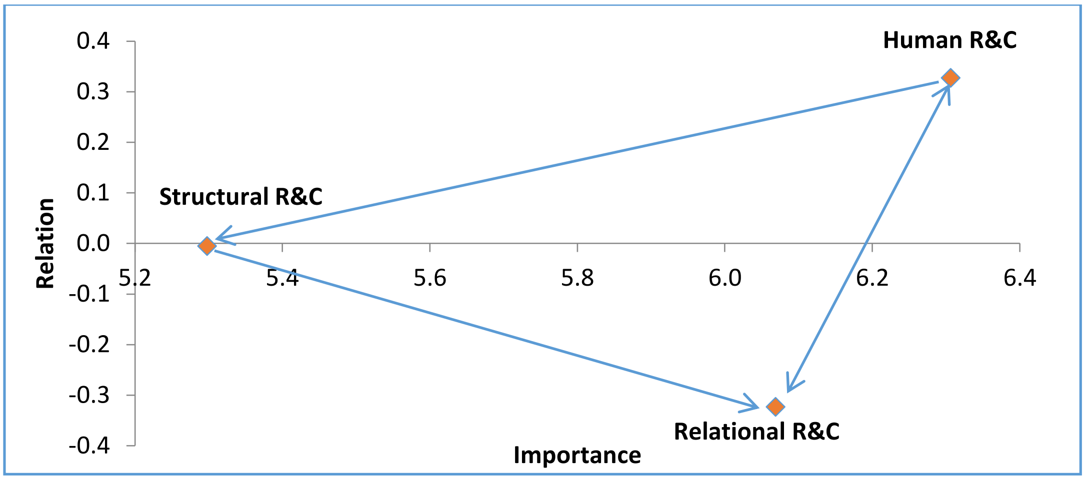

Figure 5- 7: Intangible Logistics Resources and Capabilities IRM

Human resources and capabilities

Figure 5-8 shows the mutual impact-relationship between human resources dimensions: education & training, skills and knowledge & experience. 'Education & training' is the key dimension that influences skills and knowledge. LSPs need to select the right human resources with the right levels of education and training to obtain skills and knowledge that enable them to perform their logistics activities. At the same time, LSPs need to provide continuous human education, training and development to secure the human resource skills and knowledge levels. Both 'education' and 'skills' contribute to the aggregate logistics knowledge and experience of the LSPs' human resources.

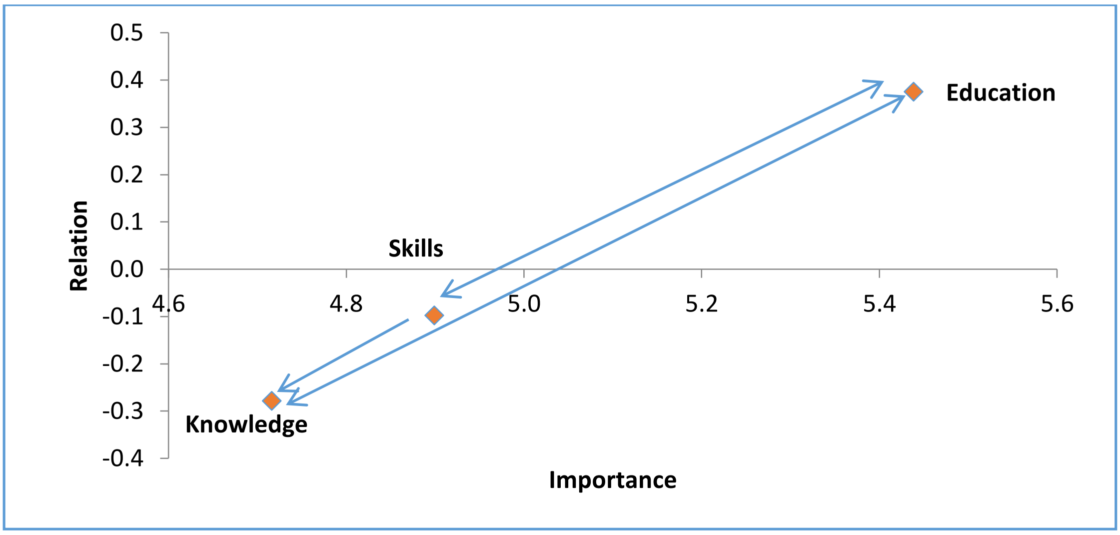

Figure 5- 8: Human Resources IRM

Relational resources and capabilities

In term of relational resources, there is a mutual impact-relationship between collaboration and long-term relationships. LSPs with good collaboration records are more capable of building and sustaining health long-term relationships. Simultaneously, the "Long-term relationships' help LSPs to build new, good 'Collaboration' records. At the same time, good collaboration records lead to more future collaborations, which explains the collaboration loop relationship (Figure 5-9). 'Information sharing' is the success key of the LSP's relations with customers, suppliers and other LSPs. LSP's capability and willingness to share information with customers, suppliers and other LSPs influences both the level of collaboration and the length of relationship.

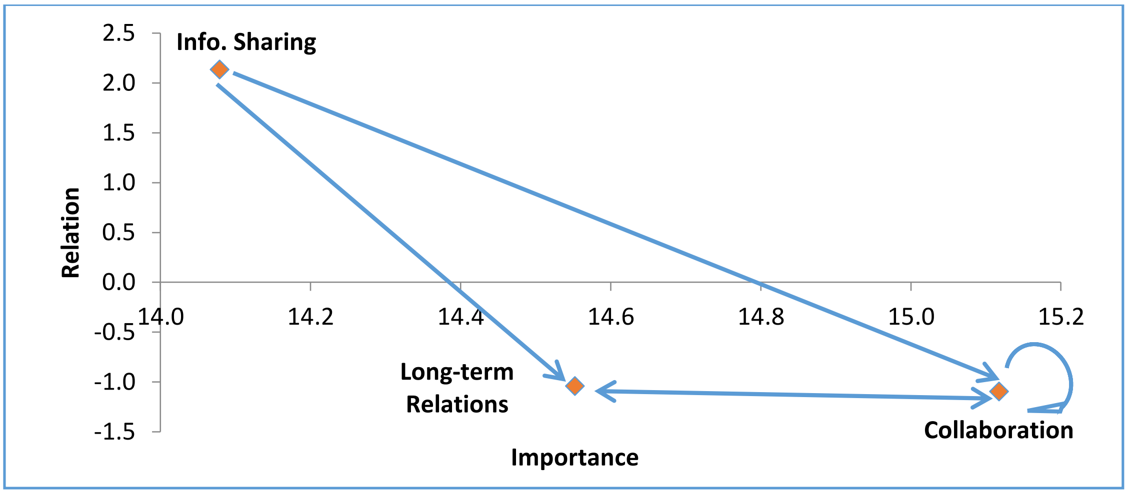

Figure 5- 9: Relational Resources IRM

Structural resource and capabilities

The logistics 'Databases & software' plays a crucial role in the LSPs' structural resources and capabilities (Figure 5-10). In addition to their internal and external support for the LSPs' structure and facilitating logistics activities, Databases and Software have a direct impact-relationship over the LSPs' 'Image & reputation' and culture. Up-to-date and compatible 'Logistics database & software' help LSPs to build and sustain a strong positive image and good reputation in the logistics industry. At the same time, these up-to-date, compatible Databases and Software affect the LSP's culture in terms of supporting or changing some of the cultural dimensions that may or may not be compatible with these Databases and Software. Meanwhile, there is a mutual impact-relationship between the LSPs' image and culture, the unique mix of the cultural dimensions directly affects the firm's image and reputation. Having a good image and reputation motivates LSPs to modify their cultural dimensions to fit and support their good status in the logistics industry.

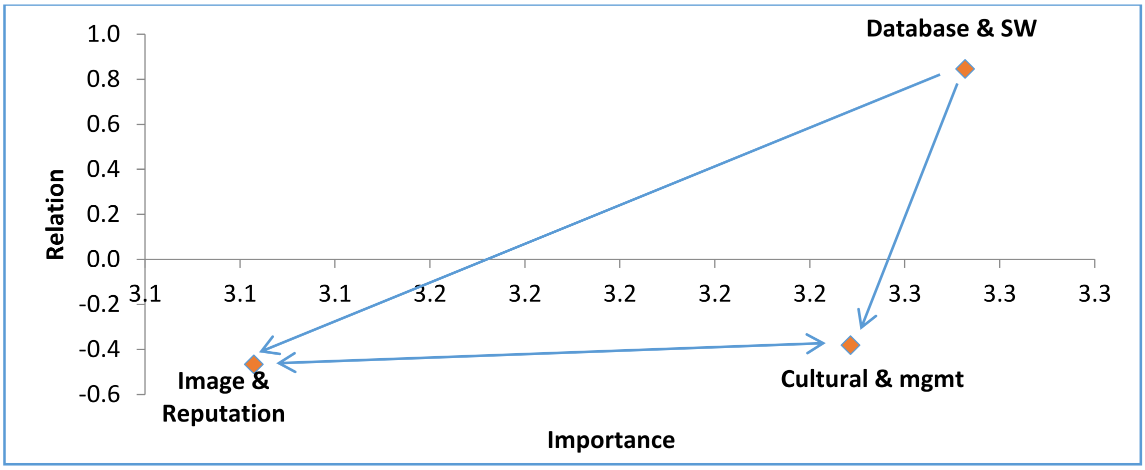

Figure 5- 10: Structural Resources IRM

This study is one of the first to integrate FDEMATEL and FTOPSIS techniques in a new way to evaluate and select appropriate LSPs based on their logistics resources and capabilities. Logistics resource weights, relative weights and impact-relationship are calculated and analysed using FDEMATEL. The next step entailed evaluating and ranking LSP alternatives based on their logistics resources and capabilities.

5.5.3. FTOPSIS

The FTOPSIS technique was used to obtain experts' evaluations of LSP alternatives against the weighted resources and capabilities criteria. Sixteen weighted resources and capabilities criteria were used in the evaluation process. These criteria consisted of C1: Warehousing & Inventory Facilities; C2: Transportation Facilities; C3: Production & Packaging Facilities; C4: Facilities Improvement & Maintenance; C5: Physical-IT; C6: Communication Tools; C7: IS & Internet-based Facilities; C8: Knowledge & Experience; C9: Education & Training; C10: Skills; C11: Collaboration; C12: Long-term Relationships; C13: Information Sharing; C14: Database & Software; C15: Image & Reputation and C16: Firm Culture.

Data on Jordanian LSP resources and capabilities were collected using an information sheet and the LSPs' websites. Thirty-five information sheets were distributed in Amman and the logistics village in Aqaba. Eight information sheets were collected. Seven LSPs provided data regarding their resources and capabilities. The collected data were used to develop a questionnaire to help logistics experts evaluate LSP alternatives. Three last-year logistics and transportation PhD candidates were asked to evaluate the seven LSPs. The linguistic variables defined in Table 3-3 were used in these evaluation processes. Table 5-8 shows the first expert's linguistic evaluation of LSP alternatives and Table 5-9 shows the average of the three experts' evaluations.

Table 5- 8: First Expert's Linguistic Evaluations of the LSP Alternatives

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16
LSP1	VP	VP	P	G	F	P	P	P	P	F	VG	P	F	VP	P	G
LSP2	F	VP	G	G	G	P	G	F	VP	F	VG	G	P	F	F	F
LSP3	F	G	P	G	G	VG	G	G	P	G	F	F	VP	G	P	G
LSP4	VG	G	P	VG	G	VG	G	G	G	F	G	G	F	G	F	G
LSP5	G	P	P	F	G	VG	VG	G	F	G	VG	VG	P	F	G	G
LSP6	VG	VG	VG	VG	VG	VG	VG	VG	VG	VG	VG	G	G	G	VG	VG
LSP7	F	G	P	VG	G	VG	F	VP	F	VP	VG	VP	VP	G	VG	VG

Where, **VG**: Very Good, **G**: Good, **F**: Fair, **P**: Poor, **VP**: Very Poor and **C1:C16** are the 16 criteria.

Table 5-10 shows the normalised fuzzy evaluation matrix using Equation (3-13). The maximum upper limit (*max* c_{ij}) equals 1. Therefore, Table 4-9 and Table 4-10 have the same values. Based on the weights obtained in the FDEMATEL stage, Table 5-11 shows the weighted fuzzy matrix using Equation (3-14).

Then, the fuzzy positive-ideal solution (FPIS) and fuzzy negative-ideal solution (FNIS) for each criterion are calculated using Equation (3-15). Using Aspiration Level, every v_i^+ is (1, 1, 1) and every v_i^- is (0, 0, 0):

FPIS = {(1, 1, 1) …, (1, 1, 1)}
FNIS= {(0, 0, 0) …, (0, 0, 0)}

The distance of each LSP alternative to FPIS (d_i^*) and FNIS (d_i^-) is calculated using Equations (3-16, 3-17). All of the values of d_i^* and d_i^- are non-fuzzy positive numbers. Table 5-9 summarises the d_i^*, d_i^- and closeness coefficient (Equation 3-18) for each LSP alternative.

Table 5- 9: Average Fuzzy Evaluation Matrix

	C1			C2			C3			C4			C5			C6			C7			C8		
1	0.00	0.00	0.25	0.00	0.00	0.25	0.00	0.08	0.33	0.25	0.42	0.67	0.25	0.50	0.75	0.17	0.33	0.58	0.25	0.50	0.75	0.00	0.25	0.50
2	0.17	0.42	0.67	0.00	0.17	0.42	0.33	0.58	0.83	0.33	0.58	0.83	0.42	0.67	0.92	0.17	0.33	0.58	0.28	0.75	0.92	0.42	0.67	0.92
3	0.25	0.50	0.75	0.33	0.58	0.83	0.08	0.33	0.58	0.42	0.67	0.92	0.42	0.67	0.92	0.19	0.58	0.75	0.36	0.83	1.00	0.33	0.58	0.83
4	0.36	0.83	1.00	0.22	0.92	1.00	0.11	0.58	0.75	0.22	0.92	1.00	0.42	0.67	0.92	0.19	0.58	0.75	0.50	0.75	1.00	0.17	0.42	0.67
5	0.25	0.50	0.75	0.25	0.50	0.75	0.17	0.42	0.67	0.33	0.58	0.83	0.50	0.75	1.00	0.36	0.83	1.00	0.36	0.83	1.00	0.42	0.67	0.92
6	0.08	1.00	1.00	0.08	1.00	1.00	0.08	1.00	1.00	0.08	1.00	1.00	0.36	0.83	1.00	0.36	0.83	1.00	0.22	0.92	1.00	0.08	1.00	1.00
7	0.33	0.58	0.83	0.42	0.67	0.92	0.17	0.42	0.67	0.28	0.75	0.92	0.50	0.75	1.00	0.22	0.92	1.00	0.42	0.67	0.92	0.17	0.33	0.58

	C9			C10			C11			C12			C13			C14			C15			C16		
1	0.19	0.67	0.83	0.42	0.67	0.92	0.03	0.50	0.67	0.00	0.25	0.50	0.17	0.42	0.67	0.03	0.42	0.58	0.19	0.67	0.83	0.50	0.75	1.00
2	0.33	0.50	0.75	0.28	0.75	0.92	0.05	0.75	0.83	0.22	0.92	1.00	0.19	0.67	0.83	0.13	0.83	0.92	0.28	0.75	0.92	0.42	0.67	0.92
3	0.33	0.58	0.83	0.50	0.75	1.00	0.28	0.75	0.92	0.42	0.67	0.92	0.19	0.58	0.75	0.17	0.33	0.58	0.00	0.17	0.42	0.22	0.92	1.00
4	0.36	0.83	1.00	0.28	0.75	0.92	0.33	0.58	0.83	0.42	0.67	0.92	0.28	0.75	0.92	0.17	0.33	0.58	0.33	0.58	0.83	0.22	0.92	1.00
5	0.33	0.58	0.83	0.50	0.75	1.00	0.36	0.83	1.00	0.28	0.75	0.92	0.19	0.67	0.83	0.08	0.25	0.50	0.33	0.58	0.83	0.22	0.92	1.00
6	0.08	1.00	1.00	0.22	0.92	1.00	0.28	0.75	0.92	0.50	0.75	1.00	0.36	0.83	1.00	0.17	0.33	0.58	0.08	1.00	1.00	0.08	1.00	1.00
7	0.33	0.58	0.83	0.25	0.42	0.67	0.19	0.67	0.83	0.33	0.50	0.75	0.19	0.58	0.75	0.17	0.33	0.58	0.08	1.00	1.00	0.22	0.92	1.00

Table 5- 10: Normalised Fuzzy Evaluation Matrix

	C1			C2			C3			C4			C5			C6			C7			C8		
1	0.00	0.00	0.25	0.00	0.00	0.25	0.00	0.08	0.33	0.25	0.42	0.67	0.25	0.50	0.75	0.17	0.33	0.58	0.25	0.50	0.75	0.00	0.25	0.50
2	0.17	0.42	0.67	0.00	0.17	0.42	0.33	0.58	0.83	0.33	0.58	0.83	0.42	0.67	0.92	0.17	0.33	0.58	0.28	0.75	0.92	0.42	0.67	0.92
3	0.25	0.50	0.75	0.33	0.58	0.83	0.08	0.33	0.58	0.42	0.67	0.92	0.42	0.67	0.92	0.19	0.58	0.75	0.36	0.83	1.00	0.33	0.58	0.83
4	0.36	0.83	1.00	0.22	0.92	1.00	0.11	0.58	0.75	0.22	0.92	1.00	0.42	0.67	0.92	0.19	0.58	0.75	0.50	0.75	1.00	0.17	0.42	0.67
5	0.25	0.50	0.75	0.25	0.50	0.75	0.17	0.42	0.67	0.33	0.58	0.83	0.50	0.75	1.00	0.36	0.83	1.00	0.36	0.83	1.00	0.42	0.67	0.92
6	0.08	1.00	1.00	0.08	1.00	1.00	0.08	1.00	1.00	0.08	1.00	1.00	0.36	0.83	1.00	0.36	0.83	1.00	0.22	0.92	1.00	0.08	1.00	1.00
7	0.33	0.58	0.83	0.42	0.67	0.92	0.17	0.42	0.67	0.28	0.75	0.92	0.50	0.75	1.00	0.22	0.92	1.00	0.42	0.67	0.92	0.17	0.33	0.58

	C9			C10			C11			C12			C13			C14			C15			C16		
1	0.19	0.67	0.83	0.42	0.67	0.92	0.03	0.50	0.67	0.00	0.25	0.50	0.17	0.42	0.67	0.03	0.45	0.64	0.19	0.67	0.83	0.50	0.75	1.00
2	0.33	0.50	0.75	0.28	0.75	0.92	0.05	0.75	0.83	0.22	0.92	1.00	0.19	0.67	0.83	0.15	0.91	1.00	0.28	0.75	0.92	0.42	0.67	0.92
3	0.33	0.58	0.83	0.50	0.75	1.00	0.28	0.75	0.92	0.42	0.67	0.92	0.19	0.58	0.75	0.18	0.36	0.64	0.00	0.17	0.42	0.22	0.92	1.00
4	0.36	0.83	1.00	0.28	0.75	0.92	0.33	0.58	0.83	0.42	0.67	0.92	0.28	0.75	0.92	0.18	0.36	0.64	0.33	0.58	0.83	0.22	0.92	1.00
5	0.33	0.58	0.83	0.50	0.75	1.00	0.36	0.83	1.00	0.28	0.75	0.92	0.19	0.67	0.83	0.09	0.27	0.55	0.33	0.58	0.83	0.22	0.92	1.00
6	0.08	1.00	1.00	0.22	0.92	1.00	0.28	0.75	0.92	0.50	0.75	1.00	0.36	0.83	1.00	0.18	0.36	0.64	0.08	1.00	1.00	0.08	1.00	1.00
7	0.33	0.58	0.83	0.25	0.42	0.67	0.19	0.67	0.83	0.33	0.50	0.75	0.19	0.58	0.75	0.18	0.36	0.64	0.08	1.00	1.00	0.22	0.92	1.00

Table 5- 11: Weighted Fuzzy Matrix

	C1			C2			C3			C4			C5			C6			C7			C8		
1	0.00	0.00	0.02	0.00	0.00	0.02	0.00	0.01	0.02	0.02	0.03	0.04	0.02	0.04	0.06	0.01	0.03	0.05	0.02	0.04	0.06	0.00	0.02	0.03
2	0.01	0.03	0.04	0.00	0.01	0.03	0.02	0.04	0.05	0.02	0.04	0.05	0.03	0.06	0.08	0.01	0.03	0.05	0.02	0.06	0.08	0.03	0.04	0.06
3	0.02	0.03	0.05	0.02	0.04	0.05	0.01	0.02	0.04	0.03	0.04	0.06	0.03	0.06	0.08	0.02	0.05	0.06	0.03	0.07	0.09	0.02	0.04	0.05
4	0.02	0.06	0.07	0.01	0.06	0.06	0.01	0.04	0.05	0.01	0.06	0.06	0.03	0.06	0.08	0.02	0.05	0.06	0.04	0.06	0.09	0.01	0.03	0.04
5	0.02	0.03	0.05	0.02	0.03	0.05	0.01	0.03	0.04	0.02	0.04	0.05	0.04	0.06	0.08	0.03	0.07	0.08	0.03	0.07	0.09	0.03	0.04	0.06
6	0.00	0.07	0.07	0.00	0.06	0.06	0.00	0.06	0.06	0.00	0.06	0.06	0.03	0.07	0.08	0.03	0.07	0.08	0.02	0.08	0.09	0.00	0.06	0.06
7	0.02	0.04	0.06	0.03	0.04	0.06	0.01	0.03	0.04	0.02	0.05	0.06	0.04	0.06	0.08	0.02	0.08	0.08	0.04	0.06	0.08	0.01	0.02	0.04

	C9			C10			C11			C12			C13			C14			C15			C16		
1	0.01	0.04	0.05	0.02	0.04	0.05	0.00	0.03	0.04	0.00	0.01	0.03	0.01	0.02	0.04	0.00	0.02	0.03	0.01	0.03	0.04	0.02	0.04	0.05
2	0.02	0.03	0.04	0.02	0.04	0.05	0.00	0.04	0.05	0.01	0.05	0.06	0.01	0.04	0.05	0.01	0.05	0.05	0.01	0.04	0.04	0.02	0.03	0.05
3	0.02	0.03	0.05	0.03	0.04	0.06	0.02	0.04	0.05	0.02	0.04	0.05	0.01	0.03	0.04	0.01	0.02	0.03	0.00	0.01	0.02	0.01	0.05	0.05
4	0.02	0.05	0.06	0.02	0.04	0.05	0.02	0.03	0.05	0.02	0.04	0.05	0.02	0.04	0.05	0.01	0.02	0.03	0.02	0.03	0.04	0.01	0.05	0.05
5	0.02	0.03	0.05	0.03	0.04	0.06	0.02	0.05	0.06	0.02	0.04	0.05	0.01	0.04	0.05	0.00	0.01	0.03	0.02	0.03	0.04	0.01	0.05	0.05
6	0.00	0.06	0.06	0.01	0.05	0.06	0.02	0.04	0.05	0.03	0.04	0.06	0.02	0.05	0.06	0.01	0.02	0.03	0.00	0.05	0.05	0.00	0.05	0.05
7	0.02	0.03	0.05	0.01	0.02	0.04	0.01	0.04	0.05	0.02	0.03	0.04	0.01	0.03	0.04	0.01	0.02	0.03	0.00	0.05	0.05	0.01	0.05	0.05

Table 5- 12: Distance to FPIS and to FNIS with CCi of the LSP Alternatives

LSP	d_i^*	d_i^-	CC_i	Rank
1	**15.798**	0.627	0.03818	7
2	**15.614**	0.822	0.05001	6
3	**15.626**	0.825	0.05014	5
4	**15.545**	0.885	0.05386	2
5	**15.584**	0.877	0.05330	3
6	**15.357**	0.976	0.05977	1
7	**15.590**	0.839	0.05107	4

The CC_i value represents the position of each LSP alternative with respect to the FPIS and FNIS. This value is used to estimate the extent to which each LSP alternative belongs to the PIS and NIS. The LSP with the highest CC_i value has the shortest distance to the FPIS and the longest distance to the FNIS. Therefore, this LSP is the best LSP.

Based on the CC_i values in Table 5-12 **LSP 6** is the most appropriate alternative. The final ranking order of the LSP alternatives is:

LSP6 ≻LSP4 ≻LSP5 ≻LSP7 ≻LSP3 ≻LSP2 ≻LSP1.

Figure 5-11 clarifies the LSPs ranking based on their CC_i scores and shows the tough competition on the second position between LSPs 4 and 5 and on the fifth position between LSPs 2 and 3.

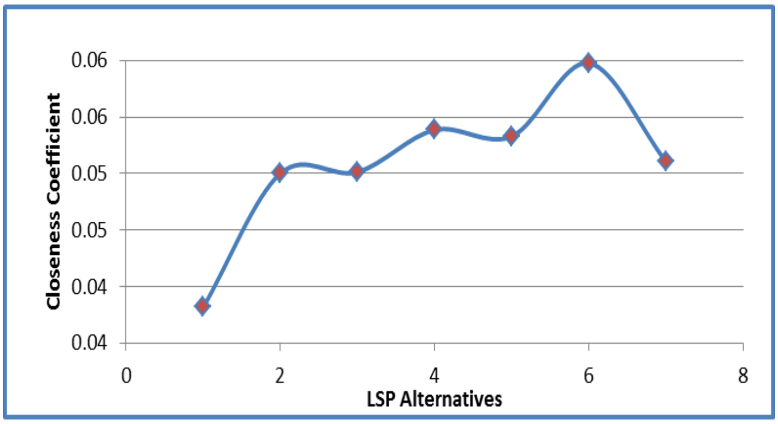

Figure 5- 11: LSPs Ranking Order based on their CCi Scores

In addition to the *CC* ranking scores, the TOPSIS technique provides more detail regarding individual differences between LSP alternatives. This additional information helps DMs to compare LSPs based on their scores in a specific criterion and help the LSPs to highlight their areas of strength and weakness and therefore, possible development opportunities. This comparison helps DMs to trade-off between two or more alternatives with similar or close CC scores. Table 5-13 summarises the defuzzified scores of each LSP alternative against each criterion.

Table 5- 13: Defuzzified Scores of the LSP Alternatives

LSP	C1	C2	C3	C4	C5	C6	C7	C8
1	0.00485	0.00449	0.00787	0.02699	0.04128	0.02913	0.04271	0.01613
2	0.02759	0.01156	0.03552	0.03591	0.05504	0.02913	0.05862	0.04303
3	0.03310	0.03578	0.02030	0.04104	0.05504	0.04785	0.06574	0.03765
4	0.05096	0.04812	0.03164	0.04830	0.05504	0.04785	0.06406	0.02689
5	0.03310	0.03067	0.02537	0.03591	0.06192	0.06313	0.06574	0.04303
6	0.04966	0.04600	0.04567	0.04617	0.06355	0.06313	0.06701	0.04840
7	0.03862	0.04089	0.02537	0.04225	0.06192	0.06435	0.05694	0.02292
LSP	**C9**	**C10**	**C11**	**C12**	**C13**	**C14**	**C15**	**C16**
1	0.03373	0.03868	0.02583	0.01424	0.02317	0.02346	0.02907	0.03745
2	0.02919	0.03982	0.03657	0.04470	0.03353	0.03947	0.03308	0.03329
3	0.03263	0.04351	0.04063	0.03798	0.03244	0.01999	0.00908	0.03917
4	0.04305	0.03982	0.03453	0.03798	0.03817	0.01999	0.02812	0.03917
5	0.03263	0.04351	0.04556	0.03910	0.03353	0.01530	0.02812	0.03917
6	0.04195	0.04551	0.04063	0.04273	0.04280	0.01999	0.03615	0.03745
7	0.03263	0.02544	0.03569	0.02973	0.03244	0.01999	0.03615	0.03917

Although LSP6 has the highest CC_i score, they need to improve their logistics resources and capabilities in some areas to protect their competitiveness position, particularly 'Structural resources' (C14, 15 and 16). LSP4 (second rank) has better scores than LSP6 in the five areas, C1, C2, C4, C9 and C16. These scores increase the level of competition and motivate LSP6 to take more actions to improve scores in these areas to protect and sustain their competitiveness advantage.

Although LSP5 is better than LSP4 in seven areas (C5, C6, C7, C8, C10, C11 and C12), LSP5 ranked third. The LSP4 good scores in the C1, C2, C3, C4, C9, C13 and C14 criteria compensate poor scores in other areas and support them to take the second rank.
Additionally, Table 5-13 shows that, most of the LSP alternatives have problems with their relational and structural resources (C13, 14, 15 and 16) compared to other areas. Based on the Relational IRM (Figure 5-9), information sharing (C13) is a cause factor that affects both, long-term relation and cooperation. Therefore, all the seven LSPs need to improve their scores in these areas to strengthen their competitive position. Moreover, Structural IRM (Figure 5-10) shows the crucial role of databases and software (C14) to support the LSPs intangible resources and capabilities. All the seven LSPs have a very low score in this area and they must take serious actions. Up-to-date databases and logistics software support the LSP competitive advantage and facilitate the flow of material and information throughout all the supply chain.

5.5.4. Independent Factors

DMs prefer to address a small number of critical factors rather than with a large number of mixed factors. FDEMATEL outcomes classified the logistics resources and capabilities into two groups: cause and effect groups (dependent and independent factors). This section determines the extent to which using independent factors produced the same results as using the 16 factors together. To make this determination, FTOPSIS outcomes are recalculated using independent factors only with their new normalised global weights (C1=0.130, C3=0.119, C5=0.250, C8=0.178, C13=0.172 and C14=0.150). The normalised weight of independent LKPIs are obtained using the following equation:

$$NW_i = \frac{W_i}{\sum_{i=1}^{n} W_i} \times W_j^p \text{ .... Equation (5-1)}$$

NW_i is the new normalised weight of the i^{th} Independent factor. W_i is the global weight of the i^{th} independent factor. $\sum_{i=1}^{n} W_i$ is the sum of Independent factor global weights under the j^{th} cluster P. and W_j^p is the global weight of cluster P. If there is one Independent factor in a specific cluster, then the NW_i of this Independent factor equals the W_j^p . Table 5-14 and Figure 5-12 compare the *CCi* values of the seven LSP alternatives in both cases.

Table 5- 14: A Comparison of the LSPs Rankings using Independent Factors and all Factors

LSP	Using Independent Factors		Using all Factors	
	CC_i	Rank	CC_i	Rank
LSP1	0.08698	7	0.03818	7
LSP2	0.13492	2	0.05001	6
LSP3	0.11904	5	0.05014	5
LSP4	0.12712	3	0.05386	2
LSP5	0.12594	4	0.0533	3
LSP6	0.14888	1	0.05977	1
LSP7	0.11886	6	0.05107	4

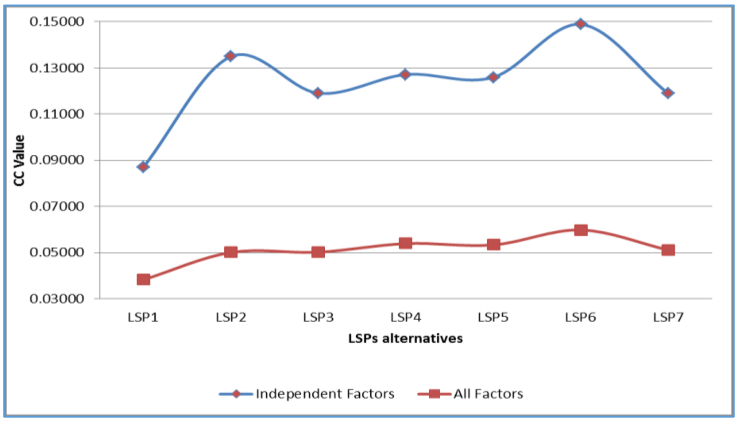

Figure 5- 12: LSPs Rankings using Independent Factors and all Factors

It is clear that independent factors provide nearly the same final LSP rankings. Therefore, DMs can simplify their decision making processes by using independent factors (cause factors) alone rather than using a large number of complex factors. Therefore, Figure 5-13 summarises the independent logistics resources and capabilities with their suggested measures.

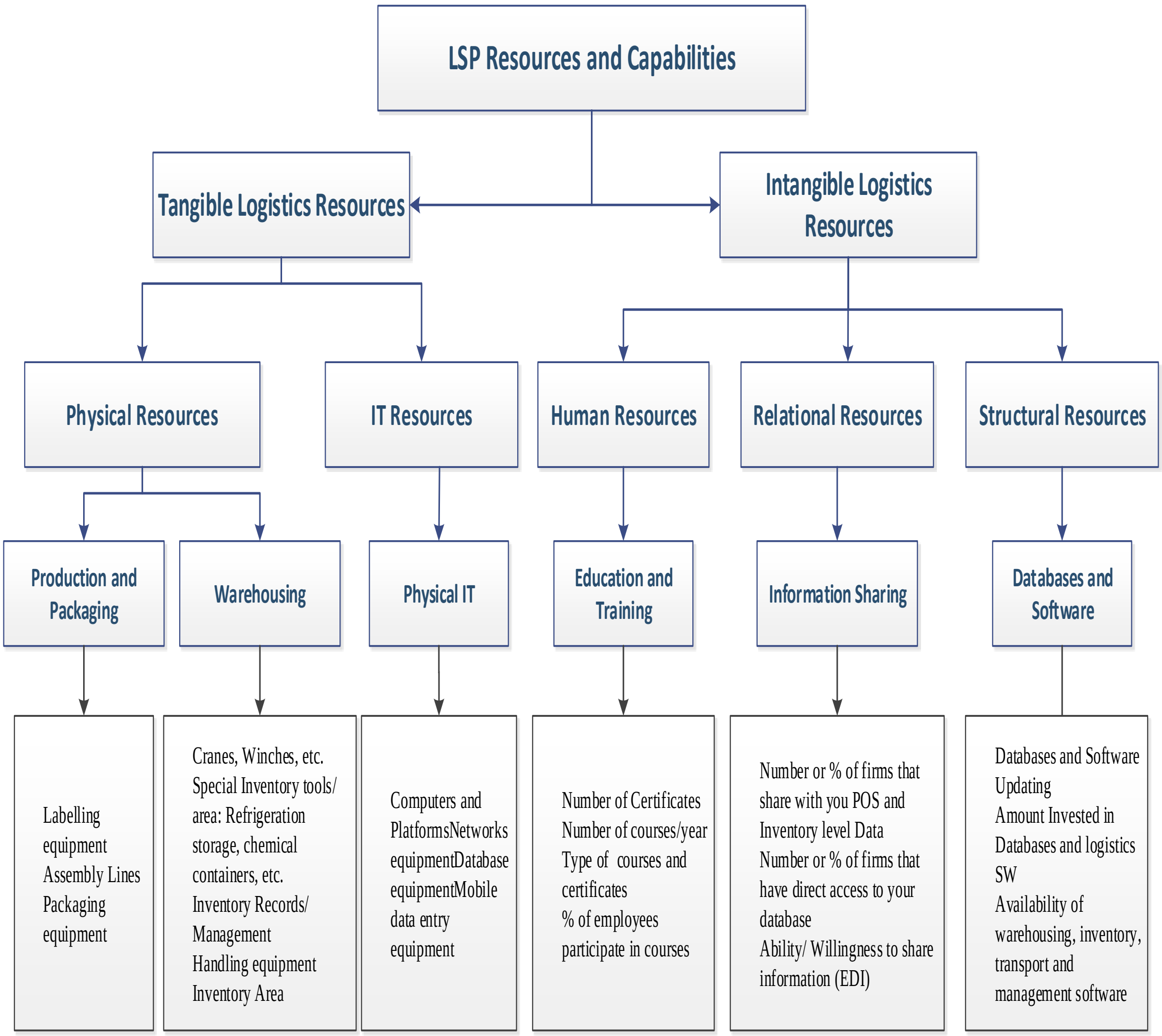

Figure 5- 13: The Hierarchy of the Independent Logistics Resources and Capabilities

However, DMs' preferences, evaluations, selection criteria and data quality affect the LSP evaluation and selection process. Additionally, working under high uncertainty conditions increases the complexity of these decisions and renders it difficult to analyse and select the most appropriate alternative. In this case, a sensitivity analysis technique was applied to test model robustness and detect the final decision certainty.

5.5.5. Sensitivity Analysis

The final selection of an alternative depends on both, the criteria weights and the MCDM method used. Changing the criteria weights may affect the decision making process and, in turn, LSP rankings. Because each MCDM method has its own features and mechanisms, different results may obtained using different MCDM methods. A two-phase sensitivity analysis is conducted to test the final solution stability to the criteria weights (independent factors) and selection method changes. In the first phase a series of tests are used to determine the extent to which changing the criteria weights affect the LSPs' CCi values and in turn their final rankings. In the second phase, the stability of the final solution was tested by changing the ranking method. Therefore, the final LSP ranking orders have been recalculated using the fuzzy VIKOR method presented by Opricovic (2011). There are at least two axioms that can be used to test the effect of criteria weight changing on the LSP evaluation and selection decision:

Axiom 1. A major increment/decrement in the criteria weight certainly results in a major effect on the CCi values and the rank of LSP alternatives with high performance levels in these criteria.

Axiom 2. A slight increment/decrement in the criteria weight should not result in a major effect on the relative CCi values and the LSPs final rankings.

To satisfy the first Axiom, an examination of the C3, C5, C13 and C14 independent criteria weight was carried out by setting each criterion weight to be 100%. Therefore, there were new LSP alternative order rankings as follow. If the weight of C3 is sit to be 100%, then the final ranking order is:

LSP6 ≻LSP2 ≻LSP4 ≻LSP5 ≻LSP7 ≻LSP3 ≻LSP1.

If the weight of C5 is site to be 100%, then, LSP alternatives 5, 6 and 7 are in the first rank, LSP alternatives 2, 3 and 4 in the second rank and LSP1 is the final one. If the weight of C13 is site to be 100%, then the final ranking order is:

LSP6 ≻LSP4 ≻LSP2 and LSP5 ≻LSP3 and LSP7 ≻LSP1.

Meanwhile, if the weight of C14 is site to be 100%, then, LSP2 is the best one, LSP1 in the second rank, alternatives 3, 4, 6 and 7 in the third ranking and LSP5 in the last rank. Therefore, these results verify the model with respect to Axiom 1. For the second Axiom, fifteen experiments were conducted in which each criterion weight was exchanged with another (Senthil et al. 2014). These experiments were conducted to find the LSPs' CCi values for each experiment and in turn the LSPs' rankings. Table 5-15 summarises the sensitivity analysis results. LSP6 had the highest *CCi* value in every experiment. LSPs 6, 2 and 1 had the same rankings in all of the experiments: first, second and last, respectively. Meanwhile, LSPs 3, 4, 5 and 7 had various rankings throughout the 15 experiments. These results verify the model with respect to the second Axiom.

Table 5- 15: Sensitivity Analysis Results

Experiment	Criteria change	Rankings
Initial	No change	LSP6>LSP2>LSP4>LSP5>LSP3>LSP7>LSP1
1	C1-3	LSP6>LSP2>LSP5>LSP4>LSP3>LSP7>LSP1
2	C1-5	LSP6>LSP2>LSP4>LSP5>LSP3>LSP7>LSP1
3	C1-8	LSP6>LSP2>LSP4>LSP5>LSP7>LSP3>LSP1
4	C1-13	LSP6>LSP2>LSP4>LSP5>LSP7>LSP3>LSP1
5	C1-14	LSP6>LSP2>LSP4>LSP5>LSP7>LSP3>LSP1
6	C3-5	LSP6>LSP2>LSP4>LSP5>LSP3>LSP7>LSP1
7	C3-8	LSP6>LSP2>LSP4>LSP5>LSP7>LSP3>LSP1
8	C3-13	LSP6>LSP2>LSP5>LSP4>LSP7>LSP3>LSP1
9	C3-14	LSP6>LSP2>LSP5>LSP4>LSP7>LSP3>LSP1
10	C5-8	LSP6>LSP2>LSP5>LSP4>LSP3>LSP7>LSP1
11	C5-13	LSP6>LSP2>LSP4>LSP5>LSP3>LSP7>LSP1
12	C5-14	LSP6>LSP2>LSP4>LSP5>LSP3>LSP7>LSP1
13	C8-13	LSP6>LSP2>LSP4>LSP5>LSP7>LSP3>LSP1
14	C8-14	LSP6>LSP2>LSP4>LSP5>LSP7>LSP3>LSP1
15	C13-14	LSP6>LSP2>LSP4>LSP5>LSP3>LSP7>LSP1

For example, C1-3 means exchanging the weights of C1 with C3.

For the second phase, this research uses the modified fuzzy VIKOR method to test the solution stability to the ranking method change. The LSP final ranking position is based on the LSP comprehensive indicator (LSP fuzzy merit Q). LSP Q is based on the fuzzy weighted sum (S) and the fuzzy operator max (R). Table 5-16 summarises the LSPs ranking order under the S, R and Q outputs.

Table 5- 16: LSPs Order Rankings – FVIKOR

		LSP1	LSP2	LSP3	LSP4	LSP5	LSP6	LSP7
S	***S_l***	16.031	15.822	15.806	15.741	15.747	15.639	15.796
	S_m	16.617	16.372	16.371	16.274	16.307	16.048	16.343
	S_u	16.943	16.739	16.736	16.648	16.689	16.431	16.704
	Defuz.	16.552	16.326	16.321	16.234	16.262	16.042	16.296
	Rank	**7**	**6**	**5**	**2**	**3**	**1**	**4**
R	***R_l***	1.009	1.008	1.037	1.037	1.007	1.000	1.028
	R_m	1.047	1.057	1.018	1.018	1.035	1.031	1.028
	R_u	1.085	1.082	1.064	1.064	1.056	1.046	1.066
	Defuz.	1.047	1.051	1.034	1.034	1.033	1.027	1.038
	Rank	**6**	**7**	**4**	**3**	**2**	**1**	**5**
Q	***Q_l***	-0.560	-0.74772	-0.59409	-0.650	-0.819	-0.952	-0.651
	Q_m	0.573	0.42061	0.19112	0.108	0.233	-0.012	0.227
	Q_u	1.000	0.80544	0.69814	0.623	0.610	0.332	0.684
	Defuz.	0.396	0.22473	0	0.047	0.064	-0.161	0.121
	Rank	**7**	**6**	**5**	**2**	**3**	**1**	**4**

It is clear that the LSP final order rankings are the same in both phases. In the first phase, the final order ranking is the same as the independent resources ranking (Table 4-14). The second phase order ranking is the same as the all resources ranking. Based on these results, we conclude that the methodology is robust and the decision making process is rarely sensitive to criteria weight and ranking method changes.

5.6. Conclusions

A novel technique for LSP evaluation and selection based on logistics resources and capabilities was introduced. This is the first time that the integrated FDEMATEL and FTOPSIS techniques were used to evaluate and select LSPs based on the logistics resources and capabilities of LSPs rather than their performance metrics. The FDEMATEL method was used to analyse the causal relationships of the LSPs' resources and capabilities. IRMs were used to clarify the strength and direction of each causal relationship in the complex logistics resources and capabilities framework. The FDEMATEL outputs help decision makers to understand how logistics resources affect each other and in turn how they affect the LSP's capability to achieve their strategic objectives effectively. Moreover, these results can help LSPs to bundle their resources into mixes that fit with the LSUs needs and preferences. The total direct and indirect effect, relative importance and global and local weight of each resource and capability were analysed to clarify dependent and independent factors and to identify crucial logistics resources and capabilities for the LSP evaluation and selection process. Warehousing, Production & Packaging, Physical IT, Employee Education, Information Sharing and Databases & Software resources and capabilities were the cause factors of this system. The FTOPSIS technique was used to evaluate LSP alternatives against weighted logistics resources and capabilities criteria. A case study for ranking seven LSPs based on their resources and capabilities was conducted to verify the effectiveness of the proposed hybrid model. Fuzzy distances to the FPIS and from the FNIS were used to find the CCi value of each LSP alternative. Additionally, a comparison between LSP ranking using independent factors and all factors was made. This comparison identified crucial factors of the logistics outsourcing decision. All of the factors were used to evaluate and select the best LSP alternative and independent factors were used to conduct the evaluation process. Based on the outcomes of both cases, DMs can use independent factors alone to evaluate and select the best LSP, which simplified the logistics outsourcing process in our study. Finally, after the systematic application of this hybrid model and a case study demonstration, a two-phase sensitivity analysis was conducted to detect the final decision certainty and analyse the methodology robustness. In the first phase, criteria weights have been exchanged. The VIKOR method has been used rather than the TOPSIS technique in the second phase to test the final solution stability. The output of the both phases shows that the methodology is robust and the decision making process is rarely sensitive to criteria weight changes.

The results of the study clarify that the proposed method is a robust and reliable tool for the LSPs evaluation and selection decision. In addition to the logistics outsourcing decision under uncertainty, this method can be used for other outsourcing MCDM problems such as supplier and contractor selection.

5.7. Chapter Contributions

This chapter provides the first integrated approach for evaluating and selecting LSPs based on the logistics resources and capabilities. Chapter contributions can be summarised by:

- Using the logistics resources and capabilities rather than performance metrics to evaluate and select LSPs.
- Integrating the FDEMATEL and FTOPSIS techniques to evaluate and select LSPs
- Investigating the interrelationships of the logistics resources and capabilities
- Developing the first logistics resources IRMs
- Identifying the dependent and independent logistics resources (independent success factors ISFs)
- Demonstrating the new integrated approach using a case study data
- Test the new model robustness using sensitivity analysis
- Presenting the FDEMATEL and FTOPSIS findings provides insights allowing LSPs to improve their logistics resources and capabilities.

Chapter 6: A hybrid model to quantify LSPs' performance measurement and evaluation

Summary

This chapter presents a new hybrid approach to quantify LSPs' performance measures and evaluation. This new approach helps LSUs in their logistics outsourcing decision under uncertainty. This new model combines FDEMATEL and FTOPSIS methods to address the impact of relationships between the LKPIs and to identify independent factors; the model also ranks LSPs against weighted LKPIs. In addition, case-study data were used to demonstrate the new hybrid model's effectiveness and a sensitivity analysis confirms its strength.

6.1. Introduction

Firms are recognising the importance of logistics outsourcing and its impact on their performance. Firms in all industries try to manage their performance in a way that aligns their performance outcomes with their strategic objectives to gain the right competitive advantage. Performance management and Key Performance Indicators (KPIs) hold special importance for logistics-based decisions, particularly in terms of logistics outsourcing (LSPs evaluation and selection). LKPIs are crucial factors to evaluating an LSP's strengths and weaknesses and in turn its capability to help LSUs achieve their strategic objectives effectively and efficiently. LSUs use various approaches to evaluate and manage their LSPs' performance. The complexity of logistics performance management and the large number of criteria involved increase the attractiveness of MCDM approaches. However, current studies on logistics outsourcing and LSP performance management suffer a number of problems, such as the large number of performance criteria, indicators and metrics that are presented in fragmented ways; therefore, it is difficult to identify the LKPIs. Few studies address the factors' interdependence and causal relationships and many studies have failed to address data uncertainty problems. These problems lead to unbalanced evaluation frameworks that focus on costs/financial metrics or operational ones and ignore other crucial performance factors, such as customers, learning & development and logistics sustainability. Solving these issues is very important and helps LSUs make better logistics outsourcing decisions. This study seeks to overcome the aforementioned problems using a new hybrid LSP model to quantify performance measurement and evaluation. A comparative literature review has been conducted to list performance metrics and LSP evaluation and selection criteria. The perspectives of both LSUs and LSPs have been used to identify the relative importance and degree to which these criteria are used. Only metrics with high importance and/or usage rate were selected to form the new balanced framework. This new framework is based on the sustainable balanced scorecard (SBSC) perspectives to structure its hierarchy. This model uses the DEMATEL technique to construct interdependency relationships between LKPIs and the TOPSIS technique to evaluate, rank and select an appropriate LSP. However, the problem of data uncertainty makes it difficult for DMs to provide a crisp value of the LKPI weights and quantify the precise rankings of LSP alternatives. Therefore, the fuzzy set is integrated with the DEMATEL and TOPSIS techniques to handle the uncertainty of the data. Fuzzy sets help DMs express their preferences using linguistic expressions with specific TFNs. The new hybrid model is one of the first approaches to identify LKPIs, analyse their impact-relationship and identify independent LKPIs to be used in the logistics outsourcing process.

6.2. Logistics Performance Background

Logistics outsourcing has been used as an effective way to achieve competitive advantages through improving customer services and reducing logistics costs. It is a key strategic decision that helps firms increase their effectiveness and efficiency by focusing more on core activities, reducing fixed costs, avoiding heavy asset investments and increasing service flexibility and quality (Hsu et al., 2012). The logistics outsourcing decision is important for LSUs that compete to satisfy customers in an effective, efficient and flexible way. Therefore, outsourcing logistics activities to an effective and efficient LSP is a critical decision to obtain and sustain competitive advantages. LSUs try to predict the LSPs' performance levels by providing an effective performance management system.

6.2.1. Performance Management

To improve performance and its metrics, they should be measured first. Performance measurement is an important element of the performance management process. Aguinis (2013, p.3) defines performance management as a three-stage continuous process that consists of identifying, measuring and developing the performance. This process includes individuals and teams, and aims to align performance results with the firm's strategic objectives. Performance management and performance appraisal have been used interchangeably. Performance appraisal is one element of the performance management big process which describes an employee's strengths and weaknesses and is used by managers to measure the goal achievement levels. Armstrong (2009) compared Management by Objectives (MBO), performance appraisal and performance management in terms of different points such as their emphasis, focus, paper work and upward or downward direction. MBO is "a dynamic system that seeks to integrate the company's needs to clarify and achieve its profit and growth goals with the managers' needs to contribute and develop them" (Robbins and Coulter 2013).

Performance management is an integrated and strategic approach for managing performance on a continuous basis, regarding broad issues and long-term goals and integrated because it links various aspects of the business (CIPD 2013). According to Homburg et al. (2012), there is a clear correlation between using performance management programmes and improving firm results, such as direct financial gains. Additionally, business is becoming more interested in the sustainability issues, such as corporate social responsibility (CSR), corporate environmental performance (CEP) or CSEP, in addition to corporate financial performance (CFP). Although some studies show various signs of the relationship between CEP and CFP (Moneva and Ortas, 2010), the expected benefits in term of performance, finance and market encourage firms to integrate sustainability into their strategy and to create new environmental divisions and departments (Willard, 2012). Therefore, the number of sustainability and environmental studies is significantly increasing and the call to integrate sustainability within the firm's strategy is increasing too. Sustainability performance is the aggregate of environmental, social and economic outcomes (Dias-Sardinha et al., 2007). Environmental performance represents the interaction with the natural environment to control the impact of the firm's actions. Social performance represents how the firm's actions affect the social environment and its stakeholders. Good performance management process needs good measures.

6.2.1.1. Performance Measures

In the performance management process, various performance measures can be used based on the evaluation level (organisation, division, department, team and individual). Good performance measures that are expressed in units and suit DMs' needs can provide the most meaningful help to DMs to improve performance. Generally, performance measures consist of five types:

1- Input measures: feed forward

2- Process measures: concurrent

3- Output measures: feedback (quantify)

4- Outcomes measures: qualify

5- Impact measures: effects and consequences

Based on these types, the University of California performance management approach identified five performance measures (TRADE 1995**;** Adarme et al., 2011):

- Efficiency: Ability of an organisation to perform a task

- Effectiveness: Ability of an organisation to plan for output from its processes
- Quality: Whether a unit of work was made correctly. Criteria to define "correctness" are established by the customer(s)
- Timeliness: Whether a unit of work was made on time. Criteria to define "on-time" are established by the customer(s)
- Productivity: The amount of a resource used to produce a unit of work

Meanwhile, Beamon (**1999**) classifies performance measures into three types, for each type different goal and purpose:

- Resources measures: the goal is resources efficiency and the purpose is profitability
- Output measures: the goal is customer service and the purpose is customer retention and acquisition
- Flexibility measures: the goal is agility and the purpose is responsiveness

Due to the large number of performance measures that are used by firms in different industries, each firm has to identify its critical KPIs that fit with its unique features. The next section provides more detail regarding KPIs.

6.2.1.2. Key Performance Indicators (KPIs)

KPIs define the desired results that are crucial to achieve high performance. These results either they are 'Outputs' can be measured quantifiably or 'Outcomes' that cannot be measured in quantifiable terms. For example, performance outputs can be financial, production, sales and time measures. Performance outcomes can be behaviour change, project completion, or standard attainment as quality levels. KPIs help firms to understand how they are performing in relation to their strategic objectives. Moreover, they help to reduce the complex nature of firms' performance into a small number of key indicators that make the performance management process more understandable and feasible. There are different perspectives of KPIs, such as customers' perspective, stockholders' perspective and social perspective. Alvandi et al. (2012) define seven KPI characteristics based on analysis and discussion with over 1,500 participants, these characteristics are: Non-financial measures, Measured frequently, Acted on by the CEO, Understanding of the measure and the corrective action required by all staff, Ties responsibility to the individual or team, Significant impact and Positive impact. The importance of these characteristics can differ between theory and practice. Firms place different emphasis on what they want to measure. There are common KPIs that span all firms in terms of logistics and supply chain performance. The main point is to select the right KPI that really adds value and help DMs to take the right decision.

6.2.2. Balanced Scorecard (BSC)

The Balanced Scorecard (BSC) approach is considered one of the most commonly used approaches to manage and measure firms' performance (Chen et al., 2011**;** Alvandi et al., 2012). The BSC was initially designed to ensure high levels of achievement of a firm's strategic objectives from the four perspectives (financial, customer, processes and learning & growth). Since 1992 when Kaplan and Norton introduced the BSC approach, it has given a wide space of discussion and has been used intensively for both academic and business purposes. BSC helps firms to achieve long-term objectives while keeping in mind the traditional financial measures. It starts with the firm's mission, vision and strategic objectives and uses four perspectives: three perspectives to evaluate intangible dimensions (Customers, internal process and learning & growth) and the financial perspective for tangible assets (Kaplan 2010). This approach emphasises the importance of strategy execution more than the strategy itself (Kaplan and Norton 1996, 2001), looking at financial and non-financial indices to see how these indices affect the efficiency of a business unit and try to explain the cause and effect relationship between objectives and the indices of the four BSC's perspectives. Figure 6-1 shows Kaplan and Norton's BSC perspectives and their measures:

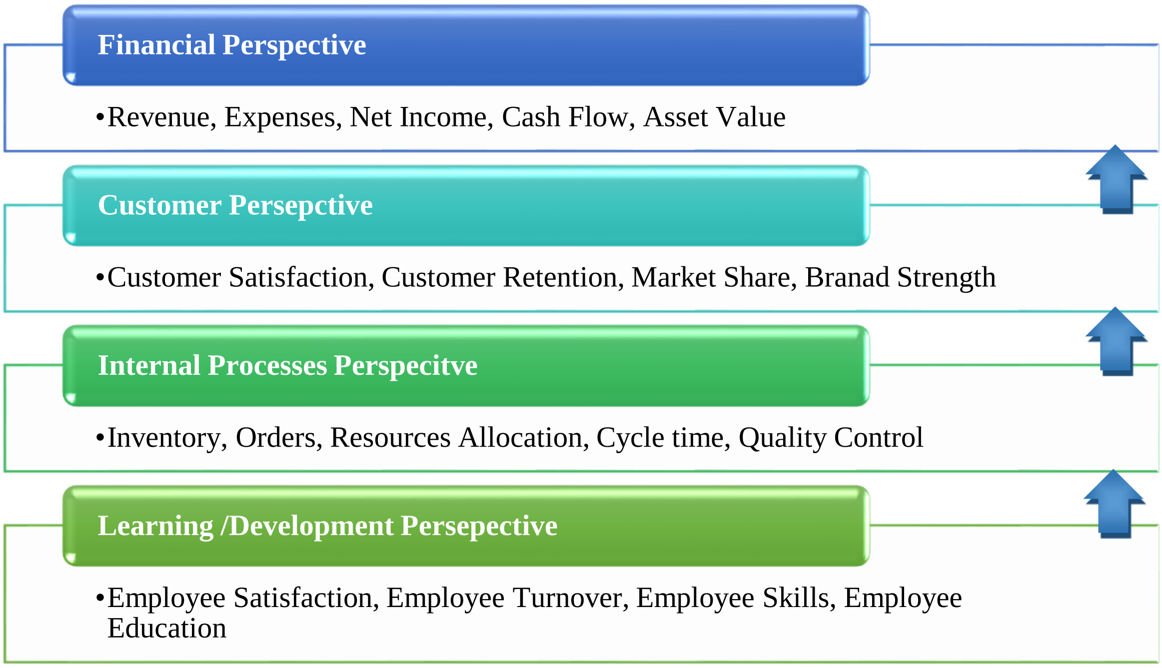

Figure 6- 1: BSC Perspectives
Source: Adapted from Kaplan and Norton 2001

For each BSC's perspective, managers must define goals and measures to reflect the factors that really matter to this perspective. Although the financial perspective is still considered an important aspect to evaluate firms' performance, the BSC adds three perspectives to achieve more balance and efficient performance evaluation. The BSC perspectives are:

- The financial perspective considers how the firm benefits from its strategic activities, using accounting numbers, such as savings and cash flow etc.
- Customer perspective considers how the firm benefits from its resources to be distinguished from its competitors, using customer satisfaction as a success factor.
- Internal process perspective considers all activities performed to satisfy stakeholders' expectations. Stakeholders are mainly shareholders and customers.
- Learning and growth perspective considers how to sustain the capability to change and improve.

By aggregating information from these four aspects managers can acquire data to improve the quality of their decision making process. Each perspective needs to be evaluated using various measures; Kaplan and Norton provided a general framework to measure these perspectives in business firms. Each DM needs to customise these aspects and measures according to the firm's needs. The process starts with customers; all firms have a mission to focus on customers' needs and satisfaction. The customer perspective aims to translate the general mission statement on customers' satisfaction into specific measures that reflect the real matters for customers (time, quality, performance and cost). The business process perspective translates the customer-based measures into operational measures, with the focus on critical operations that enable the firm to satisfy customers' needs. Learning and growth perspective, measures the firm's capability to innovate, improve and learn. Factors that reflect the firm's capability to create new product and/or services, add value to customers and improve operations' efficiency. Finally, the finance perspective provides financial performance measures that indicate the firm's capability to achieve its financial goals. These financial goals include survival, success and prosperity. The success in achieving these goals is based on the firm's success in the other perspectives. Hsu et al. (2011) integrated the FDM and ANP methods to construct an SBSC for the semiconductor industry. Although it is not a logistics study, but their methodology of integrating MDCM methods with fuzzy logic to construct an SBSC provides sufficient evidence supporting the use of SBSC in logistics performance studies.

6.2.2.1. Integrating Sustainability with BSC (SBSC)

Scholars support the integration of sustainability and BSC to have sustainable BSC (SBSC). One of the earliest studies that compiled a framework for corporate social responsibility (CSR) using the BSC approach was by Figge et al. (2002a). They provide systematic procedures to formulate an SBSC, to integrate the classical BSC with the environmental and social issues in one general approach. In their studies (2005a; 2005b; 2005c), they investigate the relationships between management actions and the environmental-impact of these actions. Three approaches are proposed in various studies (Epstein and Manzoni 1997**;** Figge et al., 2002a**;** 2002b**;** Dias-Sardinha et al., 2007**;** León-Soriano et al., 2010**;** Hsu et al., 2011**;** Liu and Lyons 2011**;** Butler et al., 2011) to integrate sustainability with BSC approach. Integration is achieved either by adding a fifth perspective to the classical four BSC perspectives, by integrating the sustainability measures within the current four perspectives, or by developing a separate SBSC. Each approach is based on various points of view, has different advantages and disadvantages and therefore suits specific situations. Based on the firm purpose of integrating sustainability within their strategy they can select the best approach to use. This study uses the second integrated approach to structure the LSP performance model.

6.2.3. Logistics Performance Management

LSP performance management is a complex system of multi-level performance metrics and indicators. It is crucial to quantify each element of this complex system to help LSPs and LSUs measure, evaluate and improve logistics performance levels and in turn to achieve their strategic objectives effectively and efficiently. There is a clear correlation between using performance management programmes and improved firm results (Homburg et al., 2012). According to Leea et al. (2005), performance management is used to correct poor performance, sustain good performance and improve overall firm performance. Therefore, logistics performance management aims to develop and improve LSP performance. In addition to LSPs evaluation and selection, LSUs can use the logistics performance management approach to monitor and improve logistics performance and to sustain a long-term healthy relationship. Both LSPs and LSUs need to identify and agree upon shared logistics performance measures to be used in the logistics performance management/logistics outsourcing process.

6.2.3.1. Logistics Performance Measures

Quantifying LSP performance measurement and evaluation is one way to improve the effectiveness and efficiency of both LSPs and LSUs. However, measuring performance is not the final objective; it is an approach used to achieve various objectives, such as the LSP evaluation and selection. LKPIs help LSPs understand how they are performing in relation to their strategic objectives and how they perform in helping and supporting LSUs to achieve their strategic objectives. Moreover, LKPIs help reduce the complex nature of LSP performance management into a small number of key indicators that make logistics outsourcing and logistics performance management processes more understandable and feasible. Therefore, selecting the right LKPIs and metrics is crucial.

Historically, a number of approaches have been used to measure and evaluate logistics performance as an element of the supply chain performance, such as Activity-Based Costing (ABC) (Wang and Li, 2013**;** Chen, 2012; and Walton, 1996) and EVA, economic impact and Gross value-added (GVA) (Sainz et al., 2013**;** Lin and Zhilin, 2008; and Liu and Lyons, 2011). However, these approaches were not initially designed for the logistics industry; they present unbalanced approaches that use historical financial metrics and ignore some important, strategic and non-financial metrics. Additionally, identifying key measures/metrics is a matter of discussion. Using a small number of effective metrics is better than a large number of mixed measures (Papakiriakopoulos and Pramatari 2010; Forslund 2014). Regardless of the approach used, it is important to select and use the appropriate LKPIs.

6.2.3.2. Logistics Key Performance Indicators (LKPIs)

Identifying and Measuring the LKPIs is an essential process for all the supply chain. According to the Canada/USA logistics report, firms that have put in place logistics and SCM KPIs have achieved a decrease of 15% or more in shipment delays compared to only 7% decrease in the shipment delays for firms that did not measure those KPIs consistently (SCLCAL, 2006). Logistics performance and LKPIs have been used as an element of the supply chain overall performance management process. The SCC developed the SCOR model that identified a large number of supply chain KPIs and grouped them into five ‘Attributes’ (SCC, 2013):

- Supply Chain Reliability: Metrics are Delivery Performance, Fill Rate and Perfect Order Fulfilment
- Supply Chain Responsiveness: Metric is Order Fulfilment Cycle Times

- Supply Chain Agility: Metrics are Supply chain Response time and Production Flexibility
- Supply Chain Costs: Metrics are Cost of goods sold, Total SCM costs, Value-added Productivity, Warranty/Returns and Processing Cost
- Supply Chain Asset Management Efficiency: Metrics are Cash-to-Cash cycle time, ROA and Return on working capital (ROWC)

SCOR model uses a large number of supply chain KPIs to measure and evaluate the supply chain performance as a whole. Some of these KPIs deal with the supply chain logistics functions. SCOR model was initially designed for supply-chain performance management, therefore, the large number of measures and metrics and different perspectives used increase the complexity of this model and reduce its logistics potential. However, SCOR attributes may help in identifying main logistics performance indicators. More detail regarding LKPIs and logistics performance management are presented in the following literature review section.

6.2.4. LSPs' SBSC

Based on the SBSC approach, each strategic objective requires different contributions from different perspectives to be achieved effectively and efficiently. The hierarchy relationship of the SBSC supports an LSU in achieving its strategic objectives through linking them by the LSP performance perspectives. The proposed framework has been structured to reflect the hierarchy of this relationship using strategic objectives of the SBSC model as a guide to select appropriate measures/indicators under each perspective without adding functions/department as a separate level in the model. This hierarchy helps to eliminate the duplication of the SBSC's perspectives and helps in selecting appropriate performance measures/indicators that really participate in achieving the firm's strategic objectives. However, each sector has its unique features and conditions that must be taken into account when developing an appropriate SBSC. The following model is one of the first hybrid models to quantify LSP performance measurement and evaluation based on the perspectives of LSPs and LSUs. Additionally, it uses the FDEMATEL and FTOPSIS integrated approach to evaluate LKPIs' impact-relationship and in turn to evaluate and select an appropriate LSP. The following sections present a systematic description of this new hybrid model.

6.3. The Hybrid Model

This study uses the SBSC approach hierarchy to develop an LSP performance measurement and evaluation model. Logistics, financial, customer, process and learning & growth perspectives are the basis of this new hybrid model.

Jordan has a competitive logistics position in the Middle East, therefore, Jordanian LSPs were chosen as a case study. Based on the Jordanian LSPs and LSUs responses (Chapter 4), only factors/metrics with importance levels ≥ 4 and/or usage rate ≥ 50% were selected to be used in the new hybrid model. Based on these thresholds, logistics performance indicators/metrics are classified into three groups: highly important and used, not highly important but used and not highly important and not highly used. Figure 6-2 summarises the numbers of metrics under each perspective.

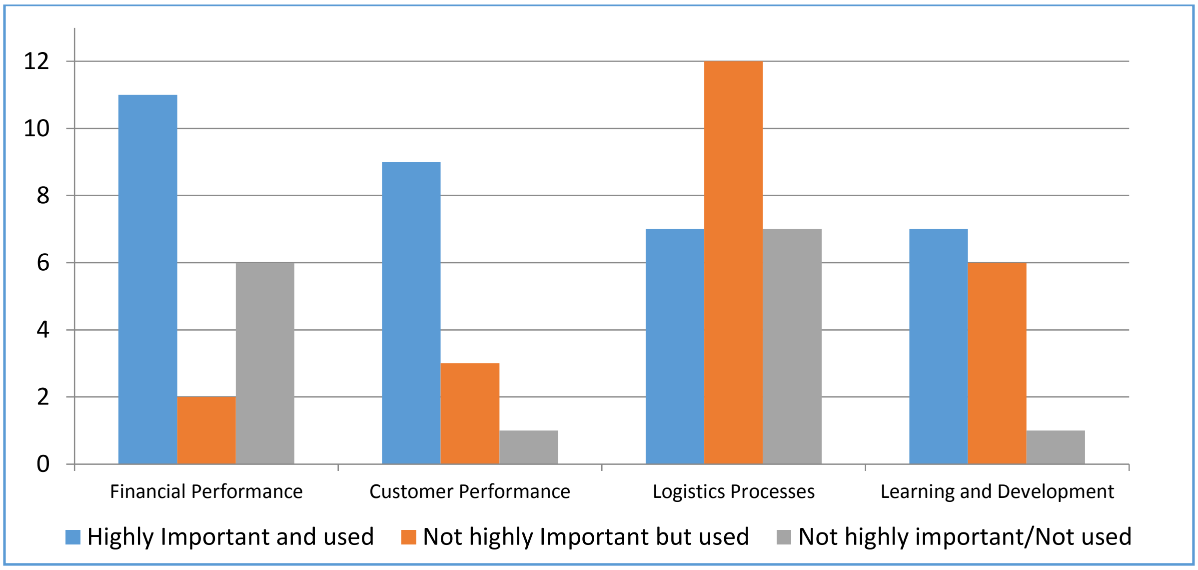

Figure 6- 2: Numbers of Logistics Performance Metrics under each Perspective

Therefore, the SBSC perspectives are redefined to match with the logistics sector and serve the research objectives:

- Financial strength perspective: represents the financial performance levels (costs and revenues) that support the strategic objectives for both LSPs and their customers. LKPIs are Profitability, Return and cash, Costs and Flexibility.
- Customer satisfaction perspective: represents the performance indicators that satisfy the LSPs' customers. LKPIs are Service quality and reliability, Service flexibility and Customer sustainability.
- Logistics processes perspective: represents the internal performance indicators that support the strategic objectives for both LSPs and their customers. LKPIs are Process quality, Process productivity, Timeliness and Process sustainability.

- Learning and growth perspective: represents the sustainability, learning, growth and improvement indicators that support other perspectives and support the strategic objectives for both LSPs and their customers. LKPIs are Human talent, Innovation and development and Resources sustainability.

SBSC perspectives and LKPIs hierarchical structure facilitates the LSP evaluation and selection process and therefore, the logistics performance management. Figure 6-3 summarises the general hierarchy of the LSPs' SBSC perspectives.

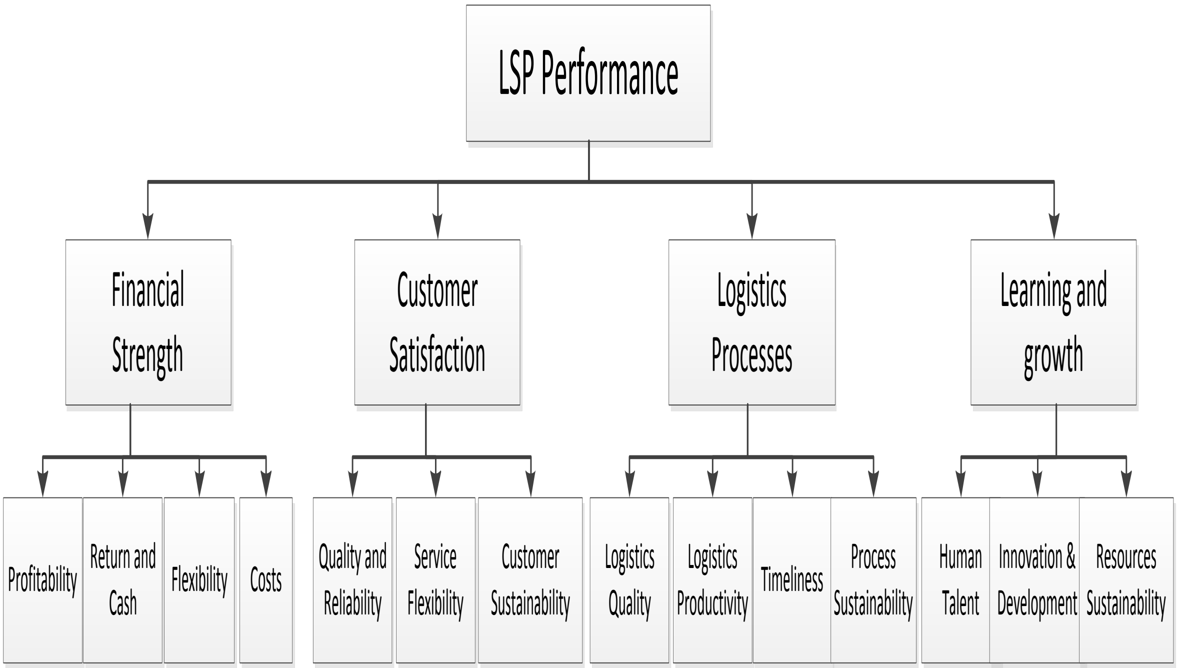

Figure 6- 3: LSPs SBSC

For each LKPI under each perspective, there are a number of measures and metrics that can be used based on the level of analysis, DMs' preferences and/or availability of data. This study does not aim to determine specific measures to be used by LSUs and LSPs under all situations. This study aims to assist logistics researchers and DMs to select measures that fit with their situations and match their preferences. Appendix 6-1 conceptualises LKPIs by providing a brief description, measures and supportive studies. Appendix 6-2 summarises the relative importance of some metrics under each LKPI based on the Jordanian LSU and LSP perspectives.

This study provides one of the first hybrid models to evaluate and select the best LSP based on the logistics performance levels of the LSP. The FDEMATEL and FTOPSIS methods were combined into one hybrid model in this study. FDEMATEL is used to construct the impact-relationship between the LSP SBSC perspectives and the LKPIs, identify independent factors and in turn to prioritise them. FTOPSIS is used to evaluate and select LSPs based on their performance levels against the prioritised LKPIs.

6.3.1. Implementation Procedures

Evaluating and selecting an appropriate LSP is an issue for all logistics service users. The selection of an inappropriate LSP directly affects logistics service users' capability to perform their core activities, satisfy their customers and achieve their strategic objectives. This study helps firms evaluate and select their appropriate LSP through an integrated approach of fuzzy DEMATEL and TOPSIS techniques (Appendix 3-1). The procedures for developing this integrated model required various types of information in various stages. Three questionnaires were developed and used: (i) An information sheet to collect LSPs' information, (ii) a FDEMATEL questionnaire to collect experts' evaluations of the LSPs' LKPI impact-relationship and (iii) a FTOPSIS questionnaire to collect experts' evaluations of the LSP alternatives against the weighted LKPIs. Figure 3-7 clarifies the hybrid model procedures.

6.4. Results

6.4.1. FDEMATEL Outputs

A questionnaire was used to ascertain experts' opinions. Seven logistics experts were approached for their expert opinions. Four experts provided a full response, including a vice president of a Freight Logistics Company with more than 30 years experience in freight management services, a logistics director with more than 35 years experience in freight services, logistics and supply chain; a president of an academic institution with more than 32 published papers and more than 43 years academic and administrative experiences; and a vice president of an academic institution with more than 52 publications, an editorial board and more than 20 years academic and administrative experience. Each expert was asked to evaluate the extent to which each SBSC perspective (Figure 6-3) influences other perspectives using the linguistic terms mentioned in Table 3-3. The fuzzy average matrix (A^{fuz}) at the perspectives level was obtained using Equation 3-4. The same procedures were repeated for each portion of the framework. Table 6-1 summarises the experts' evaluations regarding the degree of influence between the SBSC perspectives. Table 6-2 is the initial average matrix (A^{fuz}).

Table 6- 1: Experts' Opinions of the SBSC Perspectives

Experts	F-C	F-P	F-L	C-F	C-P	C-L	P-F	P-C	P-L	L-F	L-C	L-P
Exp1	H	V.H	H	V.H	H	H	V.H	V.H	H	V.H	V.H	V.H
Exp2	L	H	H	V.H	V.H	V.H	H	H	H	L	H	V.H
Exp3	L	H	L	V.H	H	H	L	H	H	H	V.H	H
Exp4	H	H	H	V.H	H	H	V.H	V.H	V.H	V.H	V.H	H

F: Financial, **C**: Customer, **P**: Processes, **L**: Learning & Growth perspectives.

Table 6- 2: Initial Average Matrix of the SBSC Perspectives

A^{fuz} matrix	Financial	Customer	Processes	Learning & Growth
Financial	(0.00 0.00 0.00)	(0.375 0.625 0.875)	(0.563 0.813 1.000)	(0.438 0.688 0.938)
Customer	(0.750 1.000 1.000)	(0.00 0.00 0.00)	(0.563 0.813 1.000)	(0.563 0.813 1.000)
Processes	(0.563 0.813 0.938)	(0.625 0.875 1.000)	(0.00 0.00 0.00)	(0.563 0.813 1.000)
Learning & Growth	(0.563 0.813 0.938)	(0.688 0.938 1.000)	(0.625 0.875 1.000)	(0.00 0.00 0.00)

Each fuzzy number in Table 6-2 is the average of the experts' evaluations of the degree of influence between two perspectives. For example, on average, the 'Financial perspective' influences 'Customer perspective' by:

$[\frac{1}{4}(H+L+L+H)] = \frac{1}{4}(2(0.25, 0.5, 0.75) + 2(0.5, 0.75, 1.0))$ = (0.375, 0.625, 0.875)

Equations (3-5, 3-6 and 3-7) were used to obtain the normalised fuzzy direct relation matrix (X^{fuz}). The normalising process transforms the various perspective scales into a comparable scale. Table 6-3 summarises the X^{fuz} matrix of the SBSC perspectives.

Table 6- 3: Normalised Fuzzy Direct Relation Matrix (X^{fuz})

X^{fuz} matrix	Financial	Customer	Processes	Learning & Growth
Financial	(0.00 0.00 0.00)	(0.125 0.208 0.292)	(0.188 0.271 0.333)	(0.146 0.229 0.313)
Customer	(0.250 0.333 0.333)	(0.00 0.00 0.00)	(0.188 0.271 0.333)	(0.188 0.271 0.333)
Processes	(0.188 0.271 0.313)	(0.208 0.292 0.333)	(0.00 0.00 0.00)	(0.188 0.271 0.333)
Learning & Growth	(0.188 0.271 0.313)	(0.229 0.313 0.333)	(0.208 0.292 0.333)	(0.00 0.00 0.00)

Equations (3-8, 3-9 and 3-10) were used to obtain the fuzzy total relation matrix (T^{fuz}) as it shown in Table 6-4. Meanwhile, Table 6-5 summarises the R_i^{fuz}, C_i^{fuz}, R_i^{def}, C_j^{def}, $(R_i+C_i)^{def}$, $(R_i-C_i)^{def}$ and the factor type.

Table 6- 4: The Fuzzy Total Relation Matrix (T^{fuz})

T^{fuz} matrix	Financial	Customers	Processes	Learning & Growth
Financial	(0.189 0.919 8.815)	(0.285 1.038 9.048)	(0.337 1.098 9.355)	(0.290 1.019 9.201)
Customers	(0.447 1.335 9.508)	(0.221 1.017 9.265)	(0.389 1.256 9.812)	(0.367 1.192 9.664)
Processes	(0.392 1.263 9.355)	(0.385 1.212 9.374)	(0.220 1.009 9.416)	(0.358 1.162 9.520)
Learning & Growth	(0.407 1.306 9.355)	(0.414 1.265 9.374)	(0.407 1.276 9.666)	(0.213 0.987 9.270)

Table 6- 5: LSPs' SBSC Perspectives

Perspective	R^{fuz}	C^{fuz}	R_i^{def}	C_i^{def}	$(R_i+C_i)^{def}$	$(R_i-C_i)^{def}$	Type
Financial	(1.101 4.075 36.419)	(1.435 4.823 37.032)	12.52	13.09	25.61	-0.57	Effect
Customer	(1.425 4.801 38.249)	(1.305 4.533 37.061)	13.43	12.95	26.38	0.487	Cause
Processes	(1.357 4.646 37.665)	(1.353 4.639 38.249)	13.18	13.35	26.53	-0.17	Effect
Learning & Growth	(1.441 4.834 37.665)	(1.229 4.360 37.655)	13.28	13.03	26.31	0.25	Cause

Each FTN in Table 6-4 is the total direct and indirect fuzzy influence of each perspective *i* over perspective *j* based on the experts' overall influence ratings. For example, the total direct and indirect fuzzy influence of 'Financial perspective' over 'Customer perspective' is (0.285, 1.038, 9.048). The sum of 'Financial' row (R_i^{fuz}) (1.101, 4.075, 36.419) is the total direct and indirect fuzzy influence that 'Financial perspective' has over the system. Meanwhile, the sum of 'Financial' column (C_i^{fuz}) (1.435, 4.823, 37.032) (Table 6-5) is the total direct and indirect fuzzy influence of the system over the 'Financial perspective'. Finally, Equation 3-11 is used to defuzzify total relation matrix (T^{fuz}) as is shown in Table 6-6. Only perspectives with an effect greater than the threshold value should be chosen and in turn shown in an IRM. The average value of the T^{def} matrix is defined as the Threshold in this hybrid model (Shieh et al. 2010). The average value of the defuzzified T^{def} matrix is (3.276). Therefore, only shaded cells in Table 6-6 with values ≥ (3.276) were represented in the IRM (Figure 6-4).

Table 6- 6: Defuzzified T matrix

T matrix	Financial	Customers	Processes	Learning & Growth
Financial	2.979	3.124	3.253	3.163
Customers	3.423	3.158	3.463	3.389
Processes	3.333	3.317	3.199	3.332
Learning & Growth	3.354	3.347	3.434	3.146

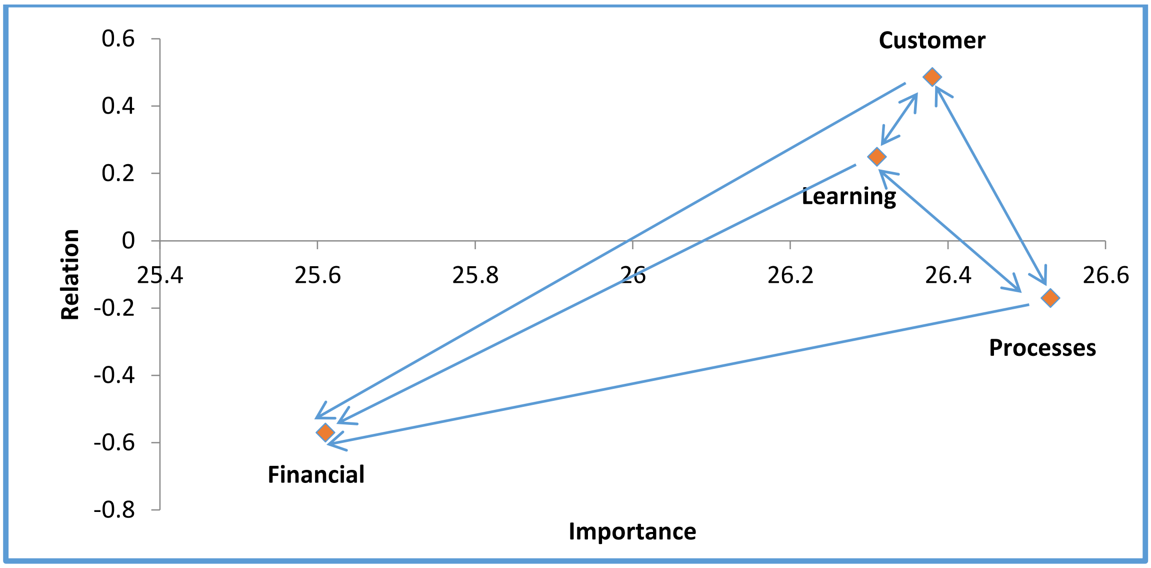

Figure 6- 4: LSPs' SBSC Perspectives IRM

The same procedures were used to evaluate the impact-relationship, relative importance and relative weights for all other factors. Table 6-8 summarises the defuzzified FDEMATEL outputs: (R_i+C_i), (R_i-C_i), factor type, relative importance and relative weight for all of the LKPIs in the LSPs' performance framework. Equations 3-1 and 3-2 are used to obtain the relative importance and relative weight of each LKPI. The global weight of each LKPI is the result of multiplying its local weight by the global weight of the cluster or group where it belongs. For example, the 'Financial' perspective global weight is (0.244). This perspective consists of four LKPIs: Profitability, Return & cash, Costs and Flexibility. The local weights of these four LKPIs are 0.258, 0.253, 0.247 and 0.242, respectively (Table 6-7). The global weights of these four LKPIs are the result of multiplying their local weights by the 'Financial' perspective global weight. Therefore, their global weights are 0.063, 0.062, 0.060 and 0.059, respectively.

Table 6- 7: DEMATEL Outputs of the LSPs' Performance Framework Evaluation

Factors	R_i+C_i	R_i-C_i	Type	Relative Importance	Local Weight	Global Weight
Financial Perspective	**25.610**	**-0.570**	**Effect**	**25.620**	**0.244**	**0.244**
Profitability	9.643	-0.297	Effect	9.648	0.258	0.063
Return & Cash	9.451	0.265	Cause	9.455	0.253	0.062
Costs	9.186	0.917	Cause	9.231	0.247	0.060
Flexibility	8.981	-0.884	Effect	9.025	0.242	0.059
Customers Perspective	**26.380**	**0.487**	**Cause**	**26.380**	**0.252**	**0.252**
Quality & Reliability	13.419	0.615	Cause	13.433	0.339	0.085
Service Flexibility	12.921	0.297	Cause	12.924	0.326	0.082
Customers Sustainability	13.264	-0.913	Effect	13.295	0.335	0.084
Processes Perspective	**26.530**	**-0.170**	**Effect**	**26.530**	**0.253**	**0.253**
Quality	20.714	0.378	Cause	20.717	0.257	0.065
Productivity	20.203	0.226	Cause	20.204	0.250	0.063
Timeliness	19.727	-0.713	Effect	19.740	0.245	0.062
Processes Sustainability	20.050	0.109	Cause	20.050	0.248	0.063
Learning & Growth Perspective	**26.310**	**0.250**	**Cause**	**26.310**	**0.251**	**0.251**
Human Talent	18.168	0.789	Cause	18.185	0.334	0.084
Innovation & Development	18.315	-0.642	Effect	18.326	0.337	0.084
Resources Sustainability	17.934	-0.146	Effect	17.935	0.329	0.083

6.4.2. Impact-Relationship

This study is one the first that analyses LKPIs' impact-relationship using the FDEMATEL. In addition to identifying independent LKPIs that are crucial to the LSP evaluation and selection process, IRMs provide a better understanding of the way that LKPIs affect one another and/or themselves.

6.4.2.1. SBSC Perspective Impact-Relationship

Figure 6-4 shows that ‘Customers’ and ‘Learning & growth’ perspectives are independent perspectives ‘Cause factors’ with a strong effect over the ‘Processes’ and ‘Financial’ perspectives which are ‘Effect factors’. The customer perspective has a direct strong effect over the financial perspective, which complements marketing and financial research that clarifies a direct positive relationship between customer satisfaction and the firm's financial performance. Meanwhile, the customer perspective has a mutual strong relationship with the ‘Learning & growth’ and ‘Processes’ perspectives. Based on these mutual impact-relationships we see that: (i) Continuous success in the learning and development activities increases the LSP’s capability to satisfy more customers and in turn to perform well financially; (ii) Continuous success in customer satisfaction enhances the LSP’s intellectual capital and improves its learning and growth performance; and (iii) Excellent logistics process records increase customers’ satisfaction and loyalty and in turn attract new customers. Meanwhile, the continuous success in customer performance helps LSPs improve their logistics processes to provide high-class logistics services. The SBSC perspectives’ impact-relationships (Figure 6-4) provide a new view of the classical hierarchy of the BSC perspectives that supposes a bottom-up linear relationship. The classical view begins with ‘Learning & growth’ performance, which affects ‘Processes’ performance which in turn affects ‘Customer’ performance and which finally affects ‘Financial’ performance. The FDEMATEL impact-relationship proposes mutual impact-relationships between the ‘Customer’, ‘Learning & growth’ and ‘Processes’ perspectives, which in turn have simultaneous impact-relationship over the ‘Financial’ performance, as shown in Figure 6-5.

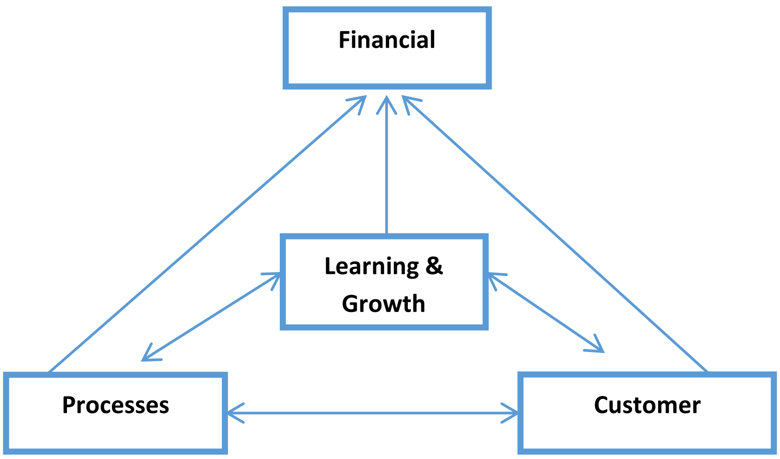

Figure 6- 5: SBSC Perspectives IRM based on FDEMATL

6.4.2.2. Financial Performance Impact-Relationship

The financial perspective consists of four LKPIs: return & cash-flow, costs, profitability and flexibility. Under each LKPI a number of financial metrics can be used to evaluate an LSP's financial performance. Based on the FDEMATEL outputs, 'profitability' is the most important financial LKPI, followed by 'return & cash-flow', 'costs' and 'flexibility' as shown in Table 6-8. Although it has a high importance rate, 'profitability' is an 'Effect factor' affected by cause factors 'costs' and 'return & cash-flow'. Logistics costs directly affect the 'profitability' and 'return & cash-flow' LKPIs. This point explains the heavy use of logistics costs in logistics literature and real logistics-based decision-making processes. Moreover, logistics 'costs', 'return & cash-flow' and 'profitability' directly affect financial flexibility, which in turn affects an LSP's capability to satisfy various customers' needs. LSPs with good return and cash-flow rates, high profitability and good control over logistics costs are expected to provide a wide range of financial flexibility that enhances customer satisfaction and attracts new customers. In addition to its impact on financial flexibility, 'return & cash-flow' has a mutual impact-relationship with the LSP profitability. This mutual impact-relationship harmonises with the financial rules that address a strong positive relationship between the firm's return and its profitability. LSPs with high return and cash-flow rates are expected to have high profits. Moreover, profitable LSPs are more capable to provide unique logistics resources and capabilities to support logistics activities, produce greater returns and enhance the cash-flow cycle.

6.4.2.3. Customer Performance Impact-Relationship

Three LKPIs were used to measure and evaluate customer performance (Figure 6-6). 'Service quality & reliability' is the central LKPI. LSPs with high quality and reliability logistics services are more capable of satisfying, keeping and renewing customers (customer satisfaction, retention and acquisition). Additionally, 'service quality & reliability' has a direct impact-relationship over the 'customer sustainability' and a mutual impact-relationship with 'service flexibility'. 'Customer sustainability' is affected by the 'service flexibility' and 'service quality & reliability' KPIs. An LSP with flexible logistics services is expected to have better sustainability levels by providing customers with more options to choose. The quality of these services also has a direct positive impact on the sustainability levels. High quality standards help LSPs increase customer satisfaction and improve customer health and safety by reducing the customer-accident number.

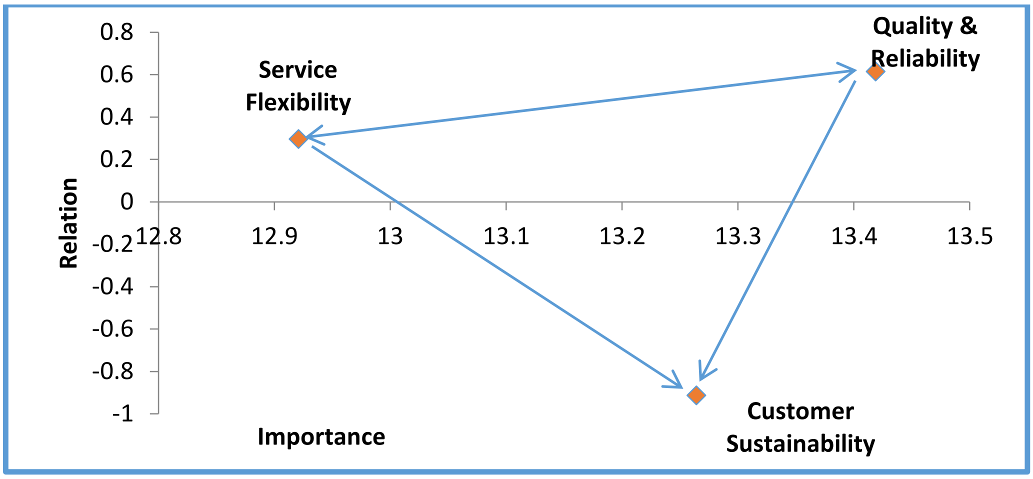

Figure 6- 6: Customer Performance IRM

6.4.2.4. Logistics Processes Performance Impact-Relationship

Four LKPIs with a large number of metrics were used to evaluate this crucial perspective. These LKPIs are processes quality, productivity, timeliness and sustainability. 'Processes quality' is the most important indicator followed by processes productivity. Based on the FDEMATEL outputs, Figure 6-7 shows that the processes' timeliness dimension is an 'Effect factor' affected by the 'Cause factors' process quality and sustainability. LSPs need to improve their process quality and sustainability levels to improve their process timeliness records. An LSP with good quality and sustainability processes is expected to be more professional and provides high levels in terms of process timeliness. Logistics processes' quality, productivity and sustainability are 'Cause factors' with mutual impact-relationship. These three LKPIs affect one another in a continuous base and affect the process timeliness dimension simultaneously. The dynamic interaction between these four LKPIs produces the overall LSP internal process performance. Therefore, DMs need to address these four LKPIs to understand measure, evaluate and in turn to improve logistics processes.

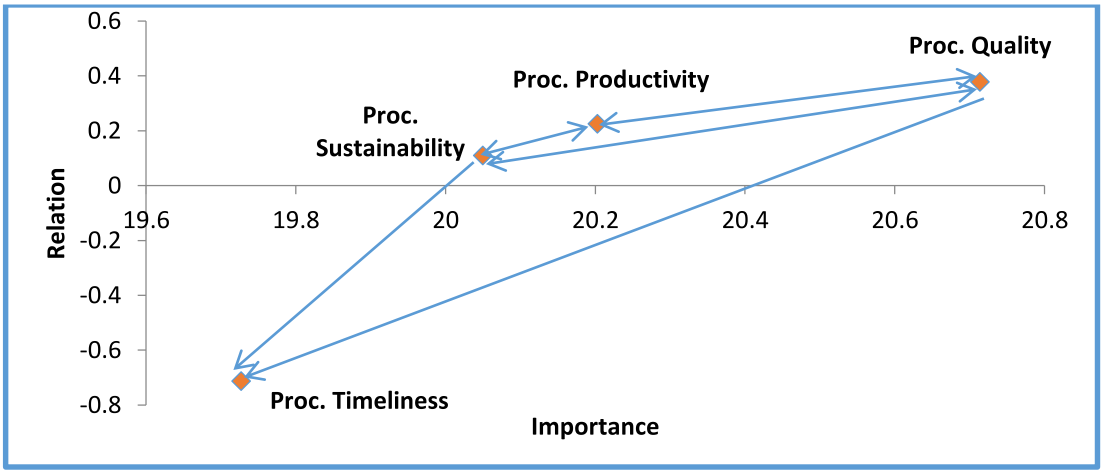

Figure 6- 7: Logistics Processes Performance IRM

6.4.2.5. Learning & Growth Performance Impact-Relationship

'Human talents' is the central factor under the 'Learning & growth' perspective (Figure 6-8). This 'Cause factor' directly affects the 'innovation & development' and 'resources sustainability' indicators. An LSP that is concerned with its human talents is expected to have better performance levels in terms of innovation, development and sustainability indicators. Human resources metrics -education, skills, knowledge and experience – directly affect the firm's innovation & development indicator. At the same time, qualified human resources can help the LSP to be more sustainable. Their logistics knowledge and experience enhance their capability to improve the firm's sustainability level and to provide customers with innovative solutions and services. Both LSUs and LSPs consider human resources to be the most important resources (Chapter 5).

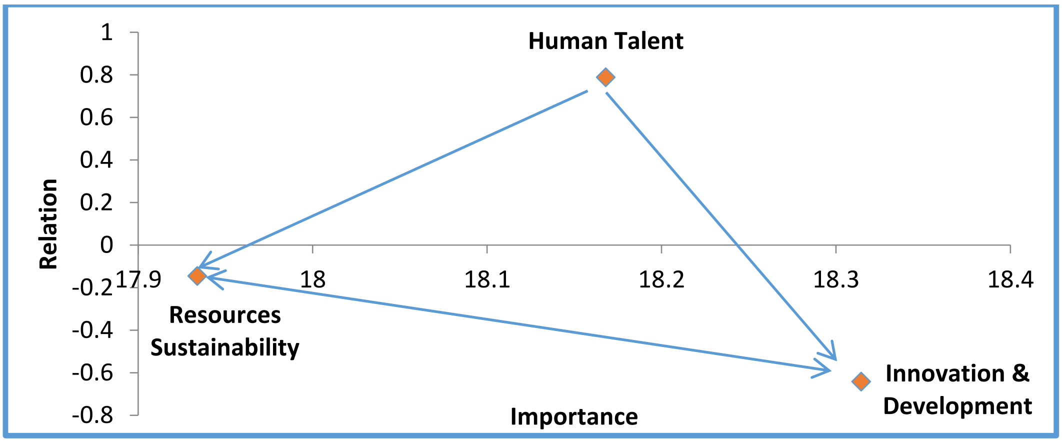

Figure 6- 8: Learning and Growth IRM

6.4.3. FTOPSIS Outputs

This study integrates the FDEMATEL and FTOPSIS techniques to quantify LSP performance measurement and evaluation. After using FDEMATEL to analyse impact-relationship and calculate weights, the next step is to evaluate and select an appropriate LSP alternative. The FTOPSIS technique was used to obtain experts' evaluations of LSP alternatives against the weighted LKPIs. Fourteen LKPIs were used in this evaluation process. LKPIs consist of C1: Profitability; C2: Return & Cash-flow; C3: Cost; C4: Finance Flexibility; C5: Services Quality & Reliability; C6: Service Flexibility; C7: Customer Sustainability; C8: Processes Quality; C9: Processes Productivity; C10: Timeliness; C11: Processes Sustainability; C12: Human Talent; C13: Innovation & Development and C14: Resources Sustainability. Thirty-five Jordanian LSPs were approached to collect their logistics performance metrics. Four LSPs provide most of the required data. In addition to the collected data, linguistic variables defined in Table 3-4 were used to develop a questionnaire to help five logistics experts evaluate LSP alternatives. Table 6-8 shows the first expert's linguistic evaluations of the LSP alternatives and Table 6-9 shows the average of the five experts' evaluations.

Table 6- 8: First Expert's Linguistic Evaluations of the LSP Alternatives

LSP	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14
LSP 1	F	F	VG	VG	VG	G	G	VG	G	G	F	F	F	F
LSP 2	F	VP	F	VP	P	F	VP	G	G	VG	VG	G	P	P
LSP 3	VP	VP	VP	VP	F	VG	G	G	VG	F	F	VG	VG	G
LSP 4	VP	VP	G	G	VG	VG	P	VG	G	F	VP	P	VP	VP

VG: Very Good, G: Good, F: Fair, P: Poor, VP: Very Poor

The normalisation process aims to facilitate the process of comparing heterogeneous criteria and to ensure that all the TFN are within the [0, 1] interval. Table 6-10 shows the normalised fuzzy matrix using Equation (3-12). Based on the FDEMATEL weights (section 5.5.1.), Table 6- 11 shows the weighted fuzzy matrix using Equation (3-13).

Table 6- 9: Average Fuzzy Evaluation Matrix

LSP	C1			C2			C3			C4			C5			C6			C7		
1	0.2650	0.6500	0.8500	0.2150	0.6000	0.8000	0.1650	0.5500	0.7500	0.2450	0.9000	1.0000	0.3150	0.7000	0.9000	0.4000	0.6500	0.9000	0.3300	0.8500	1.0000
2	0.1000	0.3500	0.6000	0.0000	0.1500	0.4000	0.3000	0.5500	0.8000	0.1000	0.2500	0.5000	0.3000	0.5500	0.8000	0.3000	0.5500	0.8000	0.0000	0.1500	0.4000
3	0.0000	0.1000	0.3500	0.0000	0.1500	0.4000	0.0000	0.0500	0.3000	0.0000	0.1000	0.3500	0.3500	0.6000	0.8500	0.1300	0.6000	0.7500	0.2450	0.9000	1.0000
4	0.0000	0.1000	0.3500	0.0000	0.1500	0.4000	0.3150	0.7000	0.9000	0.3650	0.7500	0.9500	0.0750	1.0000	1.0000	0.0950	0.7500	0.8500	0.2000	0.4500	0.7000

LSP	C8			C9			C10			C11			C12			C13			C14		
1	0.4150	0.8000	1.0000	0.2500	0.5000	0.7500	0.2000	0.4000	0.6500	0.1500	0.4000	0.6500	0.3150	0.7000	0.9000	0.4000	0.6500	0.9000	0.3000	0.5500	0.8000
2	0.2000	0.3500	0.6000	0.3500	0.6000	0.8500	0.1800	0.7000	0.8500	0.2150	0.6000	0.8000	0.4500	0.7000	0.9500	0.1000	0.3500	0.6000	0.1500	0.4000	0.6500
3	0.2000	0.4500	0.7000	0.1600	0.9500	1.0000	0.3500	0.5500	0.8000	0.3000	0.5500	0.8000	0.2800	0.8000	0.9500	0.1600	0.9500	1.0000	0.4500	0.7000	0.9500
4	0.0750	1.0000	1.0000	0.4000	0.6500	0.9000	0.1800	0.7000	0.8500	0.0000	0.1000	0.3500	0.1000	0.3500	0.6000	0.0000	0.0500	0.3000	0.0000	0.1000	0.3500

Table 6- 10: Normalised Fuzzy Evaluation Matrix

LSP	C1			C2			C3			C4			C5			C6			C7		
1	0.3118	0.7647	1.0000	0.2688	0.7500	1.0000	0.1833	0.6111	0.8333	0.2450	0.9000	1.0000	0.3150	0.7000	0.9000	0.4444	0.7222	1.0000	0.3300	0.8500	1.0000
2	0.1176	0.4118	0.7059	0.0000	0.1875	0.5000	0.3333	0.6111	0.8889	0.1000	0.2500	0.5000	0.3000	0.5500	0.8000	0.3333	0.6111	0.8889	0.0000	0.1500	0.4000
3	0.0000	0.1176	0.4118	0.0000	0.1875	0.5000	0.0000	0.0556	0.3333	0.0000	0.1000	0.3500	0.3500	0.6000	0.8500	0.1444	0.6667	0.8333	0.2450	0.9000	1.0000
4	0.0000	0.1176	0.4118	0.0000	0.1875	0.5000	0.3500	0.7778	1.0000	0.3650	0.7500	0.9500	0.0750	1.0000	1.0000	0.1056	0.8333	0.9444	0.2000	0.4500	0.7000

LSP	C8			C9			C10			C11			C12			C13			C14		
1	0.4150	0.8000	1.0000	0.2500	0.5000	0.7500	0.2353	0.4706	0.7647	0.1875	0.5000	0.8125	0.3316	0.7368	0.9474	0.4000	0.6500	0.9000	0.3158	0.5789	0.8421
2	0.2000	0.3500	0.6000	0.3500	0.6000	0.8500	0.2118	0.8235	1.0000	0.2688	0.7500	1.0000	0.4737	0.7368	1.0000	0.1000	0.3500	0.6000	0.1579	0.4211	0.6842
3	0.2000	0.4500	0.7000	0.1600	0.9500	1.0000	0.4118	0.6471	0.9412	0.3750	0.6875	1.0000	0.2947	0.8421	1.0000	0.1600	0.9500	1.0000	0.4737	0.7368	1.0000
4	0.0750	1.0000	1.0000	0.4000	0.6500	0.9000	0.2118	0.8235	1.0000	0.0000	0.1250	0.4375	0.1053	0.3684	0.6316	0.0000	0.0500	0.3000	0.0000	0.1053	0.3684

Table 6- 11: Weighted Fuzzy Matrix

LSP	C1			C2			C3			C4			C5			C6			C7		
1	0.0197	0.0483	0.0631	0.0166	0.0464	0.0618	0.0111	0.0369	0.0503	0.0145	0.0531	0.0590	0.0269	0.0597	0.0767	0.0365	0.0592	0.0820	0.0278	0.0717	0.0844
2	0.0074	0.0260	0.0445	0.0000	0.0116	0.0309	0.0201	0.0369	0.0537	0.0059	0.0148	0.0295	0.0256	0.0469	0.0682	0.0273	0.0501	0.0729	0.0000	0.0127	0.0338
3	0.0000	0.0074	0.0260	0.0000	0.0116	0.0309	0.0000	0.0034	0.0201	0.0000	0.0059	0.0207	0.0298	0.0512	0.0725	0.0118	0.0547	0.0684	0.0207	0.0759	0.0844
4	0.0000	0.0074	0.0260	0.0000	0.0116	0.0309	0.0211	0.0470	0.0604	0.0215	0.0443	0.0561	0.0064	0.0853	0.0853	0.0087	0.0684	0.0775	0.0169	0.0380	0.0591

LSP	C8			C9			C10			C11			C12			C13			C14		
1	0.0270	0.0520	0.0650	0.0158	0.0317	0.0475	0.0146	0.0291	0.0473	0.0118	0.0314	0.0511	0.0278	0.0618	0.0794	0.0338	0.0549	0.0760	0.0261	0.0479	0.0696
2	0.0130	0.0227	0.0390	0.0222	0.0380	0.0538	0.0131	0.0510	0.0619	0.0169	0.0471	0.0629	0.0397	0.0618	0.0838	0.0084	0.0296	0.0507	0.0131	0.0348	0.0566
3	0.0130	0.0292	0.0455	0.0101	0.0602	0.0633	0.0255	0.0400	0.0583	0.0236	0.0432	0.0629	0.0247	0.0706	0.0838	0.0135	0.0802	0.0845	0.0392	0.0609	0.0827
4	0.0049	0.0650	0.0650	0.0253	0.0412	0.0570	0.0131	0.0510	0.0619	0.0000	0.0079	0.0275	0.0088	0.0309	0.0529	0.0000	0.0042	0.0253	0.0000	0.0087	0.0305

Equation (3-15) was used to define the fuzzy PIS and the fuzzy NIS for each LKPI. Using Aspiration Level, all the v_i^+ are (1, 1, 1) and all the v_i^- are (0, 0, 0), then:

FPIS = {(1, 1, 1)… (1, 1, 1)}

FNIS= {(0, 0, 0)… (0, 0, 0)}

Equations (3-16 and 3-17) were used to calculate the distances of each LSP alternative to the FPIS (d_i^*) and to the FNIS (d_i^-). All of the values of d_i^* and d_i^- are non-fuzzy positive numbers. Table 6-12 summarises the: d_i^*, d_i^- and the closeness coefficient (Equation 3-18) for each LSP alternative.

Table 6- 12: Distance to FPIS and to FNIS with CC of the LSP Alternatives

LSP	d^*_i	d^-_i	*CC*	Rank
1	**13.690**	0.913	0.063	**1**
2	**13.787**	0.742	0.051	**3**
3	**13.788**	0.804	0.055	**2**
4	**13.873**	0.715	0.049	**4**

The *CC* value represents the position of each LSP alternative with respect to the FPIS and FNIS. Therefore, the LSP with the highest *CC* value is the best one. Based on the *CC* values in Table 6-13, **LSP 1** is the best alternative. The final ranking is: **LSP1 ≻LSP3 ≻PLS2 ≻LSP4.**

Figure 6-9 shows the order ranking of the LSPs based on their *CC* scores.

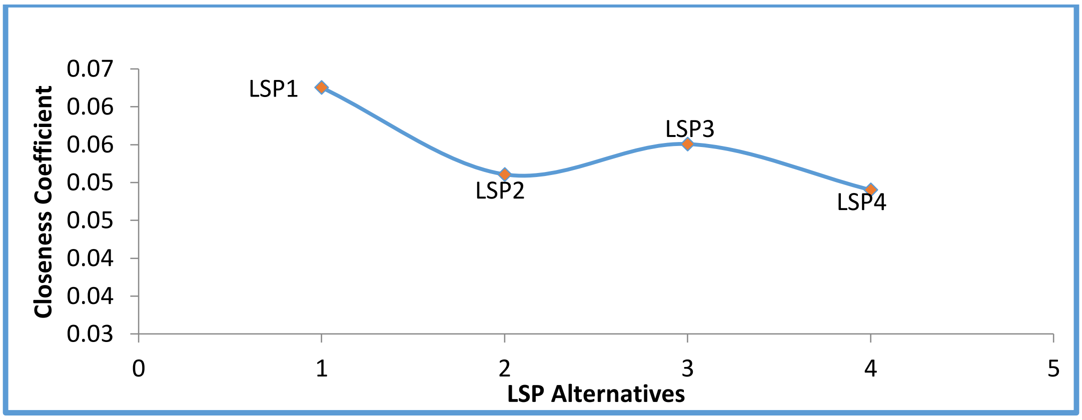

Figure 6- 9: LSPs Ranking Order based on their CC Scores

LSP1 has the first ranking in three KPIs (C2, C6 and C13) which related to the financial, internal processes and learning & growth perspectives respectively and has the second ranking in six LKPIs (C1, C3, C7, C10, C11 and C14). These good LKPIs scores compensate the low scores of the C4, C5, C8, C9 and C12 LKPIs and enable LSP1 to be considered as the most appropriate alternative. Meanwhile, LSP3 gets the second ranking due to the best scores in the C10, C11 and C14 LKPIs. These three LKPIs related to the internal processes and learning & growth perspectives respectively. This point supports the idea that financial LKPIs (particularly cost) are insufficient to provide an accurate evaluation and insufficient alone to take the right logistics-based decisions. DMs need to consider multi perspectives in order to have more balance and a reliable decision-making process. Additionally, LSP1 needs to improve customer service (C4 and C5), internal processes (C8 and C9) and learning & growth (C12) performance levels to stay in the first rank. Meanwhile, LSP3 needs to improve performance levels in a large number of the LKPIs in order to improve its competitive position and to be considered as the best LSP.

6.4.4. Independent Factors

The FDEMATEL technique classified the LKPIs into two groups cause (Independent) and effect (Dependent) factors as shown in Table 6-7. Therefore, to simplify the decision-making process without affecting its quality, this section determines the extent to which using independent LKPIs alone produced the same results as using the 14 LKPIs together. Table 6-13 summarises the Independent LKPIs with their normalised weights.

Table 6- 13: Independent LKPIs

LKPIs	Normalised Weight
Return & Cash	0.1236
Costs	0.1207
Quality & Reliability	0.1283
Service Flexibility	0.1234
Quality	0.1281
Productivity	0.1249
Human Talent	0.2510

The new normalised weights (NW_i) of the Independent LKPIs are obtained using Equ. 5-1, Where, NW_i is the normalised weight of Independent LKPI (i). W_i is the global weight of independent LKPI (i). $\sum_1^n W_i^p$ is the sum of global weights of Independent LKPIs under the cluster P. W_p is the global weight of the cluster P. If there is one cause (Independent) LKPI in a specific cluster, then the NW_i of this Independent LKPI equals W_p. Table 6-14 and Figure 6-10 compare the final CC_i values and the LSP alternatives ranking in both cases.

Table 6- 14: A Comparison of the LSPs' CC Values using all LKPIs and Independent LKPIs

LSP	Using Independent LKPIs CC	Using Independent LKPIs Rank	Using all LKPIs CC	Using all LKPIs Rank
LSP1	0.121	1	0.063	1
LSP2	0.109	2	0.051	3
LSP3	0.103	4	0.055	2
LSP4	0.108	3	0.049	4

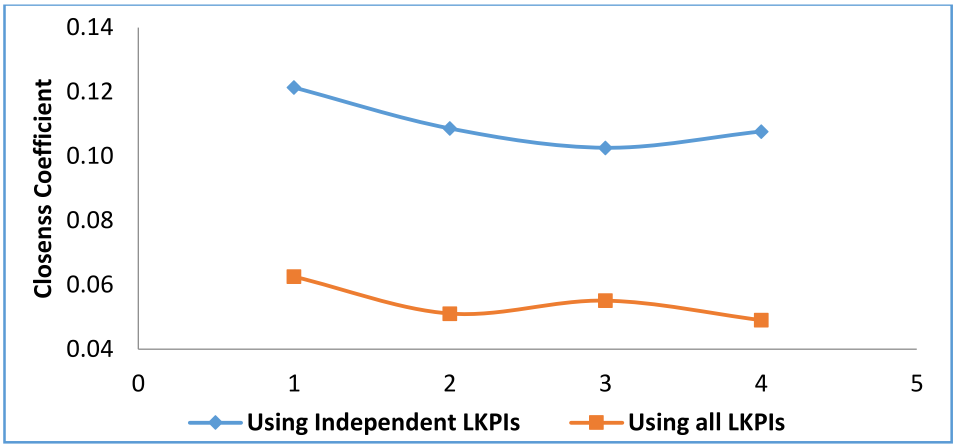

Figure 6- 10: LSPs Rankings using all LKPIs and Independent LKPIs

LSP1 has the same first ranking in both cases, while the rankings of other LSP alternatives have been changed. Therefore, managers can simplify their logistics outsourcing or performance management processes by using independent LKPIs alone. Independent LKPIs are a good choice to identify the best LSP and to provide a different view of other LSP alternatives ranking, particularly those with close CC_i values. Figure 6-11 summarises the independent LKPIs with their suggested measures.

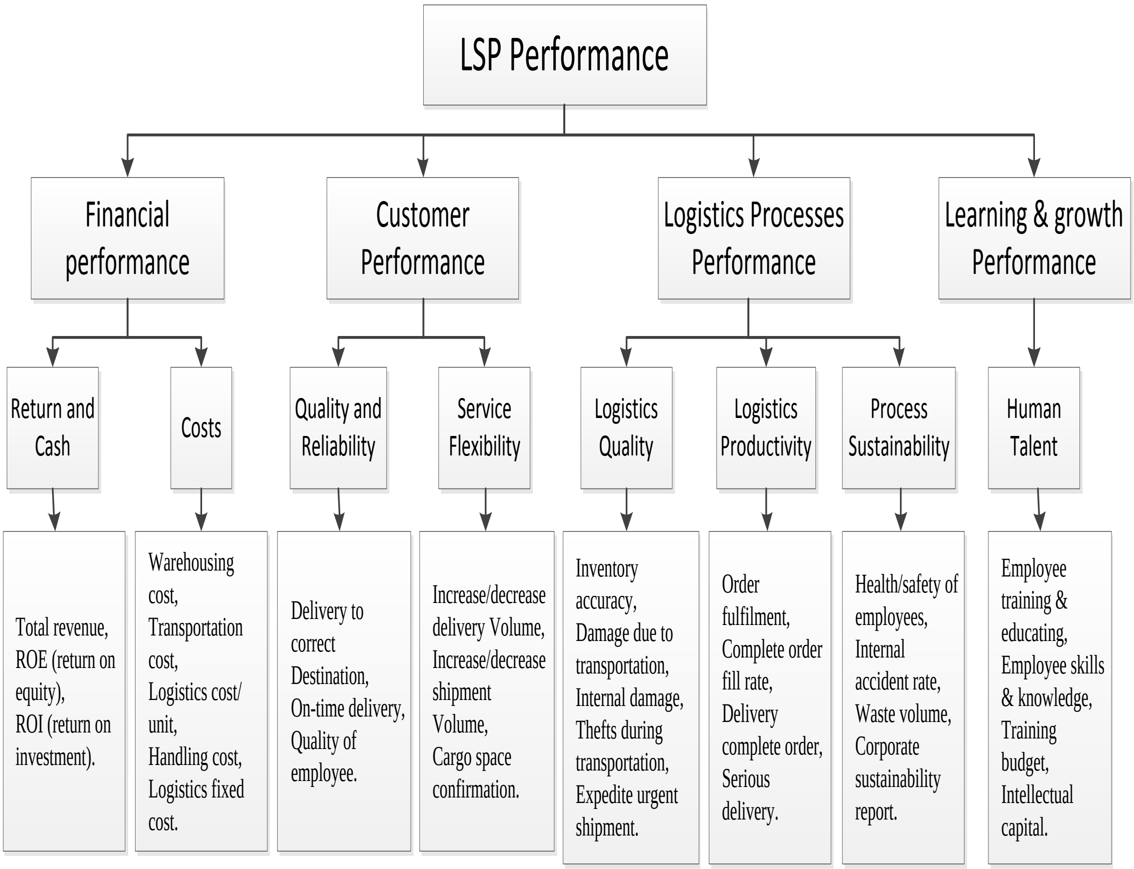

Figure 6- 11: Hierarchy of the Independent LKPIs and their Metrics

6.4.5. Sensitivity analysis

Working under conditions of high uncertainty increases the complexity of logistics outsourcing decisions and makes it difficult to analyse and select the most appropriate LSP alternative. A special technique is therefore needed to test the accuracy of the aforementioned approach. Sensitivity analysis is one of the most common validation techniques. It uses a series of tests that enable researchers and/or DMs to set parameter values to measure the change in the model's outputs. Therefore, they can detect the final decision certainty and analyse the analytical alternatives rankings.

For this hybrid model, changing the independent LKPI weights may affect the CC_i values and therefore, the LSP rankings. Sensitivity of the LSP alternatives rankings is analysed by increasing and decreasing the weights of each LKPI. Twenty-one experiments of exchanging each LKPI weight with another were conducted. Table 6-15 summarises the LSP rankings after each exchange. It is clear that LSP1 has the highest CCi values in all of the experiments, while LSP2 comes second in 15 experiments and LSP4 comes second in six other experiments. Meanwhile, LSP3 is the lowest ranking throughout all the experiments. The used methodology is therefore robust and the final decision-making outcomes are rarely sensitive to weight changes in the LKPIs.

Table 6- 15: Sensitivity Analysis Results

Experiment	Criteria weight exchange	Rankings
Initial	No exchange	**LSP1 >LSP2 >PLS4 >LSP3**
1	C2-3	**LSP1 >LSP2 >PLS4 >LSP3**
2	C2-5	**LSP1 >LSP2 >PLS4 >LSP3**
3	C2-6	**LSP1 >LSP2 >PLS4 >LSP3**
4	C2-8	**LSP1 >LSP2 >PLS4 >LSP3**
5	C2-9	**LSP1 >LSP2 >PLS4 >LSP3**
6	C2-12	**LSP1 >LSP4 >PLS2 >LSP3**
7	C3-5	**LSP1 >LSP2 >PLS4 >LSP3**
8	C3-6	**LSP1 >LSP2 >PLS4 >LSP3**
9	C3-8	**LSP1 >LSP2 >PLS4 >LSP3**
10	C3-9	**LSP1 >LSP2 >PLS4 >LSP3**
11	C3-12	**LSP1 >LSP4 >PLS2 >LSP3**
12	C5-6	**LSP1 >LSP2 >PLS4 >LSP3**
13	C5-8	**LSP1 >LSP2 >PLS4 >LSP3**
14	C5-9	**LSP1 >LSP2 >PLS4 >LSP3**
15	C5-12	**LSP1 >LSP4 >PLS2 >LSP3**
16	C6-8	**LSP1 >LSP2 >PLS4 >LSP3**
17	C6-9	**LSP1 >LSP2 >PLS4 >LSP3**
18	C6-12	**LSP1 >LSP4 >PLS2 >LSP3**
19	C8-9	**LSP1 >LSP2 >PLS4 >LSP3**
20	C8-12	**LSP1 >LSP4 >PLS2 >LSP3**
21	C9-12	**LSP1 >LSP4 >PLS2 >LSP3**

6.5. Conclusions

A new hybrid model to quantify LSP performance measurement and evaluation based on the SBSC perspectives was presented. The new technique integrated the FDEMATEL and FTOPSIS techniques to evaluate and select the most appropriate LSP based on their LKPI performance levels. The FDEMATEL technique was used to analyse the impact-relationship of the LSP SBSC perspectives and their LKPIs. The Impact-relationship maps clarified the strength and direction of each relationship in the LSPs' performance framework. Customers and Learning & Growth Perspectives are cause factors that affect processes and financial 'effect' factors. Return & cash, costs, services quality & reliability, service flexibility, processes quality, processes productivity, processes sustainability and human talent are 'Cause Factors', while profitability, flexibility, customer sustainability, timeliness, innovation & development and resources sustainability are 'Effect Factors'. Total direct and indirect effects, relative importance and the global and local weight of each LKPI are analysed to identify dependent and independent LKPIs. The FTOPSIS technique was used to evaluate LSP alternatives against the weighted LKPIs. To verify the new hybrid model's effectiveness, a case study for ranking LSP alternatives against their weighted LKPIs was conducted. A comparison between the LSP rankings using all the LKPIs and independent LKPIs was conducted as well. Based on the outcomes of both cases, independent LKPIs can be used to evaluate and select the best LSP. Finally, sensitivity analysis was used to detect the final decision confidence.

6.6. Chapter Contributions

This chapter provides an integrated approach for quantifying and evaluating logistics performance. Chapter contributions can be summarised by:

- Developing a new logistics SBSC to evaluate and manage logistics performance
- Developing a new integrated FDEMTEL and FTOPSIS approach for evaluating and selecting LSPs
- Identifying LKPIs and suggested performance measures for the logistics performance management process
- Investigating the interrelationship of the LKPIs (impact-relationship)
- Developing the first logistics IRMs
- Identifying the dependent and independent LKPIs (independent success factors ISFs)
- Demonstrating the new integrated approach using a case study data
- Testing the model robustness using sensitivity analysis
- Presenting the FDEMATEL and FTOPSIS findings can provide insights allowing LSPs to develop their logistics performance levels.

Chapter 7: An advanced model to evaluate LSP's services Value-added approach

Summary

This chapter proposes a new hybrid model to evaluate the logistics services value-added and in turn to evaluate and select the best LSP. The new model helps LSPs and LSUs to analyse the value-added of the provided logistics services under uncertain environments. This model integrates the FDEMATEL and FTOPSIS techniques to address the impact-relationship between logistics services, identifies independent services and ranks LSPs based on their value-added scores. Industrial case-study data was used to demonstrate the new model effectiveness and sensitivity analysis tests were used to confirm its rigour.

7.1. Introduction

The logistics industry faces more demand to serve the global market with contradictory needs and preferences. The increasing demand for logistics services motivates LSPs to provide a wide breadth of these services. According to Lai (2004), full service providers achieve higher value-added performance levels than limited service providers. Therefore, LSPs offer various logistics services and broaden the range of these services to provide new comprehensive solutions. Consequently, LSUs are seeking for long-term relationships and asking for more value-added logistics services. However, providing a full range of logistics services raises a number of concerns regarding the LSP's capability to manage these services in an effective and efficient way, the quality of these services and their value-added and their impact-relationship. Given these concerns, the following questions can be raised: (i) what are the logistics services that add value? (ii) What are the impact-relationships of these services? (iii) How can logistics services be used to evaluate and select the most appropriate LSP. Answering these questions becomes increasingly significant in light of the scarcity of logistics services value-added research and data uncertainty problems.

This study sets out to answer these questions through providing a model to evaluate the logistics services impact-relationship and to understand how these impacts affect the logistics services value-added. Then, using the weighted logistics services to evaluate and select the most appropriate LSP. The new model integrates the fuzzy logic with the MCDM methods (DEMATEL and TOPSIS) to investigate the impact-relationship and interdependency of logistics services and to evaluate, rank and select the most valuable LSP. This study uses the FDEMATEL-FTOPSIS integrated approach for evaluating logistics services value-added, investigate the logistics services impact-relationship and to identify independent logistics services for the logistics outsourcing process.

7.2. Logistics Services and Activities Classifications

Due to the increasing demand for logistics services, there is a big opportunity for LSPs to develop a full range of logistics services that satisfy customers' needs. Lai (2004) analysed the effect of the LSPs service capability over their service performance. The results of this study show that, full service providers achieve higher value-added performance levels than limited service providers. Therefore, LSUs prefer a one-stop LSP that can serve customers with a full range of logistics services, reduced cost and improve customer service level. By providing a wide range of logistics services, LSPs try to satisfy customers and to create strong value-based competitive advantages.

Based on the 18th Annual Third-party Logistics Study-2014, shippers outsource a wide variety of logistics services. These services are classified into three main groups based on the outsourcing frequency (Capgemini, 2014) (i) Most-frequently outsourced services (81-57% frequency rate) include the transactional, operational and repetitive services: transportation, warehousing, freight-forwarding and customer brokerage (ii) Moderate-frequently outsourced services (36-25% frequency rate) include the value-added services: reverse logistics, cross-docking, freight bill auditing and payment, product labelling–packaging-assembly and kitting, transportation planning & management and supply chain consultancy (iii) Less-frequently outsourced services (22-5% frequency rate) include the strategic and IT-intensive services: IT services, order management & fulfilment, inventory management, fleet management, lead logistics provider (LLP) and 4PL services, customer services and sustainability-green supply chain services. However, logistics service value-added is not limited to the second group. By outsourcing logistics services and activities, LSUs achieved costs reductions (logistics, inventory and logistics fixed costs) and improved their logistics performance measures (fill rates and accuracy levels) and add value for their firms and their customers. These gains expand the concept of 'value-added' to include all the outsourced logistics services if these services have been outsourced in the right way. This classification complements the Chapter three findings regarding the degree of importance and the level of use. Logistics services are not equally important nor have the same level of use, Figure 7-1 summarises the number of services based on the JLSP/JLSUs responses (Chapter 4).

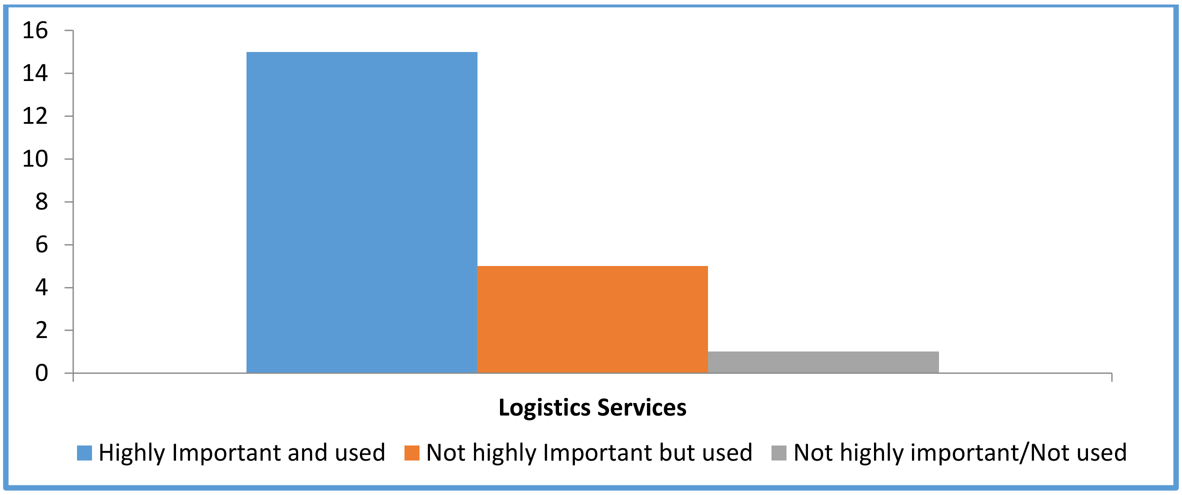

Figure 7- 1: Logistics Services Level of importance and Degree of Use

Different logistics services and activities classifications have been used in logistics literature (Sink and Langley, 1997**;** Hsiao et al., 2010**;** Rajesh et al., 2011**;** Mangan et al., 2012; and Daim et al., 2013). Daim et al. (2013) and Mangan et al. (2012) presented lists of logistics services that LSPs may provide for their customers. Hsiao et al. (2010) classify logistics services into four groups: Inventory and logistics services, Warehousing services, Transportation services and Customer services. Similar to this classification, Sink and Langley (1997) and Rajesh et al. (2011) integrate Inventory and Warehousing services in one dimension and add a production and packaging one: Inventory and Warehousing Services, Transportation Services, Production and Packaging Services and Customer Services. The large number of logistics services and activities that are provided by LSPs need to be organised and clustered into main groups. The Rajesh et al. (2011) classification provides a good starting point. Under each group, various logistics services and activities can be provided. These services help LSUs to select the best mix of logistics services that fit their needs and preferences and help them to achieve their strategic objectives effectively and efficiently.

Previous classifications underestimate the importance of electronic logistics services and logistics risks as main trends in today's logistics industry and literature. Moreover, these classifications used a large number of logistics services and activities in a fragmented way. Based on comprehensive reviews of related literature, this is one of the first studies investigating the logistics services impact-relationship and their effect on the LSPs evaluation and selection. In addition to the aforementioned four logistics services classifications, this study adds two new dimensions: e-logistics services and logistics services safety and security. Moreover, this study classified logistics services in a new hierarchy model enabled to investigate their impact-relationship (Figure 7-2).

7.2.1. Inventory and Warehousing Services

One of the main motivations for firms to outsource logistics services is to reduce the expensive stocks and inventory costs such as capital, warehousing, protection, handling, loss, insurance and packaging costs. Inventory and warehousing include various logistics services and activities covering the movement, handling and storage of material and information transfer functions.

Inventory and warehousing centres are related to different logistics services areas such as inventory and warehousing, transportation, production, packaging and customer services. LSPs use these centres to provide professional inventory and warehousing services in an effective and efficient way. Inventory and warehousing centres serve various purposes such as (Farahani et al., 2011):

- Goods storage: includes all processes related to storing items for the time they are needed
- Partial production processes: many items require storage as a production stage, others are stored as a work-in-process and parts for later finishing
- Consolidation: the process of fulfilling a customer's order includes a number of items from various places to be delivered together.
- Cross docking: arranging the flow of items in and out to ensure that inventory does not stay in more than 12hours through transferring received items to outgoing vehicles as soon as possible.
- Transhipment: the process of transferring items from one vehicle to another as necessary
- Break-bulk: the process of dividing a large received shipment in bulk into smaller less than truckload (LTL) shipments to send them to their destinations.
- Returned goods services: includes various reverse logistics activities: collecting, checking, sorting, waste management and freight back movements.
- Postponement: the process of postponing production using some light manufacturing activities such as labelling, marking and packaging.
- Product-fulfilment centre: distribution centres that connect directly with final customers, providing a higher level of customer services compared with other warehousing centres, receive customer payments directly and deal with higher levels of return items.

Additionally, LSPs use advanced inventory control software and reports, to provide contract warehousing for LSUs seeking customised distribution, centre services and Pick and Pack warehousing for business-to-business services. Pick and Pack services are offered by a number of LSPs specialising in supply chain and logistics solutions. It is one type of business-to-business logistics service designed for retail distribution where the truck or train load is picked for each destination and then re-packaged with shipping label and invoice for that destination. This service helps LSUs to place a small to medium size order and help LSPs and/or carriers to obtain a fair shipping rate and accelerate loading.

Inventory and warehousing includes various logistics services and activities. These services and activities can be classified based on the material flow directions within the inventory and warehousing centre. Inventory and warehousing services and activities include:

1. **In-store activities**: include all activities related to receiving, sorting and handling received items. These activities may include:
   - Receive and Sort items
   - Handling
   - Quality assurance
   - Documenting and inventory control
   - Monitoring and tracking activities
   - Maintain and optimise activities
   - Barcoding and radio frequency

2. **Out-store activities**: include all activities related to preparing shipments for transport and all other outside store activities, such as:
   - Order filling
   - Prepare shipments/shipment planning
   - Picking items (Order Picking)
   - Loading items

7.2.2. Transportation Services

Transportation activities focus on the physical movement of items from, to and through the inventory and warehousing centres, firms and ports. Transportation activities use various modes such as air, rail, road, water, pipelines and cables to transport different types of shipments. Transportation systems use various vehicles to transport these shipments, such as trucks, trailers, crews, containers and cars (Ghiani et al., 2004; and 2013).

Transportation services and inventory & warehousing services are closely related and support each other. For example, in 'inbound services' the process of 'storing' and 'moving' occurs simultaneously. Cross docking and consolidation activities include both inventory and transportation activities. Storage and handling systems (palletised and non-palletised) affect the moving-technology, vehicles type and size, cranes and conveyors. Therefore, these systems affect the LSP’s capability to move items inside and outside the inventory and warehousing centres. Some classifications deal with transportation services and activities based on the customer’s point of view, such as Taylor (2008) when he classified transportation services into three main categories:

- Customised transportation: specific logistics employees with vehicles dedicated to a specific customer to provide a customised logistics services
- Consolidated transportation: Receiving customer’s request for products from different sources and delivering them together to the customer
- Frequent operations: Providing fixed schedules of transportation services on a daily, weekly or monthly basis.

Based on the logistics network view, transportation activities are classified into three main categories (i) Inbound transportation, (ii) Outbound transportation and (iii) Product return (Reverse Logistics). Inbound transportation includes all movement of materials and shipment inside the inventory and warehousing centres in addition to all transportation administrative activities. Outbound transportation includes the movements from/to inventory and warehousing centres and between logistics network parties. Product return includes all activities related to moving back returned items. Although, reverse logistics and reverse LSPs (RLSPs) gained more importance due to the large size of return products from customers, logistics literature deals with RLSPs as a special logistics outsourcing decision separated from the normal logistics outsourcing process (Shaik and Abdul-Kader 2014). Alternatively, it can be added as a sub-dimension under the 'outbound' services or to 'customer service' dimension. This study uses the following transportation services classification:

1- **Inbound transportation:**

- Putting away received items
- Cross docking
- Shipping Items

2- **Outbound transportation**

- Freight forwarding
- Customised Transportation
- Consolidated Transportation
- Frequent Operations
- Product Return

7.2.3. Postponement, Production and Packaging Services

Some LSPs provide special services for some LSUs related to production/assembly processes, packaging and labelling. Packaging is an important logistics activity. This study classifies the production and postponement services into three sub-groups: Assembly, Packaging and Labelling. According to Paine (1991), packaging is the art, science and technology of enclosing products for distribution, storage, sale and use. Appropriate packaging protects products, decreases cost and makes for better handling. Paine (1991) and Robertson (1993) classified packaging functions into four categories: Protection, Communication, Convenience and containment (control). Garcia-Arca et al. (2006) assign three main functions for Packaging: Marketing functions related to product promotion through attractive designs, image and identity creation and informative function. Logistics functions related to product protection and product handling and distribution. Environmental functions related to minimising waste and encouraging reuse and recycle. According to Dominic et al. (2011), Packaging Logistics is an approach that aims to develop packages and packaging systems to support the logistics process and to meet customer/user demand (Garcia-Arca et al. 2014, pp. 328).

In order to help LSUs to focus on their core function, some LSPs provide a value-added service related to hand assembly, packaging, labelling and bar coding to facilitate item handling, storage and shipment activities. The labelling function comes after the items have been packaged. An item's label is any type of message or communication (written, electronic and graphic) used to inform users regarding items' specifications. Labels are words, code numbers, shapes and/or electronic optical scanned that are used to give users information such as date of production and expired, ingredients, using instructions and any health and environment concerns. Now, there are international standards, rules and regulations governing labelling functions in terms of content, place, materials and accuracy of data. For packaging logistics, labelling helps LSPs to sort, pick, store, handle and translate items effectively, efficiently and accurately. Packaging and labelling have an important effect on other logistics activities. According to Farahani et al. (2011), poor packaging and labelling can inhibit the material handling operations. For example, bad package design may decrease the logistics system's efficiency, inappropriate package and labelling affect sorting and picking processes and inventory accuracy. In terms of production, some LSPs provide a postponement function which helps LSUs to delay production and delivery costs until fulfilment is necessary (Ailawadi and Singh, 2012). Postponement functions are classified into two main types (i) Geographical postponement (ii) Product postponement.

7.2.4. Customer Services

Customer services in the logistics industry include a number of value-added services and activities that enabling the LSP to build and sustain healthy long-term customer relationships. These value-added services provide a competitive advantage for both LSPs and LSUs, help them to differentiate themselves and sustain desired levels of performance. These services cover various areas such as administrative, accounting and other supporting activities. This study uses the following logistics customer services classification:

- Freight Payment and Auditing
- Order management
- Order fulfilment
- Help desk
- Carrier selection
- Rate negotiation

These logistics customer services represent the most commonly used services in the logistics industry. However, there are other customer services used by some LSPs to serve specific types of LSUs such as education and training, pack design, routing guides and repackaging. Based on the JLSP/LSU responses (Chapter 3) the most important/used logistics services were 'Freight payment & Auditing', 'Order management & Fulfilment', 'Help desk' and 'Carrier Selection'.

7.2.5. Electronic Logistics Services (e-logistics)

Information technology (IT) reinforced firms' competitive advantages through increasing capability and decreasing costs (Moshiri and Simpson 2011). In logistics, the influence of IT is obvious. The advanced improvement in internet, information sharing/storage technologies and communication tools/systems motivates the emergence of new LSP forms such as 4PL and 5PL. These new LSP types try to manage the whole supply chain through providing integrated information systems that link all the supply chain members with one another in a real-time basis (Farahani et al., 2011). IT, e-commerce and grid/cloud technologies have the greatest influence on the logistics industry (Gunasekaran and Kobu, 2004; Shen, 2009; Sepehri 2012; and Huang, 2012). The role of IT in logistics includes both a valuable strategic resource and a basic mean of achieving competitive advantages.

E-logistics systems have changed the way LSPs perform their logistics activities and the way outsourcers run their business through providing a package of e-logistics services. Improving the customer responsiveness and in turn customer satisfaction, is one of the main forces driving the demand for e-logistics services. In addition to providing an information platform over the internet (cloud technology), e-logistics services enable collaborative management and monitoring between supply chain partners (Leu et al., 2011). E-logistics systems perform all the tradition logistics activities but in a new form and provide additional valued-added services that the traditional logistics systems are unable to perform. For this study, E-logistics services were classified into four services:

- Global visibility and tracing
- Real-time Information sharing
- Real-time collaboration and decision making
- E-logistics training and education

E-logistics services are expected to improve customer services, order fulfilment and customer satisfaction through improving the efficiency of the LSU's logistics network. Adding this dimension to the LSP services framework enriches the LSPs evaluation and selection process and helps DMs to evaluate the LSPs service competencies.

7.2.6. Logistics safety and security

The benefits of appropriate logistics outsourcing are obvious. Studies investigate the expected logistics outsourcing benefits, but an inappropriate logistics outsourcing decision includes a large number of risks. Logistics outsourcing risks have not received the same attention as the benefits. Logistics literature needs to consider both the benefits and risks of logistics outsourcing in order to provide a balanced logistics outsourcing study.

Different risk and security problems are encountered as a result of inappropriate logistics service outsourcing. A number of studies identified some supply chain and logistics outsourcing risks using different approaches and methodologies. Logistics risks can be: Poor communication with other supply chain members, hidden costs, loss of control on the process, lack of compatibility with other supply chain strategies, insufficient/inappropriate competences, e-logistics financial risks, company and market effects, failure to meet the supply chain members' requirements and people/equipment/cargo/places safety & security (Irina et al., 2012**;** Shen, 2009**;** Lee et al., 2012**;** Lampe and Hofmann, 2013**;** Schoenherr et al., 2008**;** Punniyamoorthy et al., 2013**;** Shaoyun, 2012; and Jereb et al., 2012). Moreover, some of these studies developed various tools to assess these risks using different techniques such as: risk scale (Punniyamoorthy et al., 2013), Bayesian network (Shen 2009), supply chain Risk-failure mode and effect analysis (SCR-FMEA) (Lee et al., 2012), β coefficient of the market and company effect (Lampe and Hofmann, 2013), Analytic Hierarchy Process (AHP) (Schoenherr et al., 2008**;** Fera and Macchiaroli, 2010**;** Shaoyun, 2012; and Ganguly, 2014), the Fuzzy logic DEMATEL technique (Mavi et al., 2013) and System Dynamic (SD) (Liu et al., 2012).

Therefore, the LSP capability to assess, manage and reduce logistics risk sources increases their attractiveness and enhances their competitive position. An LSP with good risk assessment capability is more capable of providing safe and reliable logistics services and therefore, reducing the cost of logistics outsourcing risks. Safety and security of people, equipment and cargo are a top priority for all the supply chain members and LSUs. Adding logistics service safety and security enhance the LSPs evaluation process and helps LSUs to be more confident about their logistics outsourcing decisions. Therefore, the LSP capability to provide safe and secure logistics services are evaluated by the following dimensions: (i) Risk assessment. (ii) Shipment and equipment security. (iii) People safety and security.

7.3. The Hybrid Model

Based on comprehensive reviews of related literature, this study provides a new model to evaluate and select LSPs based on their value-added logistics services. Moreover, current logistics services classifications underestimate the importance of electronic logistics services and logistics risks assessment. This study sets out to solve these problems by presenting a new hybrid model to evaluate the logistics service value-added under uncertainty. This model consists of six main dimensions: inventory & warehousing, transportation, postponement, customer services, e-logistics services and Safety & security (Figure 7-2). Appendix 7-1 conceptualises logistics services and activities with a brief description.

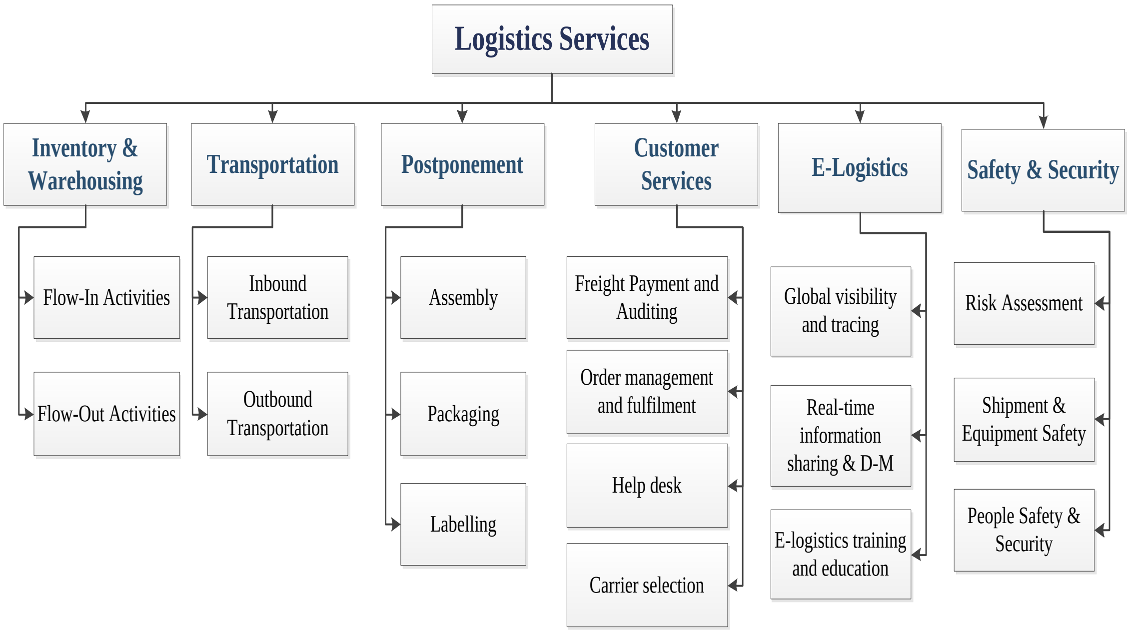

Figure 7- 2: Logistics Services Hierarchy

7.3.1. Implementation Procedures

The new model integrates FDEMATL and FTOPSIS techniques (Appendix 3-1) to evaluate and select the most appropriate LSP based on their logistics services expected value-added. This study aims to analyse the logistics services impact-relationship, to identify independent services and their weights and in turn to help firms to evaluate and select an appropriate LSP. Procedures for this integrated model required different types of information for different stages. Two questionnaires were developed and used. The (i) FDEMATEL questionnaire was to collect experts' evaluations of the logistics services value-added impact-relationship and the (ii) FTOPSIS questionnaire to collect experts' evaluations of the LSP alternatives against the weighted logistics services. Figure 3-7 clarifies the hybrid model procedures.

7.4. Results

7.4.1. FDEMATEL

Seven logistics experts were contacted using professional logistics networks. A questionnaire was used to ascertain their opinions. Four logistics experts with logistics, academic and research expertise completed the entire questionnaire. Experts who provided full responses are (i) A Vice-President of business development/logistics, Logistics Company/freight management services with more than 30 years experience in logistics and SCM. (ii) Logistics academic and researcher with more than 12 years experience, 20 published papers and 9 conferences. (iii) Senior executive/Logistics and Procurement Company and academic lecturer – faculty of business management with more than 16 years experience, 2 published papers, 6 PhD students and 7 international conferences. (iv) Logistics and IT manager and logistics academic with more than 8 years experience, 6 published papers and 10 conferences.

Beginning with the first level of the logistics services (Figure 7-2), logistics experts were asked to evaluate the extent to which providing logistics service *i* influences the value–added of the logistics service *j* by using linguistic terms defined in Table 3-3. The average matrix at the first level can be obtained using Equation 3-4. Table 7-1 summarises the experts' evaluations of the degrees of influence between main logistics services dimensions. Table 7-2 is the initial fuzzy average matrix (A^{fuz}) (direct-relations matrix).

Table 7- 1: Experts' Evaluations of the Logistics Services Impact-Relationship

Experts	1-2	1-3	1-4	1-5	1-6	2-1	2-3	2-4	2-5	2-6	3-1	3-2	3-4	3-5	3-6
Exp1	H.	H.	H.	No	H.	V.H	H.	H.	No	H.	V.H	L.	H.	No	No
Exp2	H.	H.	V.H	H.	H.	H.	V.H	V.H	H.	H.	H.	H.	H.	H.	H.
Exp3	H.	H.	H.	V.H	V.H	H.	H.	H.	V.H	V.H	H.	H.	H.	V.H	V.H
Exp4	L.	H.	L.	V.H	V.L	V.H	L.	V.H	V.H	L.	H.	H.	H.	L.	No

Experts	4-1	4-2	4-3	4-5	4-6	5-1	5-2	5-3	5-4	5-6	6-1	6-2	6-3	6-4	6-5
Exp1	No	V.L	V.L	L.	No	No	No	No	H.	No	V.H	H.	H.	L.	L.
Exp2	V.H	V.H	V.H	V.H	V.H	H.	H.	H.	V.H	H.	V.H	V.H	V.H	V.H	H.
Exp3	H.	H.	H.	V.H	V.H	V.H	V.H	V.H	V.H	V.H	V.H	V.H	V.H	V.H	V.H
Exp4	L.	V.H	H.	L.	V.L	L.	H.	H.	V.H	L.	V.L	L.	V.L	H.	L.

1: Inventory & warehousing, **2**: Transportation, **3**: Postponement, **4**: Customer service, **5**: e-logistics, **6**: Safety & security

Table 7- 2: Logistics Services Initial Fuzzy Average Matrix (A^{fuz})

A^{fuz} matrix	Inventory & Warehousing	Transportation	Postponement
Inventory & Warehousing	(0.000, 0.000, 0.000)	(0.438, 0.688, 0.938)	(0.500, 0.750, 1.000)
Transportation	(0.625, 0.875, 1.000)	(0.000, 0.000, 0.000)	(0.500, 0.750, 0.938)
Postponement	(0.563, 0.813, 1.000)	(0.438, 0.688, 0.938)	(0.000, 0.000, 0.000)
Customer Services	(0.375, 0.563, 0.750)	(0.500, 0.750, 0.875)	(0.438, 0.688, 0.875)
e-Logistics	(0.375, 0.563, 0.750)	(0.438, 0.625, 0.813)	(0.438, 0.625, 0.813)
Safety & Security	(0.563, 0.813, 0.875)	(0.563, 0.813, 0.938)	(0.500, 0.750, 0.875)
	Customer Service	**e-Logistics**	**Safety & Security**
Inventory & Warehousing	(0.500, 0.750, 0.938)	(0.500, 0.688, 0.813)	(0.438, 0.688, 0.875)
Transportation	(0.625, 0.875, 1.000)	(0.500, 0.688, 0.813)	(0.500, 0.750, 0.938)
Postponement	(0.500, 0.750, 1.000)	(0.375, 0.563, 0.750)	(0.313, 0.438, 0.625)
Customer Services	(0.000, 0.000, 0.000)	(0.500, 0.750, 0.875)	(0.375, 0.563, 0.688)
e-Logistics	(0.688, 0.938, 1.000)	(0.000, 0.000, 0.000)	(0.375, 0.563, 0.750)
Safety & Security	(0.563, 0.813, 0.938)	(0.438, 0.688, 0.875)	(0.000, 0.000, 0.000)

Each fuzzy number in Table 7-2 is the average of experts' evaluation of the impact-relationship between two logistics services. For example, on average, providing 'Inventory & Warehousing' services affects the value-added of the 'Transportation' services by (0.4375, 0.6875, 0.9375). Meanwhile providing 'Transportation' services affects the value-added of the 'Inventory & Warehousing' services by (0.625, 0.875, 1.0). The normalised fuzzy direct relation matrix (X^{fuz}) is obtained using Equations (3-5, 3-6 and 3-7). Table 7- 3 summarises the logistics services X^{fuz} matrix. Normalising fuzzy direct relation matrix transforms the various criteria scales into a comparable scale.

Table 7- 3: Normalised Fuzzy Direct Relation Matrix (Xf^{uz})

X^{fuz} matrix	Inventory & Warehousing	Transportation	Postponement
Inventory & Warehousing	(0.000, 0.000, 0.000)	(0.090, 0.141, 0.192)	(0.103, 0.154, 0.205)
Transportation	(0.128, 0.180, 0.205)	(0.000, 0.000, 0.000)	(0.103, 0.154, 0.192)
Postponement	(0.115, 0.167, 0.205)	(0.090, 0.141, 0.192)	(0.000, 0.000, 0.000)
Customer Services	(0.077, 0.115, 0.154)	(0.103, 0.154, 0.180)	(0.090, 0.141, 0.180)
e-Logistics	(0.077, 0.115, 0.154)	(0.090, 0.128, 0.167)	(0.090, 0.128, 0.167)
Safety & Security	(0.115, 0.167, 0.180)	(0.115, 0.167, 0.192)	(0.103, 0.154, 0.180)
	Customer Service	**e-Logistics**	**Safety & Security**
Inventory & Warehousing	(0.103, 0.154, 0.192)	(0.103, 0.141, 0.167)	(0.090, 0.141, 0.180)
Transportation	(0.128, 0.180, 0.205)	(0.103, 0.141, 0.167)	(0.103, 0.154, 0.192)
Postponement	(0.103, 0.154, 0.205)	(0.077, 0.115, 0.154)	(0.064, 0.090, 0.128)
Customer Services	(0.000, 0.000, 0.000)	(0.103, 0.154, 0.180)	(0.077, 0.115, 0.141)
e-Logistics	(0.141, 0.192, 0.205)	(0.000, 0.000, 0.000)	(0.077, 0.115, 0.154)
Safety & Security	(0.115, 0.167, 0.192)	(0.090, 0.141, 0.180)	(0.000, 0.000, 0.000)

The fuzzy total-relation matrix is obtained using Equations (3-8, 3-9 and 3-10) as is shown in Table 7-4.

Table 7- 4: Logistics Services Fuzzy Total-Relation Matrix (T^{fuz})

T^{fuz} matrix	Inventory & Warehousing	Transportation	Postponement
Inventory & Warehousing	(0.088, 0.341, 1.371)	(0.167, 0.461, 1.565)	(0.178, 0.471, 1.575)
Transportation	(0.215, 0.525, 1.573)	(0.097, 0.369, 1.436)	(0.190, 0.502, 1.599)
Postponement	(0.186, 0.457, 1.477)	(0.161, 0.434, 1.499)	(0.079, 0.311, 1.340)
Customer Services	(0.154, 0.424, 1.373)	(0.172, 0.450, 1.421)	(0.161, 0.440, 1.423)
e-Logistics	(0.157, 0.421, 1.387)	(0.165, 0.429, 1.426)	(0.165, 0.429, 1.428)
Safety & Security	(0.201, 0.512, 1.506)	(0.197, 0.507, 1.548)	(0.187, 0.498, 1.540)
	Customer Service	**e-Logistics**	**Safety & Security**
Inventory & Warehousing.	(0.194, 0.516, 1.663)	(0.176, 0.446, 1.445)	(0.155, 0.413, 1.385)
Transportation	(0.229, 0.571, 1.707)	(0.189, 0.476, 1.476)	(0.176, 0.451, 1.424)
Postponement	(0.186, 0.486, 1.602)	(0.149, 0.401, 1.375)	(0.128, 0.351, 1.291)
Customer Services	(0.095, 0.360, 1.359)	(0.171, 0.436, 1.331)	(0.139, 0.376, 1.240)
e-Logistics	(0.223, 0.521, 1.544)	(0.081, 0.302, 1.192)	(0.142, 0.374, 1.261)
Safety & Security	(0.214, 0.556, 1.645)	(0.174, 0.472, 1.439)	(0.080, 0.313, 1.219)

Table 7-4 summarises the logistics services overall influence relationships. Each fuzzy number in this table is the total direct and indirect fuzzy influence of each logistics service over the value-added of other logistics services. For example, the total direct and indirect fuzzy influence of 'Inventory & warehousing' over the value-added of 'Transportation' is (0.1672, 0.4611, 1.5646). Meanwhile, the 'Transportation' services total direct and indirect fuzzy influence over the value-added of the 'Inventory & warehousing' services is (0.2150, 0.5253, 1.5728). Additionally, Table 7-4 helps to understand the logistics services complex relationships through clarifying the highest influence that each logistics service affects and is affected by. For example, the highest fuzzy influence over the 'Inventory & warehousing' services comes from the 'Transportation' services. While, the highest fuzzy influence of 'Inventory & warehousing' services is over the 'Customer service' dimension. Table 7-5 summarises the highest influence affecting and affected by each logistics service.

Table 7- 5: Highest Fuzzy Influence between Logistics Services

Logistics Service	Highest influence received from…	Highest influence over …
Inventory & Warehousing	Transportation	Customer Service
Transportation	Inventory & Warehousing	Customer Service
Postponement	Transportation	Customer Service
Customer Services	Transportation	Postponement
e-Logistics	Transportation	Customer Service
Safety & Security	Transportation	Customer Service

Table 7-5 shows the key role of the 'Transportation' services in the logistics industry. 'Transportation' services have the highest influence over the value-added of all other logistics services. LSPs need to improve their transportation services in order to improve their overall services value-added. While, the 'Customer service' value-added is affected by all other logistics services.

The sum of 'Inventory & Warehousing' row (R_i^{fuz}) is the total direct and indirect fuzzy influence that 'Inventory & Warehousing' services have over the system (0.958, 2.649, 9.004) as is shown in Table 6-6. Meanwhile, the sum of 'Inventory & Warehousing' column (C_i^{fuz}) is the total direct and indirect influence of the system over the 'Inventory & Warehousing' services (1.001, 2.680, 8.687).

Using Equation 3-11 to defuzzify (R_i^{fuz}) and (C_i^{fuz}) values gives the $R_i^{\,def}$ and $C_i^{\,def}$ values. These defuzzified values are used to provide the $(R_i+C_i)^{\,def}$ and $(R_i\text{-}C_i)^{\,def}$ values, which in turn are used to acquire the IRM. Table 7-6 summarises the R_i^{fuz}, C_i^{fuz}, $R_i^{\,def}$, $C_j^{\,def}$, $(R_i+C_i)^{\,def}$, $(R_i\text{-}C_i)^{\,def}$ values and factor type. The $(R_i+C_i)^{\,def}$ is the horizontal axis of the IRM. It is called 'Prominence' or 'Importance'. The 'Importance' axis clarifies the importance of each service within a set of services. The $(R_i\text{-}C_i)^{\,def}$ is the vertical axis and is called 'Relation'. The 'Relation' axis classifies criteria into 'cause' and 'effect' groups. If the $(R_i\text{-}C_i)^{\,def}$ is positive, then the service is a 'Cause' one. If the $(R_i\text{-}C_i)^{\,def}$ is negative, then the service is an 'Effect' one.

Table 7- 6: Logistics Services Importance, Relations and Types

Factors	R_i^{fuz}	C_i^{fuz}	$R_i^{\,def}$	$C_i^{\,def}$	$R_i+C_i^{\,def}$	$R_i\text{-}C_i^{\,def}$	Type
Inventory & Warehousing	(0.958, 2.649, 9.004)	(1.001, 2.680, 8.687)	3.948	3.882	7.830	0.066	Cause
Transportation	(1.096, 2.894, 9.214)	(0.959, 2.650, 8.894)	4.149	3.917	8.066	0.232	Cause
Postponement	(0.888, 2.441, 8.582)	(0.959, 2.651, 8.904)	3.722	3.920	7.641	-0.198	Effect
Customer Services	(0.891, 2.485, 8.146)	(1.141, 3.009, 9.519)	3.615	4.297	7.911	-0.682	Effect
e-Logistics	(0.933, 2.477, 8.237)	(0.940, 2.534, 8.258)	3.650	3.682	7.332	-0.031	Effect
Safety & Security	(1.053, 2.858, 8.896)	(0.820, 2.279, 7.819)	4.030	3.416	7.446	0.614	Cause

Finally, T^{fuz} matrix is defuzzified using Equation 3-11. Only factors with effect greater than the threshold value should be chosen and shown in the IRM (visual diagram). The average value of the defuzzified T matrix (T^{def}) is defined as the 'Threshold' in this hybrid model. The average value of the (T^{def}) is (0.64205). Therefore, only shaded cells in Table 7-7 were represented in the IRM (Figure 7-3).

Table 7- 7: Logistics Services Defuzzified T Matrix (Tdef)

T^{def} matrix	Inventory & Warehousing	Transportation	Postponement	Customer Services	e-Logistics	Safety & Security
Inventory & Warehousing.	0.558	0.687	0.697	0.745	0.649	0.612
Transportation	0.729	0.591	0.720	0.790	0.674	0.645
Postponement	0.666	0.655	0.534	0.713	0.602	0.552
Customer Services	0.613	0.642	0.635	0.564	0.610	0.550
e-Logistics	0.616	0.633	0.633	0.722	0.489	0.557
Safety & Security	0.701	0.709	0.700	0.762	0.657	0.501

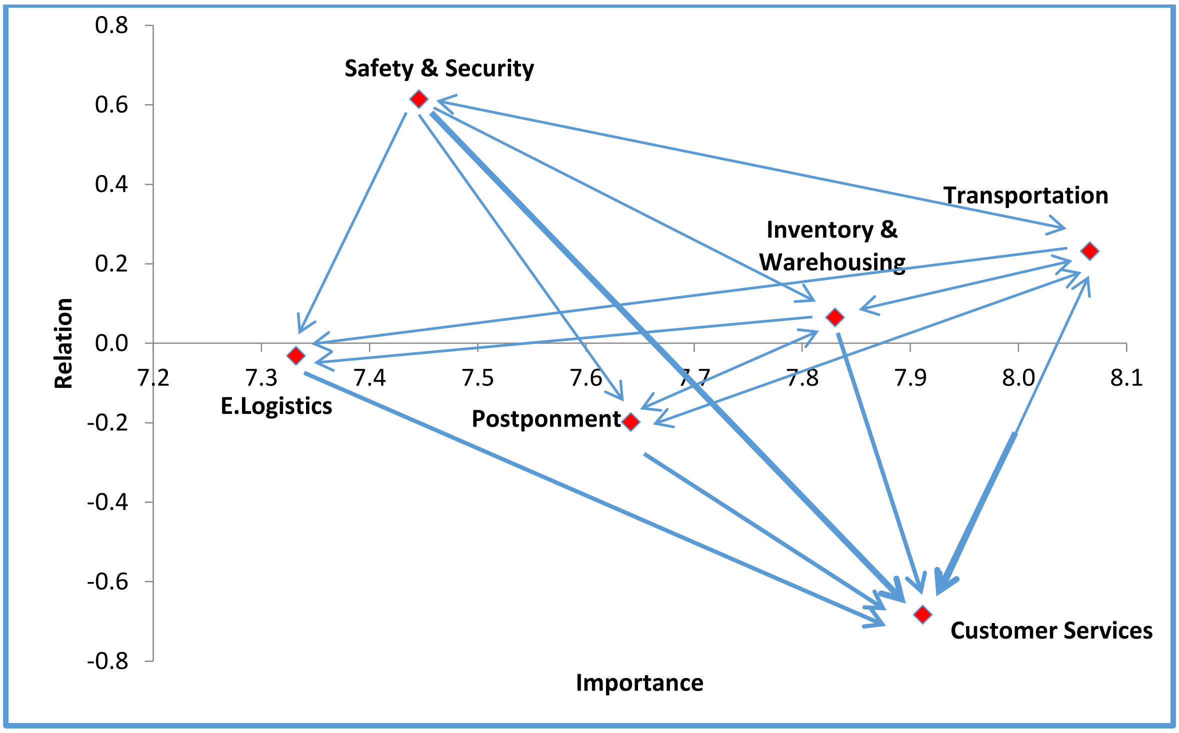

Figure 7- 3: Logistics Services IRM

The local and global weights of each criterion in this group are obtained using Equations 3-1 and 3-2. The global weight of any criterion is the result of the multiplying its local weight with the global weight of the cluster or group where it belongs. For example, the local weight of the 'Flow-in activities' is (0.500). This factor is under the 'Inventory & warehousing' dimension. The global weight of 'Inventory & warehousing' dimension is (0.169), then the global weight of the 'Flow-in activities' is (0.500×0.169) equals (0.085) as is shown in Table 7-8. The same procedures were used to evaluate the cause and effect relationships, relative importance and relative weights for all the logistics services and their sub-dimensions in all levels. Table 7-8 summarises $(R_i+C_i)^{def}$,

$(R_i\text{-}C_i)^{def}$, service type, relative importance and relative weight (global and local) for all the logistics services throughout the logistics service model.

Table 7- 8: FDEMATEL Outputs of the Logistics Services Evaluation

Logistics Services	$R_i+C_i^{def}$	$R_i\text{-}C_i^{def}$	Type	Relative	Local	Global
Inventory & Warehousing	**7.8303**	**0.0655**	**Cause**	**7.8306**	**0.1692**	**0.1692**
Flow-In Activities	18.5865	-0.3497	Effect	18.5898	0.5000	0.0846
Flow-Out Activities	18.5865	0.3497	Cause	18.5898	0.5000	0.0846
Transportation	**8.0658**	**0.2320**	**Cause**	**8.0692**	**0.1743**	**0.1743**
Inbound	16.6581	-0.3536	Effect	16.6618	0.5000	0.0872
Outbound	16.6581	0.3536	Cause	16.6618	0.5000	0.0872
Postponement	**7.6414**	**-0.1982**	**Effect**	**7.6440**	**0.1651**	**0.1651**
Assembly	7.5632	-0.2025	Effect	7.5659	0.3192	0.0527
Packaging	7.8082	-0.3132	Effect	7.8145	0.3297	0.0544
Labelling	8.3086	0.5162	Cause	8.3246	0.3512	0.0580
Customer Services	**7.9114**	**-0.6823**	**Effect**	**7.9408**	**0.1716**	**0.1716**
Freight Payment & Auditing	9.4816	-0.2432	Effect	9.4848	0.2544	0.0436
Order mgmt. & Fulfilment	9.9133	0.0407	Cause	9.9134	0.2659	0.0456
Help Desk	8.9104	0.4831	Cause	8.9235	0.2393	0.0411
Carrier Selection	8.9603	-0.2809	Effect	8.9647	0.2404	0.0412
e-Logistics	**7.3319**	**-0.0311**	**Effect**	**7.3320**	**0.1584**	**0.1584**
Global Visibility	61.4122	-0.0036	Effect	61.4122	0.3358	0.0532
Real-time info. Sharing &	60.9020	-0.6639	Effect	60.9056	0.3330	0.0527
e-Logistics training &	60.5768	0.6675	Cause	60.5805	0.3312	0.0525
Safety & Security	**7.4457**	**0.6144**	**Cause**	**7.4710**	**0.1614**	**0.1614**
Risk assessment	30.3687	1.2611	Cause	30.3948	0.3269	0.0528
Shipment & equipment	31.4633	-0.7256	Effect	31.4716	0.3384	0.0546
People safety & security	31.1191	-0.5355	Effect	31.1237	0.3347	0.0540

The DEMATEL technique is used to study the causal relationships existing in the logistics services complex system. The technique's capability to analyse the cause and effect relationships between logistics services, classifying them into cause and effect services and providing a visual diagram of their relationships helps us to understand the impact-relationship of this complex system and provide more information regarding appropriate logistics services mix. Appropriate service mix provides more value for LSUs and improves the LSP's competitiveness. The following sections provide more in-depth insights regarding the logistics services impact-relationship.

7.4.1.1. Logistics Services Impact-relationship

Back to Figure 7-3 (logistics services impact-relationship), logistics services classified into Cause and Effect groups based on the total net influence they receive and/or give to the logistics services value-added system. ‘E-logistics’, ‘Postponement’ and ‘Customer service’ are effect services with negative value-added effect. While ‘Transportation’, ‘Inventory & warehousing’ and ‘Safety & security’ services are ‘Cause’ services with a positive value-added effect.

‘Transportation’ service is the most important one in terms of the value-added. ‘Transportation’ service has a strong impact-relationship with all other logistics services. It has strong mutual impact-relationships with ‘Customer Service’, ‘Inventory & warehousing’, ‘Postponement’ and ‘Safety & security’ services and has a strong direct effect over the ‘e-logistics’ service. ‘Transportation’ service has a central role in the logistics services value-added system. According to the DEMATEL outputs (Table 6-8) ‘Transportation’ service has the highest weight (0.174), followed by ‘Customer service’, ‘Inventory & warehousing’ and ‘Postponement’ services with (0.172), (0.169) and (0.165) weights respectively.

From the mutual impact-relationship between the ‘Transportation’, ‘Customer Service’, ‘Inventory & warehousing’, ‘Postponement’ and ‘Safety & security’ services we can conclude the following points:

- LSPs need to manage these service on a simultaneous basis to improve their overall value-added level
- ‘Transportation’ service is the central service that affects the value-added of all others logistics services
- ‘Customer service’ value-added is the aggregate values-added of all other logistics services
- ‘Inventory & warehousing’ service has a strong impact influence over the ‘Customer service’ and ‘e-logistics’ services, while its value-added is affected by the ‘Safety & security’, ‘Postponement’ and ‘Transportation’ services
- ‘Postponement’ service influences the value-added of the ‘Inventory & warehousing’, ‘Transportation’ and ‘Customer service’ services, while its value added is heavily affected by the ‘Safety & security’ service
- ‘Safety & security’ service affects the value-added of all other logistics service and has a mutual impact-relationship with the ‘Transportation’ service

Meanwhile, ‘e-logistics’ service has the lowest weight in the logistics services value-added model (0.158). The ‘e-logistics’ service value-added affected by the ‘Transportation’, ‘Inventory & warehousing’ and ‘Safety & security’ services, while it has a strong impact over the ‘Customer service’ value-added. Understanding these relationships helps LSPs and LSUs to understand the complex system of the logistics services value-added. This understanding helps them to design, select and manage their logistics service packages in a way that creates more value-added and helps both of LSUs and of LSPs to achieve their strategic objectives.

7.4.1.2. Inventory & Warehousing Impact-relationship

Inventory & warehousing service consists of a large number of activities classified into two main groups based on the flow of materials: Flow-in activities and Flow-out activities. Based on the FDEMATEL outputs (Table 7-8), both of the two groups are important and complement each other in terms of the value-added with equal local weights (0.5). The Inventory & warehousing T^{def} matrix (Table 7-9) with threshold (4.6466) and the impact-relationship (Figure 7-4) show the mutual impact-relationship between these two groups and the cause-effect classification.

Table 7- 9: Inventory & Warehousing Services Defuzzified T Matrix (T^{def})

T^{def} matrix	Flow-In	Flow-Out
Flow-In	4.423	4.695
Flow-Out	5.045	4.423

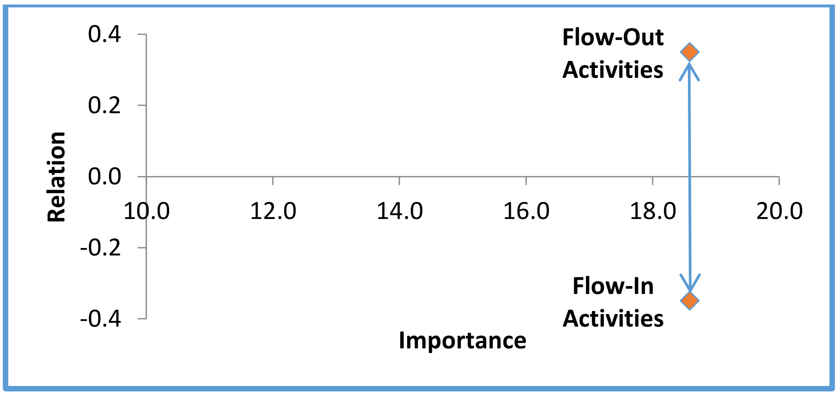

Figure 7- 4: Inventory & Warehousing Services IRM

Both groups are important and affect the value-added of the ‘Inventory & warehousing’ service. However, in terms of the impact-relationship, ‘Flow-out’ activities are the ‘Cause’ group that affect the value-added of the ‘Flow-in’ activities (Effect group). Due to the large number of these activities, LSUs and LSPs need to select the appropriate ones to evaluate the value-added of the inventory & warehousing dimension. The following list clarifies the most important/used Flow-in and Flow-out activities:

1- Flow-In activities

- Receive and Sort items: The basic function of inventory centres is to receive and store items for future usages
- Quality assurance: All inspection activities of items' type, time, place and features
- Documentation and inventory control: Activities related to data entry and record documentation of all items across all stages
- Barcoding and radio frequency: Item barcoding to facilitate storage, handling and monitoring activities, RFID system used for internal and external communication to facilitate logistics activities
- Handling: Includes all the movement of the items inside the centres (manually or automatically)
- Monitoring and tracking activities: Internal monitoring and controlling system inside the inventory centres to ensure the smooth flow, right sequence and high quality of logistics activities.
- Maintain and optimise activities: Activities related to development and optimisation of logistics activities to provide more efficient logistics services

2- Flow-Out activities

- Order filling: Receiving customers' orders is the first step in preparing outgoing shipments
- Prepare shipments/shipment planning: Activities related to planning, preparing and monitoring an order's items.
- Pick items (Order Picking): Pre-allocation allocates inventory before the items are picked and group shipment's items in one place for transfer.
- Loading order's items to vehicles

7.4.1.3. Transportation Service Impact-relationship

Transportation as the most important logistics service consists of two main groups of activities based on the place and direction of movements: Inbound activities (internal transportation) and outbound activities (external transportation). Table 6-8 shows that both groups are important and affect the value-added of the 'Transportation' service provided by the LSP. With equal local weights (0.5), LSPs need to improve their 'Inbound' and 'Outbound' activities in a parallel manner in order to provide a high value-added transportation services. Transportation T^{def} matrix (Table 7-10) with threshold of (4.1645) and the impact-relationship (Figure 7-5) clarify the mutual relationship between these two groups and their cause-effect relationship. Transportation services under each group are presented in section (7.2.2.)

Table 7- 10: Transportation Services Defuzzified T Matrix (T^{def})

T^{def} matrix	Inbound	Outbound
Inbound	3.952	4.201
Outbound	4.554	3.952

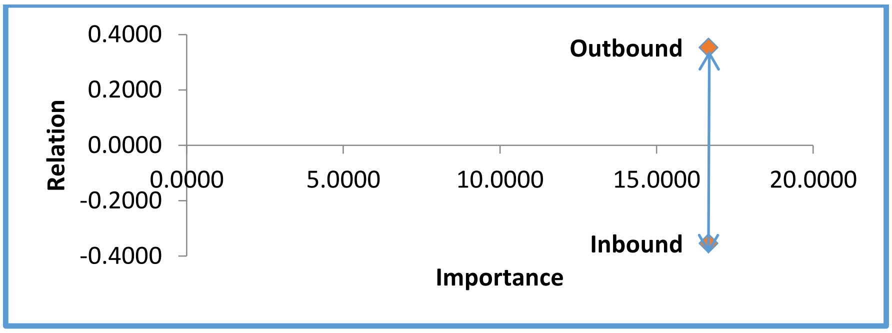

Figure 7- 5: Transportation Services IRM

7.4.1.4. Postponement Service Impact-relationship

Postponement logistics service consists of 'Packaging', 'Labelling' and 'Assembly' activities. Labelling activities are the most important one with (0.3512) and (0.0580) local and global weights respectively (Table 7-8). Followed by packaging activities with (0.3297) and (0.0544) weights and finally, assembly activities with (0.3192) and (0.0527) weights. The postponement T^{def} matrix (Table 7-11) with (1.3156) threshold shows the key role of the 'Labelling' activities in the postponement value-added system. As is shown in Figure 7-6, labelling activities have a direct impact over the assembly activities and mutual impact with the packaging activities.

Table 7- 11: Postponement Services Defuzzified T Matrix (T^{def})

T^{def} matrix	Assembly	Packaging	Labelling
Assembly	1.045	1.339	1.297
Packaging	1.286	1.114	1.348
Labelling	1.553	1.608	1.252

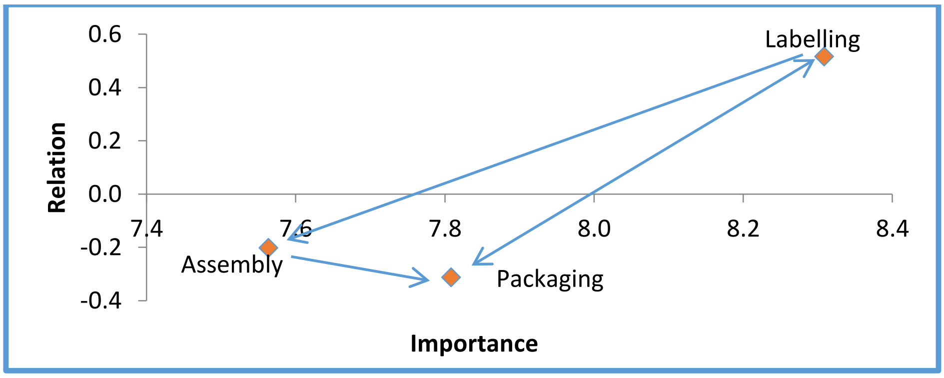

Figure 7- 6: Postponement Services IRM

Because of these impact-relationships, 'Assembly' and 'Packaging' activities are 'Effect' ones affected by the Labelling activities, the 'Cause' one. LSPs need to understand these impact-relationships in order to manage and improve the postponement value-added. In addition to the 'packaging' activities –the most used one- LSPs need to focus more on their labelling activities that add more value for their postponement value-added. According to the 2014 18th annual third-party logistics study (Capgemini, 2014) product labelling, packaging and assembly are one of the main value-added logistics services provided by the 3PLs these days.

7.4.1.5. Customer Service Impact-relationship

Four main services have been selected under the 'Customer service' dimension. With (0.2659) local weight and (0.0456) global weight 'Order management and fulfilment' is the most important one. Then 'Freight payment & auditing', 'Carrier selection' and 'Help desk' with (0.2544), (0.2404) and (0.2393) local weight respectively (Table 7-8) Table 7-12 (T^{def} matrix) and Figure 7-7 show the central role of the 'Order management & fulfilment' in the customer service value-added system. Order management has mutual impact-relationships with all other customer service elements. The LSP capability to manage and fulfil orders heavily affects the value-added of the 'Help desk', 'Carrier selection' and 'Freight payment' services, and moreover, affects the overall customer service value-added.

Table 7- 12: Customer Service Defuzzified T Matrix (T^{def})

T^{def} matrix	Freight payment & Auditing	Order mgmt. & fulfilment	Help Desk	Carrier Selection
Freight payment & Auditing	1.056	1.292	1.093	1.179
Order mgmt. & fulfilment	1.358	1.157	1.178	1.284
Help Desk	1.285	1.265	0.939	1.207
Carrier Selection	1.164	1.223	1.003	0.951

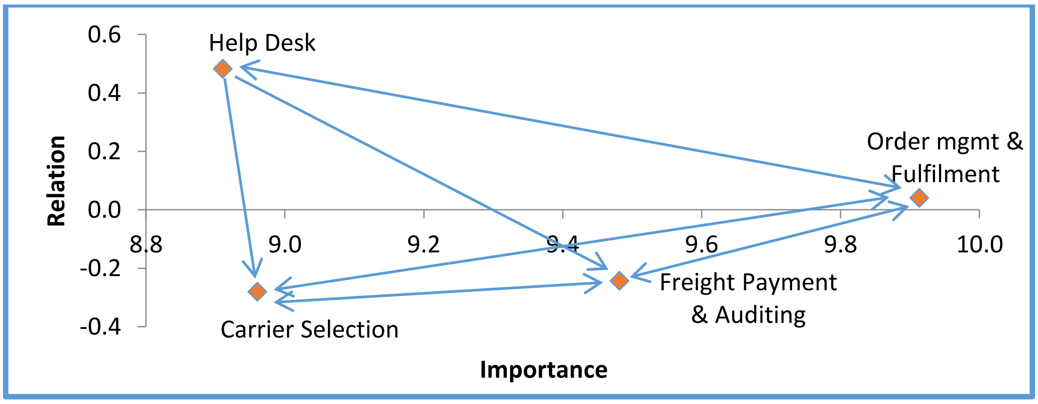

Figure 7- 7: Customer Service Services IRM

In addition to the 'Order management & fulfilment', 'Help desk' is another 'Cause' service that affects the value-added of the 'Carrier selection' and 'Freight payment &

auditing' 'Effect' services. 'Help desk' has a strong direct impact over the 'Carrier selection' and 'Freight payment & auditing' services value-added and a mutual impact-relationship with the 'Order management & fulfilment' service. LSPs need to rethink the way they serve their customers and the appropriate mix to provide. 'Carrier selection', 'Freight payment & auditing' and 'Order management & fulfilment' have a very strong mutual impact-relationship and should be provided together to ensure a high level of value-added. Meanwhile, 'Help desk' service supports the value-added of these three services.

7.4.1.6. E-logistics Service Impact-relationship

'Global visibility' is the most important element in the e-logistics service dimension with (0.3358) local and (0.0532) global weights. Followed by the 'Real-time information sharing & Decision-making' and 'e-logistics training & education' with (0.0527) and (0.0525) global weight respectively (Table 7-8).

Table 7-13 shows the e-logistics services T^{def} matrix. Only impact-relationships with a threshold of (10.1606) or more have been represented in Figure 7-8. 'Real-time information sharing & Decision-making' and 'Global visibility' have a strong mutual impact-relationship. These two 'Effect' factors represent the main value-added uses of e-logistics services. Although 'e-logistics training & education' is in the third rank, its 'Cause' position and its direct impact effect over the 'Global visibility' and the 'Real-time information sharing & Decision-making' increase its importance in the e-logistics services value-added system.

Table 7- 13: E-Logistics Services Defuzzified T Matrix (T^{def})

T^{def} matrix	Global visibility	Real-time info. sharing & Decision-making	e-logistics training & education
Global visibility	10.116	10.439	10.150
Real-time info. sharing & Decision-making	10.222	9.942	9.955
e-logistics training & education	10.370	10.402	9.850

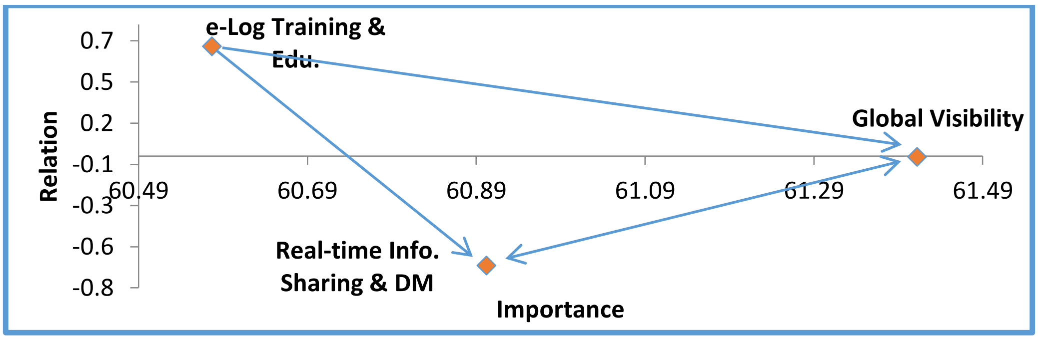

Figure 7- 8: E-Logistics Services IRM

LSPs need to provide an appropriate e-logistics training and education to support the e-logistics services value-added. As is shown in Chapter 5, well-trained and educated staff are crucial logistics resource and therefore they are able to deliver superior e-logistics values to the LSUs and to support and help LSPs to improve their competitiveness. LSPs can provide e-logistics training for their staff and other firms too.

7.4.1.7. Safety & Security Services Impact-relationship

'Safety & security' services have a significant impact over other logistics services value-added (Figure 7-3). The value-added of the 'Safety & security' services have been analysed through three main sub-dimensions: Risk assessment, shipment & equipment security and people safety & security. 'Risk assessment' service is the 'Cause' factor that influences the value-added of the shipments and people safety and security. LSP's capability to assess risk, to determine hazards sources and to estimate risk likelihood and consequences are vital elements and have a significant impact over the LSP's capability to secure shipments and people and retain them safe.

With a (0.3384) local weight and (0.0546) global weight 'Shipment security' is the most important factor in the 'Safety & security' value-added system (Table 7-8). With very close scores (0.3347 and 0.0540 local and global weight respectively) 'People Safety & security' is the second most important factor. 'Risk assessment' service comes third with (0.3269) and (0.0528) local and global weights respectively. Table 7-14 summarises the impact-relationship between the 'Safety & security' factors. Figure 7-9 shows the IRM for the relationship that is equal to or more than the threshold (5.1640). Because of the mutual impact-relationship between 'Shipment security' and 'People safety & security', LSPs must address them simultaneously to improve their safety and security services and to provide more value-added logistics services for their customers.

Table 7- 14: Safety & Security Services Defuzzified T Matrix (T^{def})

T^{def} matrix	Risk Assessment	Shipment & equipment security	People safety & security
Risk Assessment	4.773	5.568	5.475
Shipment & equipment security	4.907	5.126	5.336
People safety & security	4.875	5.401	5.017

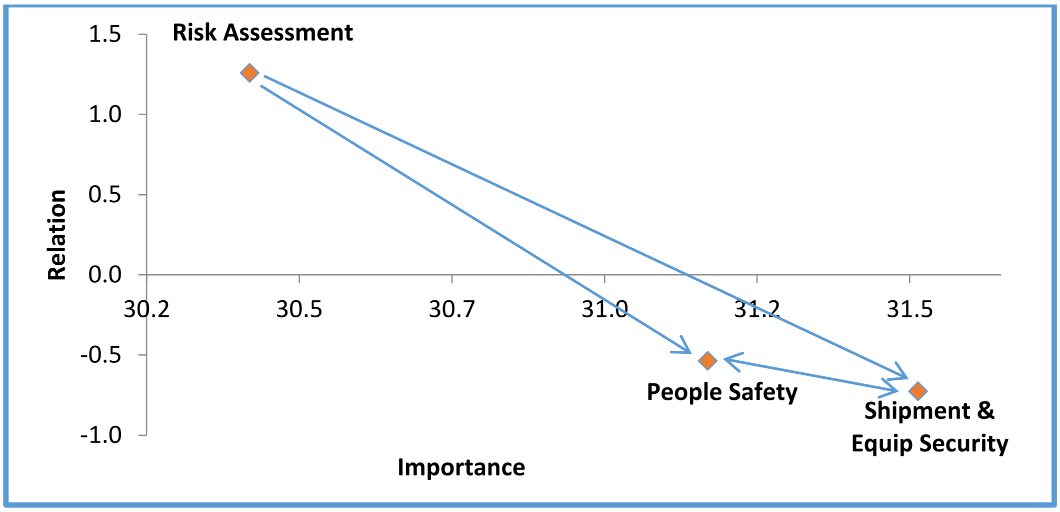

Figure 7- 9: Safety and Security Services IRM

7.4.2. FTOPSIS

The FDEMATEL technique was used to find the local and global weights of the logistics services value-added and their impact-relationship. Then, the FTOPSIS technique is used to evaluate the LSP alternatives against the weighted logistics services. Because it was difficult to find a number of logistics experts who dealt with the same LSP, an electronic questionnaire was developed and used. The Armstrong and Associates top 50 global 3PLs ranking is used as the initial LSPs list (Burnson, 2014). Each logistics expert was asked to select an LSP that he/she had dealt with before to evaluate their logistics services' value-added using the following seventeen weighted criteria. C1: Flow-in activities C2: Flow-out activities C3: Inbound activities C4: Outbound activities C5: Assembly C6: Packaging C7: Labelling C8: Freight payment & auditing C9: Order management & fulfilment C10: Help desk C11: Carrier selection C12: Global visibility C13: Real-time information sharing & decision-making C14: e-logistics training & education C15: Risk assessment C16: Shipment security and C17: People safety & security. Five LSPs have been evaluated by six logistics experts. Table 7-15shows the six experts' linguistics evaluations of the five LSPs.

Table 7- 15: Expert Linguistics Evaluations of the LSP alternatives

	Exp.	C1	C2	C3	C4	C5	C6	C7	C8	C9
LSP1	**1-1**	HVA	HVA	GVA	GVA	AVA	AVA	AVA	HVA	AVA
LSP2	**2-1**	HVA	AVA	HVA	HVA	HVA	HVA	AVA	AVA	HVA
LSP3	**3-1**	HVA	HVA	HVA	HVA	AVA	HVA	HVA	HVA	AVA
LSP4	**4-1**	NVA	WVA	AVA	AVA	WVA	AVA	HVA	AVA	HVA
LSP5	**5-1**	HVA	NVA	GVA	GVA	NVA	GVA	GVA	NVA	GVA
	5-2	HVA	HVA	GVA	GVA	HVA	GVA	GVA	HVA	GVA
		C10	**C11**	**C12**	**C13**	**C14**	**C15**	**C16**	**C17**	
LSP1	**1-1**	HVA	GVA	HVA	GVA	AVA	AVA	HVA	HVA	
LSP2	**2-1**	HVA	HVA	AVA	AVA	AVA	AVA	GVA	GVA	
LSP3	**3-1**	HVA	AVA	GVA	HVA	AVA	HVA	HVA	HVA	
LSP4	**4-1**	AVA	WVA	AVA	HVA	AVA	WVA	NVA	WVA	
LSP5	**5-1**	HVA	NVA	GVA	GVA	NVA	GVA	GVA	GVA	
	5-2	HVA	AVA	HVA	HVA	AVA	GVA	HVA	HVA	

NVA: No value-added, WVA: weak value-added, AVA: Acceptable value-added, HVA: High value-added, GVA: Great value-added.

Each linguistics expression has a specific fuzzy triangle value as is clarified in the FTOPSIS section. In case there is more than one evaluation for the same LSP alternative, experts' evaluation average is used, as in LSP5 case. Equation 3-12 used to normalised the initial fuzzy matrix to ensure that all the TFN are ranged within [0, 1] interval. Except C14, all the upper limit of the highest TFN under each criterion is (1); therefore, the normalised fuzzy matrix is the same average fuzzy initial matrix except C14 column. Table 7-17 shows normalised fuzzy evaluation matrix.

The weighted fuzzy matrix is developed using Equation 3-13. This matrix is based on the weights of the logistics service obtained in the FDEMATEL stage. Using the weight of each criterion reflects the rule of each service in the logistics service value-added system. Table 7-18 shows the weighted fuzzy matrix. Table 7-16 shows experts' evaluation averages of the LSP alternatives (initial fuzzy matrix).

Equation 3-12 used to normalised the initial fuzzy matrix to ensure that all the TFN are ranged within [0, 1] interval. Except C14, all the upper limit of the highest TFN under each criterion is (1); therefore, the normalised fuzzy matrix is the same average fuzzy initial matrix except C14 column. Table 7-17 shows normalised fuzzy evaluation matrix.

The weighted fuzzy matrix is developed using Equation 3-13. This matrix is based on the weights of the logistics service obtained in the FDEMATEL stage. Using the weight of each criterion reflects the rule of each service in the logistics service value-added system. Table 7-18 shows the weighted fuzzy matrix.

Table 7- 16: Average of Expert Evaluations of the LSP alternatives

LSP	C1			C2			C3			C4			C5			C6			C7			C8			C9		
1	0.5000	0.750	1.000	0.500	0.750	1.000	0.750	1.000	1.000	0.750	1.000	1.000	0.250	0.500	0.750	0.250	0.500	0.750	0.250	0.500	0.750	0.500	0.750	1.0000	0.25	0.500	0.750
2	0.5000	0.750	1.000	0.250	0.500	0.750	0.500	0.750	1.000	0.500	0.750	1.000	0.500	0.750	1.000	0.500	0.750	1.000	0.250	0.500	0.750	0.250	0.500	0.7500	0.50	0.750	1.000
3	0.5000	0.750	1.000	0.500	0.750	1.000	0.500	0.750	1.000	0.500	0.750	1.000	0.250	0.500	0.750	0.500	0.750	1.000	0.500	0.750	1.000	0.500	0.750	1.0000	0.25	0.500	0.750
4	0.0000	0.000	0.250	0.000	0.250	0.500	0.250	0.500	0.750	0.250	0.500	0.750	0.000	0.250	0.500	0.250	0.500	0.750	0.500	0.750	1.000	0.250	0.500	0.7500	0.50	0.750	1.000
5	0.5000	0.750	1.000	0.250	0.375	0.625	0.750	1.000	1.000	0.750	1.000	1.000	0.250	0.375	0.625	0.750	1.000	1.000	0.750	1.000	1.000	0.250	0.375	0.6250	0.75	1.000	1.000

LSP	C10			C11			C12			C13			C14			C15			C16			C17		
1	0.5000	0.7500	1.0000	0.7500	1.0000	1.0000	0.5000	0.7500	1.0000	0.7500	1.0000	1.0000	0.2500	0.5000	0.7500	0.2500	0.5000	0.7500	0.5000	0.7500	1.0000	0.5000	0.7500	1.0000
2	0.5000	0.7500	1.0000	0.5000	0.7500	1.0000	0.2500	0.5000	0.7500	0.2500	0.5000	0.7500	0.2500	0.5000	0.7500	0.2500	0.5000	0.7500	0.7500	1.0000	1.0000	0.7500	1.0000	1.0000
3	0.5000	0.7500	1.0000	0.2500	0.5000	0.7500	0.7500	1.0000	1.0000	0.5000	0.7500	1.0000	0.2500	0.5000	0.7500	0.5000	0.7500	1.0000	0.5000	0.7500	1.0000	0.5000	0.7500	1.0000
4	0.2500	0.5000	0.7500	0.0000	0.2500	0.5000	0.2500	0.5000	0.7500	0.5000	0.7500	1.0000	0.2500	0.5000	0.7500	0.0000	0.2500	0.5000	0.0000	0.0000	0.2500	0.0000	0.2500	0.5000
5	0.5000	0.7500	1.0000	0.1250	0.2500	0.5000	0.6250	0.8750	1.0000	0.6250	0.8750	1.0000	0.1250	0.2500	0.5000	0.7500	1.0000	1.0000	0.6250	0.8750	1.0000	0.6250	0.8750	1.0000

Table 7- 17: Normalised Fuzzy Evaluation Matrix

LSP	C1			C2			C3			C4			C5			C6			C7			C8			C9		
1	0.500	0.750	1.000	0.500	0.750	1.000	0.750	1.000	1.000	0.750	1.000	1.000	0.250	0.500	0.750	0.250	0.500	0.750	0.250	0.500	0.750	0.500	0.750	1.000	0.250	0.500	0.750
2	0.500	0.750	1.000	0.250	0.500	0.750	0.500	0.750	1.000	0.500	0.750	1.000	0.500	0.750	1.000	0.500	0.750	1.000	0.250	0.500	0.750	0.250	0.500	0.750	0.500	0.750	1.000
3	0.500	0.750	1.000	0.500	0.750	1.000	0.500	0.750	1.000	0.500	0.750	1.000	0.250	0.500	0.750	0.500	0.750	1.000	0.500	0.750	1.000	0.500	0.750	1.000	0.250	0.500	0.750
4	0.000	0.000	0.250	0.000	0.250	0.500	0.250	0.500	0.750	0.250	0.500	0.750	0.000	0.250	0.500	0.250	0.500	0.750	0.500	0.750	1.000	0.250	0.500	0.750	0.500	0.750	1.000
5	0.500	0.750	1.000	0.250	0.375	0.625	0.750	1.000	1.000	0.750	1.000	1.000	0.250	0.375	0.625	0.750	1.000	1.000	0.750	1.000	1.000	0.250	0.375	0.625	0.750	1.000	1.000

LSP	C10			C11			C12			C13			C14			C15			C16			C17		
1	0.5000	0.7500	1.0000	0.7500	1.0000	1.0000	0.5000	0.7500	1.0000	0.7500	1.0000	1.0000	0.3333	0.6667	1.0000	0.2500	0.5000	0.7500	0.5000	0.7500	1.0000	0.5000	0.7500	1.0000
2	0.5000	0.7500	1.0000	0.5000	0.7500	1.0000	0.2500	0.5000	0.7500	0.2500	0.5000	0.7500	0.3333	0.6667	1.0000	0.2500	0.5000	0.7500	0.7500	1.0000	1.0000	0.7500	1.0000	1.0000
3	0.5000	0.7500	1.0000	0.2500	0.5000	0.7500	0.7500	1.0000	1.0000	0.5000	0.7500	1.0000	0.3333	0.6667	1.0000	0.5000	0.7500	1.0000	0.5000	0.7500	1.0000	0.5000	0.7500	1.0000
4	0.2500	0.5000	0.7500	0.0000	0.2500	0.5000	0.2500	0.5000	0.7500	0.5000	0.7500	1.0000	0.3333	0.6667	1.0000	0.0000	0.2500	0.5000	0.0000	0.0000	0.2500	0.0000	0.2500	0.5000
5	0.5000	0.7500	1.0000	0.1250	0.2500	0.5000	0.6250	0.8750	1.0000	0.6250	0.8750	1.0000	0.1667	0.3333	0.6667	0.7500	1.0000	1.0000	0.6250	0.8750	1.0000	0.6250	0.8750	1.0000

Table 7- 18: Weighted Fuzzy Evaluation Matrix

LSP	C1			C2			C3			C4C			C5			C6			C7			C8			C9		
1	0.042	0.063	0.084	0.042	0.063	0.084	0.065	0.087	0.087	0.065	0.087	0.087	0.013	0.026	0.039	0.013	0.027	0.040	0.014	0.029	0.043	0.021	0.032	0.043	0.011	0.022	0.034
2	0.042	0.063	0.084	0.021	0.042	0.063	0.043	0.065	0.087	0.043	0.065	0.087	0.026	0.039	0.052	0.027	0.040	0.054	0.014	0.029	0.043	0.010	0.021	0.032	0.022	0.034	0.045
3	0.042	0.063	0.084	0.042	0.063	0.084	0.043	0.065	0.087	0.043	0.065	0.087	0.013	0.026	0.039	0.027	0.040	0.054	0.029	0.043	0.058	0.021	0.032	0.043	0.011	0.022	0.034
4	0.000	0.000	0.021	0.000	0.021	0.042	0.021	0.043	0.065	0.021	0.043	0.065	0.000	0.013	0.026	0.013	0.027	0.040	0.029	0.043	0.058	0.010	0.021	0.032	0.022	0.034	0.045
5	0.042	0.063	0.084	0.021	0.031	0.052	0.065	0.087	0.087	0.065	0.087	0.087	0.013	0.019	0.032	0.040	0.054	0.054	0.043	0.058	0.058	0.010	0.016	0.027	0.034	0.045	0.045

LSP	C10			C11			C12			C13			C14			C15			C16			C17		
1	0.0205	0.0308	0.0411	0.0309	0.0412	0.0412	0.0266	0.0399	0.0532	0.0396	0.0527	0.0527	0.0175	0.0350	0.0525	0.0132	0.0264	0.0396	0.0273	0.0410	0.0546	0.0270	0.0405	0.0540
2	0.0205	0.0308	0.0411	0.0206	0.0309	0.0412	0.0133	0.0266	0.0399	0.0132	0.0264	0.0396	0.0175	0.0350	0.0525	0.0132	0.0264	0.0396	0.0410	0.0546	0.0546	0.0405	0.0540	0.0540
3	0.0205	0.0308	0.0411	0.0103	0.0206	0.0309	0.0399	0.0532	0.0532	0.0264	0.0396	0.0527	0.0175	0.0350	0.0525	0.0264	0.0396	0.0528	0.0273	0.0410	0.0546	0.0270	0.0405	0.0540
4	0.0103	0.0205	0.0308	0.0000	0.0103	0.0206	0.0133	0.0266	0.0399	0.0264	0.0396	0.0527	0.0175	0.0350	0.0525	0.0000	0.0132	0.0264	0.0000	0.0000	0.0137	0.0000	0.0135	0.0270
5	0.0205	0.0308	0.0411	0.0052	0.0103	0.0206	0.0332	0.0465	0.0532	0.0330	0.0462	0.0527	0.0087	0.0175	0.0350	0.0396	0.0528	0.0528	0.0341	0.0478	0.0546	0.0338	0.0473	0.0540

Aspiration level has been used in Equation 3-15 to identify the fuzzy PIS and the fuzzy NIS for each criterion. Therefore the v_i^+ is (1,1,1) and all the v_i^- is (0,0,0) and the FPIS, FNIS are:

FPIS = {(1, 1, 1)… (1, 1, 1)}

FNIS= {(0, 0, 0) … (0, 0, 0)}

The distance of each LSP alternative from the FNIS (d_i^-) and to the FPIS (d_i^*) are obtained using Equations 3-16 and 3-17. All the d_i^- and d_i^* values are non-fuzzy positive numbers and are used to find the closeness coefficient (*CC*) for each LSP alternative (Equation 3-18) to find the final LSP alternatives ranking. Table 7-19 summarises the LSP rankings based on their d_i^-, d_i^* and CC values.

Table 7- 19: LSP Alternatives Ranking based on the di-, di* and CCi Values

LSP	d_i^*	d_i^-	CC_i	Rank
1	16.508	0.934	0.054	**2**
2	16.568	0.914	0.052	**3**
3	**16.530**	**0.965**	**0.055**	**1**
4	16.813	0.661	0.038	**5**
5	16.455	0.894	0.052	**4**

The CC_i value used to estimate the extent to which each LSP alternative belongs to the PIS and NIS. Therefore, the LSP with the highest CC_i value is the best one; providing the highest value-added service. All the LSP alternatives are so far from the PIS and so close to the NIS, therefore the overall value-added of their services is not close to the Aspiration level. Based on the CC_i values (Table 7-19) LSP3 is the best alternative. The final LSP rankings list is **LSP3 ≻LSP1 ≻PLS2 ≻LSP5≻LSP4.** Figure 7-10 represents the ranking of the LSP alternatives based on their CC scores.

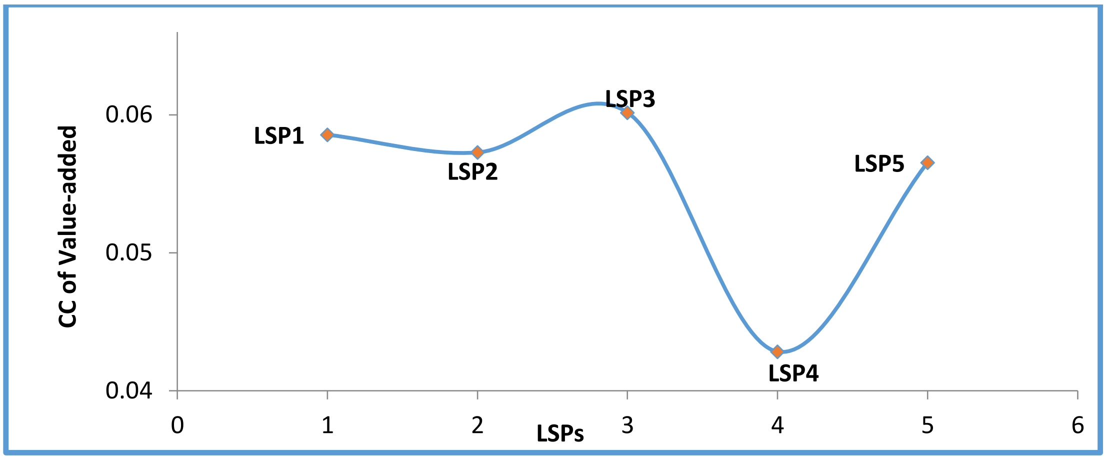

Figure 7- 10: LSP Rankings Order based on their CC Scores

The TOPSIS technique provides more detail regarding the individual differences between LSP alternatives. These details help DMs to compare LSPs based on their scores in a specific criterion and help them to highlight their strengths and weaknesses and development potentials. Moreover, this comparison helps DMs to choose between two or more alternatives with similar or close CC scores. Table 7-20 summarises the defuzzified scores of each LSP alternative against each criterion.

Table 7- 20: Defuzzified Scores of LSP Alternatives Value-added

LSP	C1	C2	C3	C4	C5	C6	C7	C8	C9
LSP1	0.063	0.063	0.065	0.065	0.026	0.027	0.029	0.033	0.023
LSP2	0.063	0.042	0.065	0.065	0.040	0.041	0.029	0.022	0.034
LSP3	0.063	0.063	0.065	0.065	0.026	0.041	0.044	0.033	0.023
LSP4	0.006	0.021	0.044	0.044	0.013	0.027	0.044	0.022	0.034
LSP5	0.063	0.035	0.065	0.065	0.022	0.041	0.044	0.018	0.034

	C10	C11	C12	C13	C14	C15	C16	C17
LSP1	0.031	0.031	0.040	0.040	0.035	0.026	0.041	0.041
LSP2	0.031	0.031	0.027	0.026	0.035	0.026	0.041	0.041
LSP3	0.031	0.021	0.040	0.040	0.035	0.040	0.041	0.041
LSP4	0.021	0.010	0.027	0.040	0.035	0.013	0.004	0.014
LSP5	0.031	0.012	0.041	0.041	0.020	0.040	0.043	0.042

Comparing with other LSPs, LSP3 has good value-added scores in six main criteria: C1, C2, C8, C10, C12 and C14. High scores in C2, C8 and particularly C12 support the LSP3's overall value-added ranking and compensate the low scores in C5, C9, C11, C13 and C15 criteria. LSP1 (second rank) has good scores close to LSP3 which increases the competition level. To protect his competitive position, LSP3 needs to improve quality of the low score services and support good ones.

In addition to the LSP individual comparisons, Table 7-20 figures out the best logistics services that are used to compare, evaluate and select the best LSP. For example, under the C1, C10 and C14 services, nearly all LSPs have the same value-added score that make it difficult to select the best one of them. Meanwhile, there are clear value-added scores under the C5, C6, C7, C9, C11, C12, C13, C15, C16 and C17 services. For this case study, these ten services are more able to differentiate between LSP alternatives in terms of their total value-added.

7.4.3. Independent Factors:

FDEMATEL outputs classified the decision factors into two groups cause (Independent) and effect (Dependent) factors as is shown in Table 6-8. Therefore, in order to simplify the decision-making process without affecting the quality of this process, managers and DMs can use the cause (Independent) factors to take their decision. Table 7-21 summarises the Independent factors with their normalised weights.

Table 7- 21: Independent Logistics Services

Criteria	Independent Services	Normalised weight
C2	Flow-Out Activities	0.1692
C4	Outbound	0.1743
C7	Labelling	0.1651
C9	Order mgmt. & Fulfilment	0.0903
C10	Help Desk	0.0813
C14	e-Logistics training &	0.1584
C15	Risk assessment	0.1614

The normalised weight of Independent factors is obtained using Equation (5-1), Where, NW_i is the normalised weight of Independent factor (i). W_i is the global weight of independent factor (i). $\sum_1^n W_i^p$ is the sum of global weights of Independent factors under the cluster P. W_p is the global weight of the cluster P. Therefore, if there is one cause (Independent) factor in a specific cluster, then the NW_i of this Independent factor equals W_p. Table 7-22 compares the final CC_i values and the LSP alternatives rankings under the both cases. Figure 7-11 compares between the CC_i values using all factors and independent factors.

Table 7- 22: CCi Values using Independent Services and all Services

LSP	Independent Services		All services	
	CC	**Rank**	***CC***	**Rank**
1	0.120	3	0.054	2
2	0.116	4	0.052	3
3	**0.130**	**1**	**0.055**	**1**
4	0.102	5	0.038	5
5	0.121	2	0.052	4

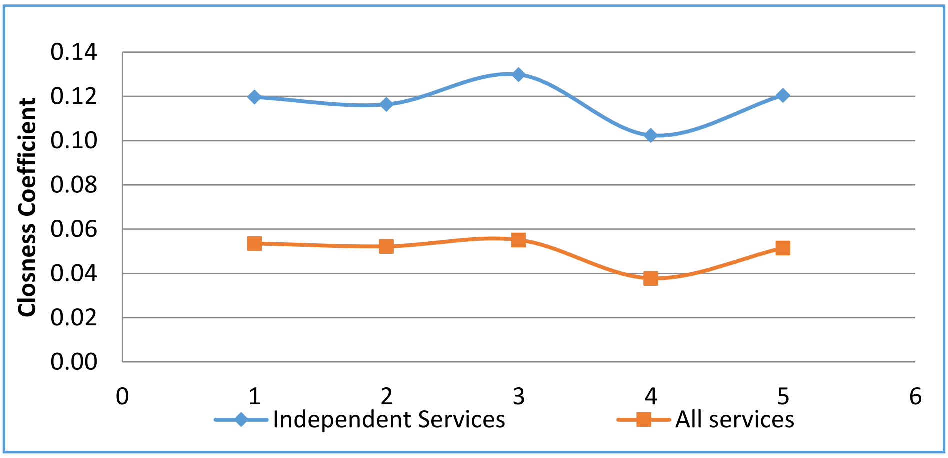

Figure 7- 11: LSP's CCi Values using Independent Services and all Services

LSP 3 and 4 have the same ranking in both cases (the first and the fifth respectively). Meanwhile LSP 1, 2 and 5 have various rankings in both cases. Therefore, managers and DMs can use the Independent logistics services to identify the best and/or worst LSP and use all the logistics service factors to find the overall rankings of all alternatives. Figure 7-12 summarises independent logistics services with their sub-dimensions.

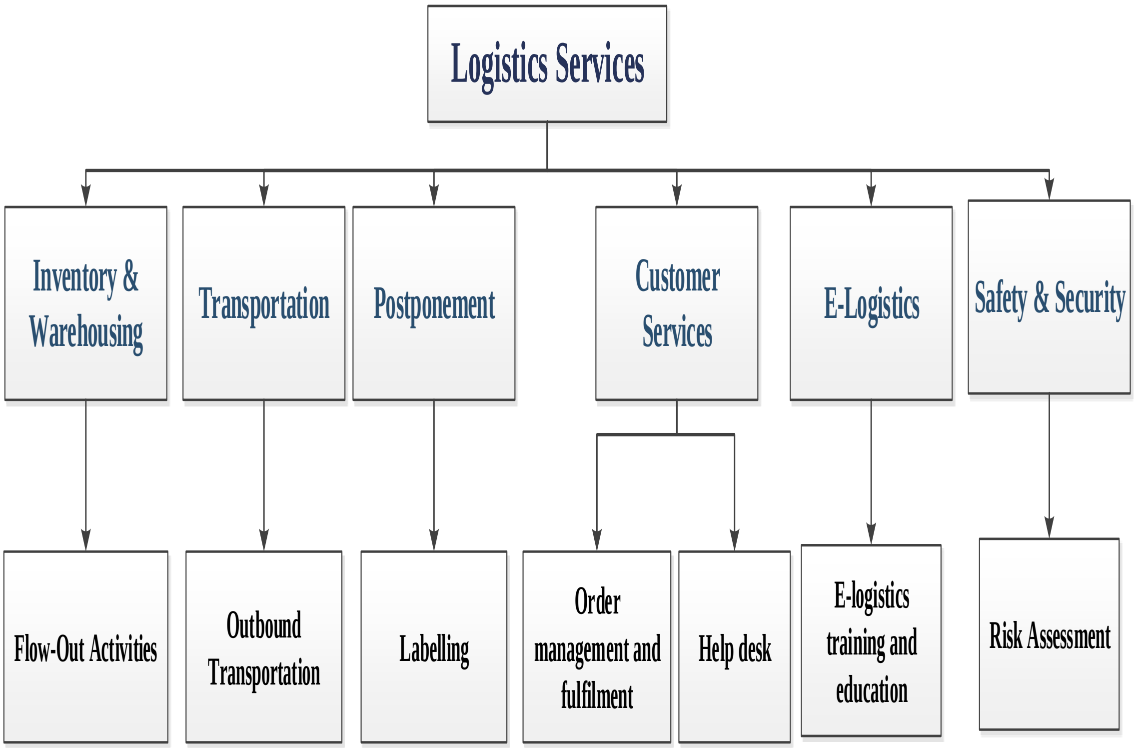

Figure 7- 12: Independent Logistics Services

7.4.4. Sensitivity Analysis

Sensitivity analysis helps DMs to be more confident about their choices under high uncertainty decision-making environments. It is used to detect the final decision certainty and analyse the analytical alternatives rankings. Modifying criteria weights affects the final LSP *CC* values. To conduct the effect of changing criteria weight on the LSPs evaluation and selection decision, twenty-one experiments of exchanging each criterion weight with another have been made (Senthil et al. 2014). The purpose is to find the LSP CC_i values for each experiment and in turn the LSP rankings. Table 7-23 summarises the sensitivity analysis results. It is clear that LSP3 has the highest *CCi* values in all experiments. LSP 5, 1 and 2 have almost the same rankings in all experiments, the second the third and the fourth rankings respectively. Meanwhile, LSP 4 has the last ranking throughout the experiments. Based on these results we see that, the used methodology is robust and the decision-making process is rarely sensitive to the criteria weights changes.

Table 7- 23: Sensitivity Analysis Results

#	Criteria change	Rankings
Initial	**No change**	**LSP3>LSP5>LSP1>LSP2>LSP4**
1	C2-4	LSP3>LSP5>LSP1>LSP2>LSP4
2	C2-7	LSP3>LSP5>LSP1>LSP2>LSP4
3	C2-9	LSP3>LSP5>LSP2>LSP1>LSP4
4	C2-10	LSP3>LSP5>LSP1>LSP2>LSP4
5	C2-14	LSP3>LSP5>LSP1>LSP2>LSP4
6	C2-15	LSP3>LSP5>LSP1>LSP2>LSP4
7	C4-7	LSP3>LSP5>LSP1>LSP2>LSP4
8	C4-9	LSP3>LSP5>LSP1>LSP2>LSP4
9	C4-10	LSP3>LSP5>LSP1>LSP2>LSP4
10	C4-14	LSP3>LSP1>LSP5>LSP2>LSP4
11	C4-15	LSP3>LSP5>LSP1>LSP2>LSP4
12	C7-9	LSP3>LSP5>LSP1>LSP2>LSP4
13	C7-10	LSP3>LSP1>LSP5>LSP2>LSP4
14	C7-14	LSP3>LSP5>LSP1>LSP2>LSP4
15	C7-15	LSP3>LSP5>LSP1>LSP2>LSP4
16	C9-10	LSP3>LSP5>LSP1>LSP2>LSP4
17	C9-14	LSP3>LSP5>LSP1>LSP2>LSP4
18	C9-15	LSP3>LSP5>LSP1>LSP2>LSP4
19	C10-14	LSP3>LSP5>LSP1>LSP2>LSP4
20	C10-15	LSP3>LSP1>LSP5>LSP2>LSP4
21	C14-15	LSP3>LSP5>LSP1>LSP2>LSP4

For example, C2-4 means exchange the weight of criteria 2 with criteria 4.

7.5. Conclusions

A new model to evaluate and select the appropriate LSP based on the LSP value-added services was introduced. It is the first time that the integrated FDEMATEL and FTOPSIS techniques have been used to evaluate the value-added of the logistics services, and therefore, to evaluate and select the most appropriate LSP based on their value-added scores. Six main logistics service dimensions with a number of sub-services were used. The FDEMATEL technique is used to analyse the logistics services impact-relationship. Impact-relationship maps were used to clarify the strength and direction of each causal relationship. These causal relationships help to understand 'Cause' and 'Effect' logistics services and how different logistics service mixes can provide different value-added. Study findings show that 'Inventory & warehousing', 'Transportation' and 'Safety & security' services are cause factors affecting the value-added of the effect factors services: 'Postponement', 'Customer service' and 'e-logistics'. Total direct and indirect effect, relative importance, global and local weight of each logistics service are summarised in Table 7-8. Meanwhile, the FTOPSIS technique is used to evaluate LSP alternatives against weighted logistics services. First, all factors were used to evaluate and select the best LSP alternative, then, independent services alone were used to conduct the evaluation process. Based on the outcomes of both cases, DMs can use independent factors alone to evaluate and select the best LSP, which simplified the logistics outsourcing process. Additionally, the defuzzified scores of LSP alternatives provide more detail regarding LSPs' strengths, weaknesses and improvement opportunities. Finally, to detect the final decision certainty and to analyse the methodology robustness, sensitivity analysis was conducted.

7.6. Chapter Contributions

This chapter provides an integrated approach for evaluating logistics services and their value-added. Moreover, the new proposed model helps to evaluate and select the best LSP with the highest logistics value-added. Chapter contributions can be summarised by:

- Identifying a new logistics service classification with more focus on e-services and risk issues
- Developing the first logistics service value-added model
- Developing a new hybrid FDEMTEL-FTOPSIS approach for evaluating and selecting LSPs
- Investigating the logistics services impact-relationships and their effects
- Identifying dependent and independent logistics services (independent success factors ISFs)
- Demonstrating the new approach using LSP data
- Testing the model robustness using sensitivity analysis
- Using the new approach outputs to provides insights allowing LSPs to bundle their service in a way that provide more value for LSUs

Chapter 8: Strategic logistics outsourcing - An advanced hybrid model

Summary

Based on stage two findings and outputs, this chapter proposed a new hybrid model to perform effective and efficient strategic logistics outsourcing. The ISFs identified in stage two in addition to the FQFD technique are used to link the LSU strategic objectives with their logistics requirements and in turn with the LSPs' ISFs to evaluate and select an LSP that fits with firm's strategic objectives and logistics requirements.

8.1. Introduction

Logistics outsourcing is an effective approach for achieving competitive advantage. This approach is important for all firms that compete to achieve competitive advantages through improving customers' services and reducing logistics costs. The strategic benefits of logistics outsourcing may include focus on core competencies, quality of service, recruiting the best, better technology, wider skills pool, agility and employee benefits (Benn and Pearcy, 2002; Alkhatib et al. 2015). However, evaluating and selecting LSPs without considering the firm's strategic objectives cannot lead to these expected benefits. Therefore, outsourcing logistics activities to an effective and efficient LSP to obtain and sustain these competitive advantages is a strategic decision.

The strategic logistics outsourcing process is different from the classical logistics outsourcing one. While the classical process is cost, short-term and limited-perspective oriented, strategic logistics outsourcing is a multi-perspective, multi-stakeholder and long-term oriented process (Chai and Ngai, 2014**;** Ho et al., 2015). Firms use various approaches to evaluate and select their LSP partners. These approaches use a large number of factors in fragmented ways to serve this purpose. However, in most cases using these factors alone is insufficient for performing a comprehensive evaluation. Moreover, many outsourcing studies have failed to address the inherent uncertainty in data and the interdependencies between the evaluation and selection factors. Additionally, LSPs provide various logistics services all through the supply chain. Each member in the supply chain may need to outsource different logistics services with different requirements and under different conditions. Generally speaking, a supply chain consists of three main streams: upstream, midstream and downstream (Silvestre, 2015). Each stream has its own features and characteristics and therefore, LSUs at each stream perform their logistics outsourcing process differently. LSUs need to link their strategic objectives and the LSPs evaluation and selection process to ensure that the selected LSP will strategically fit with their strategic objectives. Therefore, a strategic logistics outsourcing approach must deal with different supply chain members and their preferences. To contribute towards solving these problems, this study integrates the FDEMATEL and the FQFD techniques in one advanced strategic logistics outsourcing approach. The FDEMATEL integrated approach is used to construct interdependency relationships between evaluation factors, develop their IRMs and to identify the ISFs (Chapters 5, 6, and 7). Meanwhile, the FQFD integrated approach is used to link the firm's strategic objectives with their logistics requirements and in turn with the ISFs. This integration helps firms to be more confident about the LSP appropriateness to their strategic objectives.

This integration enables firms to use evaluation and selection criteria that really fit with their strategic objectives. QFD is a product planning and development technique that enables product developers to specify customer's wants and needs and to evaluate each proposed product systematically in terms of its impact on meeting those needs (Hauser and Clausing, 1988). This technique aims to display the relationship between customer voice (needs) and quality characteristics. The same logic is used to ensure that, the firms strategic objectives (needs) are considered in the LSPs evaluation and selection process. Meanwhile, the fuzzy logic theory helps decision makers to address different quantitative and qualitative data and their uncertainty problems. Moreover, it helps them to make pairwise comparisons and to express their preferences using linguistic variables.

8.1.1. Quality Function Deployment (QFD)

QFD is a Quality Management technique, offering guidelines for converting customer's needs into product specifications. Therefore, it helps to provide an efficient and effective successful product that satisfies customers' needs at the highest levels. QFD logic involves developing multiple matrices or houses of quality (HOQ) until the final "house" represents the final applicable design of the product. Each HOQ consists of six basic components that can be expanded to other elements according to the DMs' needs. Figure 8-1 summarises these six elements. Meanwhile other additional components such as competitive evaluation/analysis and specification target values are relevant to the product development process and therefore they didn't used in current approach. Only elements A, B, C, D and F have been used to link the strategic objective, logistics requirements and ISFs in one general approach.

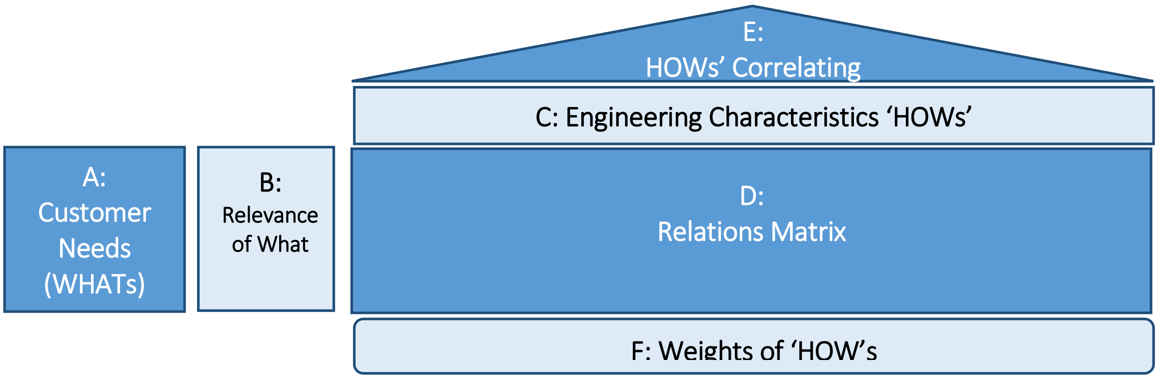

Figure 8- 1: HOQ Components

Element "A" is the customers' needs "WHATs"; it represents the desired attributes that the customer needs to see in the final product, mainly they are conflicting needs. These conflicting needs have different weights (importance) from various customers' points of view. It is difficult to satisfy all of them at the same time due to manufacturing constraints. Therefore, the relative importance of these needs is important to reflect their relationships with other components. Element "B" represents the priority of needs from the customer point of view. There are different techniques that can be used to aggregate these priorities/weights. Element "C" is the HOWs, the specifications that should be used to satisfy the WHATs"; these HOWs are called measurable requirements. Element "D" is the relation matrix, this element is used to know which "HOW" affects which "WHAT" and to what degree. Therefore, the relationship matrix can be established. This matrix helps to find the most important "HOWs" that affect most of the "WHATs". Element "E" is the correlation matrix that is used to trade-off between the HOWs to see the extent to which changing one of these manufacturing requirements can affect the others. Finally, element "F" provides the weights of "HOWs"; the main output of HOQ1 that is used as input in the next HOQ, where the survivor "HOWs" move to be "WHATs" and its Weights is the "Relevance". The same logic is used to build other HOQs. Normally, the QFD approach involves 4 HOQs: Product planning HOQ; product design HOQ; process planning HOQ; and process control HOQ (Bouchereau and Rowlands, 2000). QFD approach benefits include: customer-oriented, strengthens the relationship between customers and firms, brings together multi-function teams with a large amount of verbal data, reduces development and start-up time of new products, organises data in a logical way and can be used for more than product design. However, QFD has some drawbacks to consider such as ambiguity in the customers' needs, dealing with a large amount of subjective data and it can become very large and complex. These drawbacks motivate researchers to integrate the QFD approach with Fuzzy logic.

8.1.2. QFD and Fuzzy Logic

Using a Fuzzy approach to constructing QFD increases its attractiveness and broadens its applicability in different areas (Chen et al., 2013). Integrating FQFD helps the DMs to express their preferences easily and enables them to address the data uncertainty problems and complex decision-making processes. Fuzzy logic plays a significant role in the QFD models effectiveness, increasing the quality of the model by translating experts' opinions into fuzzy numbers and using them to evaluate "WHATs" "HOWs" and their interrelations. (Bevilacqua et al., 2012**;** Chen et al., 2013; and Wang et al., 2012). This study attempts to integrate the fuzzy logic with the QFD techniques to link the LSUs strategic objectives with their logistics requirements and finally with the ISFs in one hybrid model. This new model helps the LSUs to reflect their strategic objectives and logistics requirement correctly and therefore, to evaluate and select the best LSP. The new hybrid model enables the LSUs to perform an effective strategic outsourcing process and helps them to be more confident about their logistics decision under uncertain environments.

8.2. QFD and Outsourcing Literature review

8.2.1. QFD

Different evaluation and selection problems in different areas have been studied. In terms of logistics outsourcing, findings of a focused literature review of the period 2008-2013 presented in Chapter 2 show that, QFD was one of the techniques that was integrated with AHP to solve selection problems. A number of studies used the QFD approach to solve evaluation and selection problems in different areas. For example: Kazancoglu and Aksoy (2011) use FQFD to identify key factors of e-learning. Bevilacqua et al. (2006) and Dursun and Karsak (2012) apply FQFD for supplier selection problems. Kumar and Kumanan (2011) integrate AHP and FQFD for location selection problem. Na et al. (2012) develop a decision-making model base on QFD to improve power utility services. While, Ho et al. (2011) and Ho et al. (2012) integrate AHP, FQFD for strategic outsourcing decision. Although, some of these studies considered the firms' strategic 'needs' and linked them to the selection criteria, the way that criteria have been selected and the 'key' criteria have been identified is still questionable. Additionally, using AHP in the logistics outsourcing process underestimates the importance of factor-interdependency in such a process.

8.2.2. Strategic Outsourcing

Over the course of the author's research study, the International Journal of Production Economics published a special issue regarding strategic supplier selection using multi-stakeholder and multi-perspective approaches (Ho et al., 2015). Although this issue is focused on supplier selection, it provides a good platform for multi-stakeholder, multi-perspective strategic outsourcing. The issue itself and the large number of submissions reflect the importance of strategic outsourcing as a contemporary issue and increase the significance of this research. The aforementioned special issue and this research shared common interest, particularly the impact of strategies, strategic objectives and stakeholders' perspectives in relation to the criteria selection and alternatives evaluation processes. This research congregates with this special issue in the importance of taking a comprehensive stakeholders' perspective to select strategic partners and the importance of using a firm's strategy and strategic objectives to evaluate and select strategic partners. Moreover, they congregate upon the importance of using various MCDM integrated models to handle the data uncertainty problems in such a complex process. Some of the papers presented in this special issue based on a number of frameworks that were used by previous studies, e.g. Ji et al (2015) use the De Boer (2001) model, Sarkis and Dhavale (2015) base on the triple-bottom-line approach and Bhattacharya et al. (2015) base on the transaction cost economics theory. Additionally, some of these papers did not specify which stakeholders were involved in the outsourcing process (Chithambaranathan et al., 2015; Sarkis and Dhavale, 2015). Moreover, the AHP technique is strongly presented in this issue which affects some models' capability to analyse the interdependency relationships of the strategies, objectives, requirements and evaluations factors (Dey et al., 2015 and Scott et al., 2015) which affects the significance and the applicability of these models.

8.2.3. QFD/FQFD Applications

In addition to product design (Kuo et al., 2009a**;** Kuo et al. 2009b; and Lin et al. 2011), QFD/FQFD can be used for various purposes such as supply chain management (Zhang and Chu 2007**;** Wang et al., 2007**;** Rau and Fang 2009**;** Bottani and Rizzi 2006**;** Amin and Razmi 2009; and Sohn and Choi 2001) strategy development (Jia and Bai 2011) and software selection (Sen and Baracli 2010). Most of the FQFD studies used a group of decision makers (experts) to reduce the group work bias. A number of studies integrated fuzzy logic with QFD to evaluate different selection processes. Chen et al. (2013) employ fuzzy set theory to develop fuzzy approaches for constructing the HOQ. Ertay et al. (2011) and (2005) employed the ANP to prioritise "HOWs" to consider the degree of the interdependence between the “WHATs” and the “HOWs” and the interdependence within themselves. Karsak (2004) applies Delphi technique first to take the experts’ opinion and determine the fuzzy importance levels of “WHATs” before using the FQFD. Zhang and Chu (2009) provide two models, one to aggregate the fuzzy pairwise comparisons and another one to aggregate linguistic preference relations between “WHATs” and “HOWs” and between “HOWs” themselves. Ho et al. (2012); Tidwell and Satterfield (2012); and Rajesh and Malliga (2013) employ the QFD approach to evaluate and select external partners. Tidwell and Satterfield (2012) employ QFD alone to evaluate and select the best supplier. Rajesh and Malliga (2013) integrate QFD and AHP to serve the same purpose. Meanwhile, Ho et al. (2012) integrate FQFD and AHP to evaluate and select the optimal 3PL based on the stakeholders’ requirements. In addition to Fuzzy logic, Bouchereau and Rowlands (2000) outlined how to combine artificial neural network (ANN) and Taguchi methods with QFD to resolve some of its drawbacks. In terms of selection criteria, cost/price, quality and delivery are the most used criteria in evaluation and selection studies. Additionally, other criteria that were formed due to the clustering of a number of old criteria into new dimensions are also used, such as reliability, flexibility, resources, management and sustainability. A large number of evaluation and selection criteria were used in a fragmented way. Therefore, they failed to identify the key criteria and they failed to link them with the firms’ strategic objectives. Moreover, they failed to identify the impact-relationships between evaluation criteria.

This study sets out to solve these problems by integrating a number of MCDM methods through a series of stages. The first stage aims to analyse the impact-relationship of the LSPs evaluation and selection framework and therefore, identify the key independent factors using the fuzzy DEMATEL technique. The second stage aims to identify and prioritise the strategic objectives of a case-study firm and their logistics requirements to achieve these strategic objectives. The third stage aims to use the FQFD approach to link the strategic objectives, logistics requirements, selection criteria and LSP alternatives. These links help firms to be sure that their strategic objectives are considered in the LSPs selection process.

8.3. The hybrid approach

The new hybrid approach integrates the FDEMATEL and FQFD in an advanced way to evaluate and select appropriate LSPs. The new hybrid approach considers the firms' strategic objectives and needs and connects strategic objectives with logistics requirements with evaluation and selection criteria. This connection enables firms to perform their strategic logistics outsourcing processes effectively and efficiently. The proposed hybrid approach consists of three main stages:

- FDEMATEL stage to analyse the LSPs framework impact-relationship, cause and effect factors to identify ISFs to use
- Data collection stage, a number of fuzzy questionnaires to identify the firm's strategic objectives, logistics requirements and their weights
- FQFD stage, a transferring tool to evaluate and select the most appropriate LSP through linking the strategic objectives, logistics requirements, evaluation factors and LSP alternatives. Figure 8-2 summarises the new hybrid approach procedures.

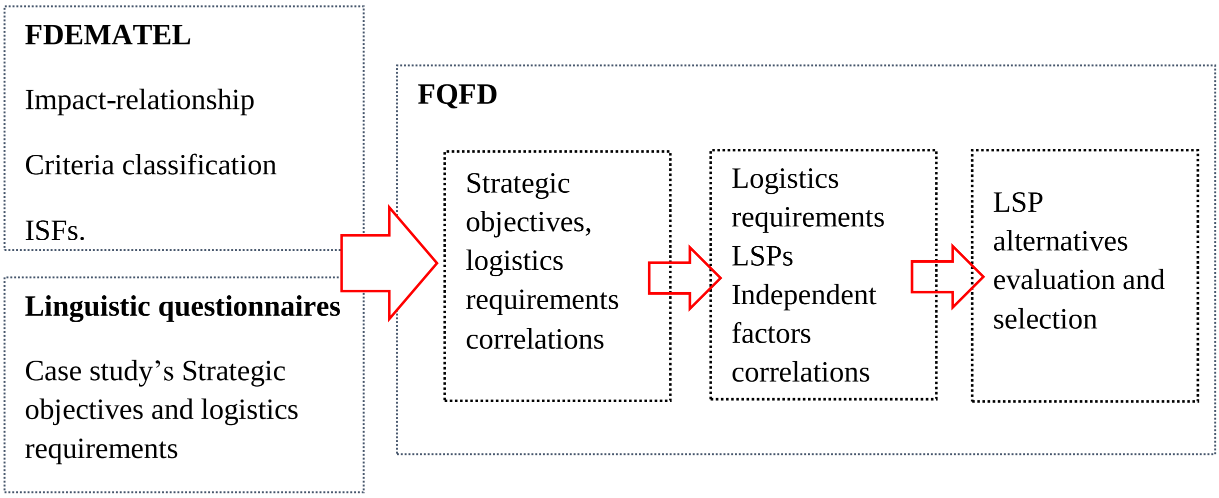

Figure 8- 2: Strategic Logistics Outsourcing Integrated Model

8.3.1. First Stage: FDEMATEL

The FDEMATEL technique was used to analyse the impact-relationship of the LSPs framework elements (Chapters 5, 6 and 7). Impact-relationship maps were used to clarify the strength and direction of each relationship in the complex logistics performance, resources & capabilities and services framework. Seven logistics experts were asked to evaluate the Logistics Performance-Logistics Resources and Capabilities-Logistics Services interrelationships. Table 8-1 summarises the FDEMTEL outputs of these dimensions. Figure 8-3 shows their IRM.

Table 8- 1: Main Dimensions FDEMATEL Outputs

Dimension	R^{fuz}	C^{fuz}	R^{def}	C^{def}	$R+C$	R-C	**Weight**
Performance	(1.146, 3.702, 22.284)	(1.054, 3.520, 21.429)	8.270	7.922	16.192	0.348	**0.338**
Resources	(1.023, 3.458, 21.130)	(1.085, 3.582, 21.713)	7.801	8.038	15.839	-0.237	**0.330**
Services	(1.025, 3.461, 21.444)	(1.054, 3.520, 21.716)	7.894	8.005	15.899	-0.111	**0.332**

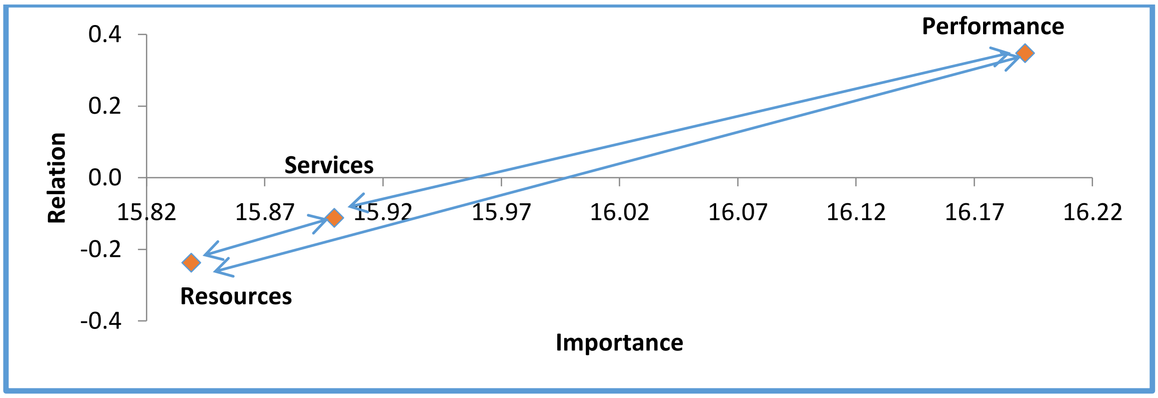

Figure 8- 3: Logistics Performance, Resources and Services IRM

The IRM shows that, there are mutual impact-relationships between logistics performance, resources and services. Each dimension has a direct effect on and is affected by other dimensions simultaneously. Equations 3-1 and 3-2 are used to find the logistics performance, resources and services weights. Therefore, the DEMATEL outputs in Tables (5-7, 6-7 and 7-8) can be normalised according to the performance, resources and services global weights. Table 8-2 summarises the final aggregate weights.

Table 8- 2: FDEMATEL Outputs

Factor	R_i+C_i	R_i-C_i	**Type**	**Relative Importance**	**Local Weight**	**Global Weight**
Logistics Resources and Capabilities						**0.3305**
Tangible R & C	**6.0267**	**0.6041**	**Cause**	**6.0569**	**0.5000**	**0.1652**
Physical R&C	**5.8410**	**-0.7051**	**Effect**	**5.8834**	**0.5000**	**0.0826**
Warehousing	8.8950	0.1034	Cause	8.8956	0.2648	0.0219
Transportation	8.2194	-0.6006	Effect	8.2413	0.2454	0.0203
Production and packaging	8.1487	0.7224	Cause	8.1807	0.2436	0.0201
Improvement and maintenance	8.2683	-0.2250	Effect	8.2713	0.2463	0.0203
IT-based R&C	**5.8410**	**0.7051**	**Cause**	**5.8834**	**0.5000**	**0.0826**
Physical IT	9.8080	0.5688	Cause	9.8244	0.3302	0.0273
Communication Tracking & Tracing	9.7592	-0.1484	Effect	9.7603	0.3281	0.0090
IS and in turn et based systems	10.1553	-0.4203	Effect	10.1640	0.3417	0.0031

Continue ➔

Factor	R_i+C_i	R_i-C_i	Type	Relative Importance	Local Weight	Global Weight
Intangible R & C	**6.0267**	**-0.6041**	**Effect**	**6.0569**	**0.5000**	**0.1652**
Human R & C	**6.3065**	**0.3277**	**Cause**	**6.3150**	**0.3570**	**0.0590**
Education	5.4385	0.3753	Cause	5.4514	0.3616	0.0213
Knowledge	4.7164	-0.2780	Effect	4.7246	0.3134	0.0185
Skills	4.8993	-0.0972	Effect	4.9003	0.3250	0.0192
Relational R & C	**6.0690**	**-0.3229**	**Effect**	**6.0776**	**0.3436**	**0.0568**
Collaboration	15.1174	-1.0942	Effect	15.1570	0.3446	0.0196
Long-term relationships	14.5524	-1.0394	Effect	14.5894	0.3317	0.0188
Information sharing	14.0788	2.1328	Cause	14.2395	0.3237	0.0184
Structural R & C	**5.2977**	**-0.0048**	**Effect**	**5.2977**	**0.2995**	**0.0495**
Databases and Software	3.2728	0.8459	Cause	3.3803	0.3446	0.0171
Image & Reputation	3.1229	-0.4659	Effect	3.1575	0.3219	0.0159
Cultural & management	3.2486	-0.3802	Effect	3.2708	0.3335	0.0165
Factor	**R_i+C_i**	**R_i-C_i**	**Type**	**Relative Importance**	**Local Weight**	**Global Weight**
Logistics Performance						**0.3379**
Financial Pers.	**25.6100**	**-0.5700**	**Effect**	**25.6152**	**0.2443**	**0.0825**
Profitability	9.6430	-0.2970	Effect	9.6480	0.2583	0.0213
Return & Cash	9.4510	0.2650	Cause	9.4546	0.2531	0.0209
Costs	9.1860	0.9170	Cause	9.2313	0.2471	0.0204
Flexibility	8.9810	-0.8840	Effect	9.0249	0.2416	0.0199
Customers Pers.	**26.3800**	**0.4870**	**Cause**	**26.3832**	**0.2517**	**0.0850**
Quality & Reliability	13.4188	0.6149	Cause	13.4329	0.3388	0.0288
Service Flexibility	12.9207	0.2973	Cause	12.9242	0.3259	0.0277
Customers Sustainability	13.2640	-0.9126	Effect	13.2954	0.3353	0.0285
Processes Pers.	**26.5300**	**-0.1700**	**Effect**	**26.5308**	**0.2531**	**0.0855**
Quality	20.7137	0.3779	Cause	20.7171	0.2567	0.0219
Productivity	20.2025	0.2259	Cause	20.2038	0.2503	0.0214
Timeliness	19.7269	-0.7130	Effect	19.7398	0.2446	0.0209
Processes Sustainability	20.0496	0.1094	Cause	20.0499	0.2484	0.0212
Learning & Growth Pers.	**26.3100**	**0.2500**	**Cause**	**26.3105**	**0.2510**	**0.0848**
Human Talent	18.1682	0.7886	Cause	18.1853	0.3340	0.0283
Innovation & Development	18.3145	-0.6424	Effect	18.3257	0.3366	0.0285
Resources Sustainability	17.9340	-0.1463	Effect	17.9346	0.3294	0.0279

Continue ➔

Factor	R_i+C_i	R_i-C_i	Type	Relative Importance	Local Weight	Global Weight
Logistics Services						0.3317
Inventory & Warehousing	**7.8303**	**0.0655**	**Cause**	**7.8306**	**0.1692**	**0.0561**
Flow-In Activities	18.5865	-0.3497	Effect	18.5898	0.5000	0.0281
Flow-Out Activities	18.5865	0.3497	Cause	18.5898	0.5000	0.0281
Transportation	**8.0658**	**0.2320**	**Cause**	**8.0692**	**0.1743**	**0.0578**
Inbound	16.6581	-0.3536	Effect	16.6618	0.5000	0.0289
Outbound	16.6581	0.3536	Cause	16.6618	0.5000	0.0289
Postponement	**7.6414**	**-0.1982**	**Effect**	**7.6440**	**0.1651**	**0.0548**
Assembly	7.5632	-0.2025	Effect	7.5659	0.3192	0.0175
Packaging	7.8082	-0.3132	Effect	7.8145	0.3297	0.0181
Labelling	8.3086	0.5162	Cause	8.3246	0.3512	0.0192
Customer Services	**7.9114**	**-0.6823**	**Effect**	**7.9408**	**0.1716**	**0.0569**
Freight Payment & Auditing	9.4816	-0.2432	Effect	9.4848	0.2544	0.0145
Order mgmt. & Fulfilment	9.9133	0.0407	Cause	9.9134	0.2659	0.0151
Help Desk	8.9104	0.4831	Cause	8.9235	0.2393	0.0136
Carrier Selection	8.9603	-0.2809	Effect	8.9647	0.2404	0.0137
e-Logistics	**7.3319**	**-0.0311**	**Effect**	**7.3320**	**0.1584**	**0.0525**
Global Visibility	61.4122	-0.0036	Effect	61.4122	0.3358	0.0176
Real-time info. Sharing & DM	60.9020	-0.6639	Effect	60.9056	0.3330	0.0175
e-Logistics training & education	60.5768	0.6675	Cause	60.5805	0.3312	0.0174
Safety & Security	**7.4457**	**0.6144**	**Cause**	**7.4710**	**0.1614**	**0.0535**
Risk assessment	30.3687	1.2611	Cause	30.3948	0.3269	0.0175
Shipment & equipment safety	31.4633	-0.7256	Effect	31.4716	0.3384	0.0181
People safety & security	31.1191	-0.5355	Effect	31.1237	0.3347	0.0179

The FDEMATEL outputs, classify the LSPs framework elements into two groups: Cause and Effect factors. Based on the case studies conducted in chapters 5, 6 and 7, DMs can use the cause factors (ISFs) in the LSPs evaluation and selection process. There are forty-seven factors in the LSPs framework. Out of the 47 factors, twenty-one are 'Cause Factors' (ISFs) to be used in the FQFD stage.

8.3.2. Second Stage: Strategic Objectives and Logistics Requirements

After identifying the firms DMs and stakeholders who have a say in the LSPs evaluation and selection and/or are affected by the LSP's performance, a linguistic-based questionnaire is used to identify the firm's strategic objectives, their importance ratings and the logistics requirements that LSPs must provide to help LSUs to achieve these strategic objectives. First part includes a list of Peter Drucker's well-known eight strategic objective areas (Drucker 1974; 2011**,** Swaim 2010): market standing, innovation, human resources, financial resources, physical resources, productivity, social responsibility and profit requirements. In addition to these areas, DMs and stakeholders can add their own strategic objectives. The second part askes DMs and stakeholders to evaluate the relative importance of these strategic objectives using a five-point linguistic scale. The average of the stakeholders' evaluations determines the importance rating of the strategic objectives. The linguistic variables enable DMs and stakeholders to express their preferences and evaluations easily. For each linguistic variable there is a TFN. The TFN is used to transfer the DMs and stakeholders evaluations into quantitative values to find the final importance ranking of the strategic objectives. Table 8-3 summarises these linguistic variables and their TFNs.

Table 8- 3: Strategic Objectives Linguistic Variables and their TFNs

Linguistic Variable	TFN
Most Important	(0.75, 1.0, 1.0)
High Importance	(0.5, 0.75, 1.0)
Moderate Importance	(0.25, 0.5, 0.75)
Low Importance	(0.0, 0.25, 0.5)
Least Importance	(0.0, 0.0, 0.25)

Let *n* be the number of DMs and stakeholders who have a say in the LSPs evaluation and selection processes and let *n1* be the number of strategic objectives to evaluate. Then for each strategic objective (*i*) there are *n* evaluations e_{ji}^{SO}, *j*= 1, 2, … *n*. Where e_{ji}^{SO} is a TFN. Then, the fuzzy importance rating $R1_i^{fuz}$ of the strategic objective *i* is a TFN, which is the fuzzy average of the e_{ji}^{SO} (Equation 8-1):

Strategic Objective Fuzzy Importance Rating

$$R1_i^{fuz} = (\sum_{j=1}^{n} e_{ij}^{SO}) / n \text{ ....(8-1)}$$

Each $R1_i^{fuz}$ value can be defuzzified using Equation (3-11) (Dalalah et al. 2011) to find the $R1_i$. Then, each $R1_i$ value can be normalised to find the strategic objective weight $W1_i$ as follow:

Strategic Objective Weight

$$W1_i = R1_i / \sum_{i=1}^{n1} R1_i \text{ ………………..(8-2)}$$

Then, weighted strategic objectives can be used to establish the HOQ_1, meanwhile, relationships between 'What' and 'How' factors at each HOQ can be evaluated using linguistic variables. These linguistic variables help the stakeholders to express their preferences and judgements effectively. Table 8-4 summarises the linguistic variables with their TFNs to be sued for this purpose.

Table 8- 4: Interrelationship Linguistic Variables and their FTNs

Linguistic Variables	FTN
No Relation	(0.0, 0.0, 0.25)
Low Relation	(0.0, 0.25, 0.5)
Moderate Relation	(0.25, 0.5, 0.75)
Strong Relation	(0.5, 0.75, 1.0)
Very strong Relation	(0.75, 1.0, 1.0)

The third part aims to identify logistics requirements that are crucial to achieve the strategic objectives. Several initial logistics requirements are suggested as a starting point to help DMs and stakeholders to identify their own logistics requirement list. Eight suggested requirements used by Ho et al. (2012): reduce total logistics costs, reduce cycle time, assure quality in distribution, provide customised logistics services, increase customer satisfaction, possess state of the art hardware and software, able to provide guidance on time and able to resolve problems effectively. Additionally, another five crucial requirements are added based on the logistics experts' feedbacks: acquiring logistics resources and capabilities; able to provide value-added logistics services; able to assess logistics risks; providing sustainable logistics services; and able to build and sustain long-term collaborations. After determining the firm's strategic objectives with their importance ratings and logistics requirements, the next stage aims to determine the best LSPs through linking the strategic objectives, logistics requirements and LSPs selection criteria using the FQFD approach.

8.3.3. Third Stage: FQFD approach

In this stage, the FQFD approach is used as a transferring tool to link the strategic objectives, logistics requirements, LSPs criteria and LSP alternatives. The strategic objectives "customers' needs" with their logistics requirements are used to establish the first house of quality (HOQ_1). The same logic used in Stage 2 is used to find relationship weights between each requirement and related strategic objective(s). HOQ_1 identifies logistics requirements and their corresponding importance rating weights. Figure 8-4 clarifies the sequence of the three HOQs within the new FQFD approach.

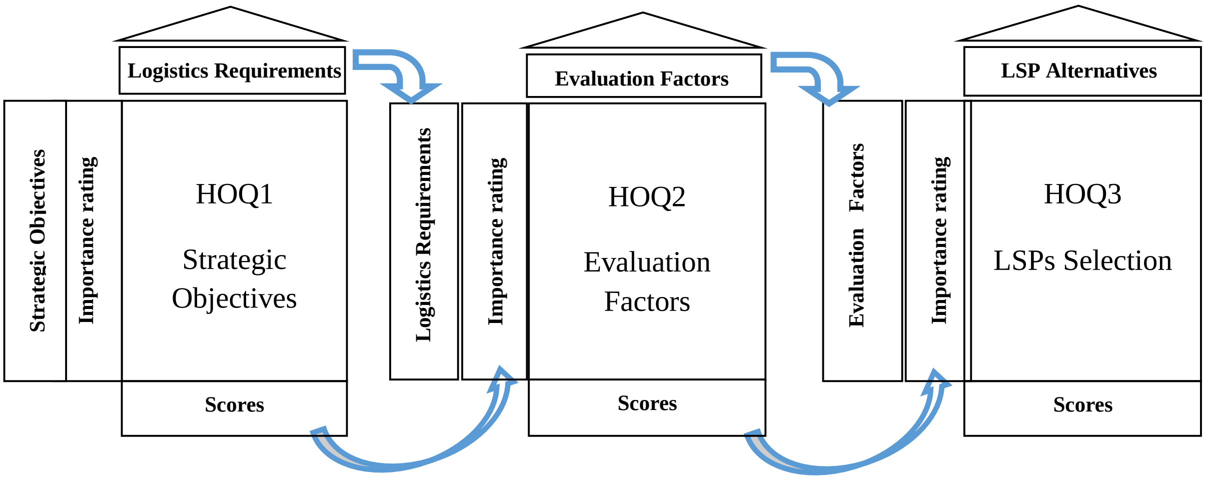

Figure 8- 4: The FQFD Approach

This new approach outstrips other approaches by providing the impact-relationship of the LSPs evaluation and selection criteria, selecting critical ISFs and linking the LSPs evaluation and selection process with the firm's strategic objectives and stakeholders' logistics requirements. It provides a more strategic logistics outsourcing decision support tool.

8.3.3.1. HOQ_1

In HOQ1, Let i denote the strategic objectives, let j denote the logistics requirements and let $n2$ be the number of logistics requirements to evaluate. The fuzzy importance rating of the logistic requirement j is $R2_j^{fuz}$, which is TFN that represents the weighted average of the DMs' and stakeholders' evaluations of the strategic objectives and logistics requirements relationships.

Let e_{ij}^{RQ} be a TFN representing the average DMs' evaluations of the i^{th} strategic objective and j^{th} logistics requirement relationship and $W1_i$ is a non-fuzzy number representing the i^{th} strategic objective weight. Therefore, $R2_j^{fuz}$ can be obtained by Equation 8-3:

Logistics Requirement Fuzzy Importance Rating

$$R2_j^{fuz} = \sum_{i=1}^{n1} (W1_i \times e_{ij}^{RQ}) \text{ ………………..(8-3)}$$

Then, Equation (3-11) can be used to defuzzify $R2_j^{fuz}$. Each $R2_j$ is a non-fuzzy number represents the j^{th} logistics requirement importance rating. Then, the $R2_j$ can be normalised using Equation (8-4) to find the j^{th} logistics requirement weight $W2_j$.

Logistics Requirement Weight

$$W2_j = R2_j / \sum_{j=1}^{n2} R2_j \text{ ………………..(8-4)}$$

The final output $W2_j$, is non-fuzzy number representing the final logistics requirement' weight to be used in HOQ2.

8.3.3.2. HOQ2

In HOQ_2, weighted logistics requirements and LSPs evaluation factors (ISFs) are used to find the LSPs evaluation factor weights. Here, let *i* denote the logistics requirements, *j* denotes the LSPs criteria and let *n3* be the number of LSPs criteria to evaluate. Therefore, the fuzzy importance rating of the j^{th} LSPs evaluation factor is $R3_j^{fuz}$, which is the weighted fuzzy average of the DMs' and stakeholders' evaluations of the Logistics requirements and the LSPs evaluation factors relationships.

Let e_{ij}^{Cr} be a TFN representing the average DMs' evaluations of the i^{th} logistics requirement and j^{th} LSPs evaluation criterion relationship and $W2_i$ is a non-fuzzy number representing the i^{th} logistics requirement weight. Therefore, $R3_j^{fuz}$ can be obtained by Equation 8-5:

ISF Fuzzy Importance Rating

$$R3_j^{fuz} = \sum_{i=1}^{n2} (W2_i \times e_{ij}^{Cr}) \text{ ………………..(8-5)}$$

Then, Equation (3-11) can be used to defuzzify $R3_j^{fuz}$ values. Each $R3_j$ is a non-fuzzy number representing the j^{th} LSPs evaluation criterion importance rating. Then, Equation (8-6) can be used to normalise each $R3_i$ to find the j^{th} LSPs evaluation criterion weight $W3_j$.

ISF Weight

$$W3_j = R3_j / \sum_{j=1}^{n3} R3_j \text{ ………………..(8-6)}$$

The final output $W3_j$ is a non-fuzzy number and represents the final j^{th} LSPs criterion weight to be used in the HOQ_3.

8.3.3.3. HOQ3

In HOQ_3, weighted LSPs evaluation criteria are used to evaluate the LSP alternatives. The LSP with the highest total score is the best. Here, let *i* denote the LSPs evaluation criteria and let *j* denote the LSP alternatives. Each j^{th} LSP alternative can be evaluated against the LSPs evaluation criteria. Table 8-5 shows the linguistic variables that DMs and stakeholders can use to evaluate the LSP alternatives.

Table 8- 5: Linguistic Variables to Evaluate LSP Alternatives

Linguistic Variables	FTN
Very Good	(0.75, 1.0, 1.0)
Good	(0.5, 0.75, 1.0)
Acceptable	(0.25, 0.5, 0.75)
Weak	(0.0, 0.25, 0.5)
Very Weak	(0.0, 0.0, 0.25)

Let e_{ij}^{LSP} be a TFN denoting the average of DMs' evaluations of the j^{th} LSP alternative against i^{th} LSPs evaluation criterion. Let $W3_i$ be the weight of the ith LSPs evaluation criterion and let S_j^{fuz} be a TFN denoting the total score of the j^{th} LSP. Then, S_j^{fuz} can be obtained using Equation (8-7).

LSP Fuzzy Total Score

$$S_j^{fuz} = \sum_{i=1}^{n3}(W3_i \times e_{ij}^{LSP}) \ldots\ldots\ldots\ldots\ldots\ldots..(8\text{-}7)$$

Finally, Equation (3-11) can be used again to defuzzify S_j^{fuz} values and therefore, the final LSP alternatives ranking can be found.

8.4. Implementation procedures

Figure 8-5 summarises the new strategic outsourcing integrated approach implementation procedures.

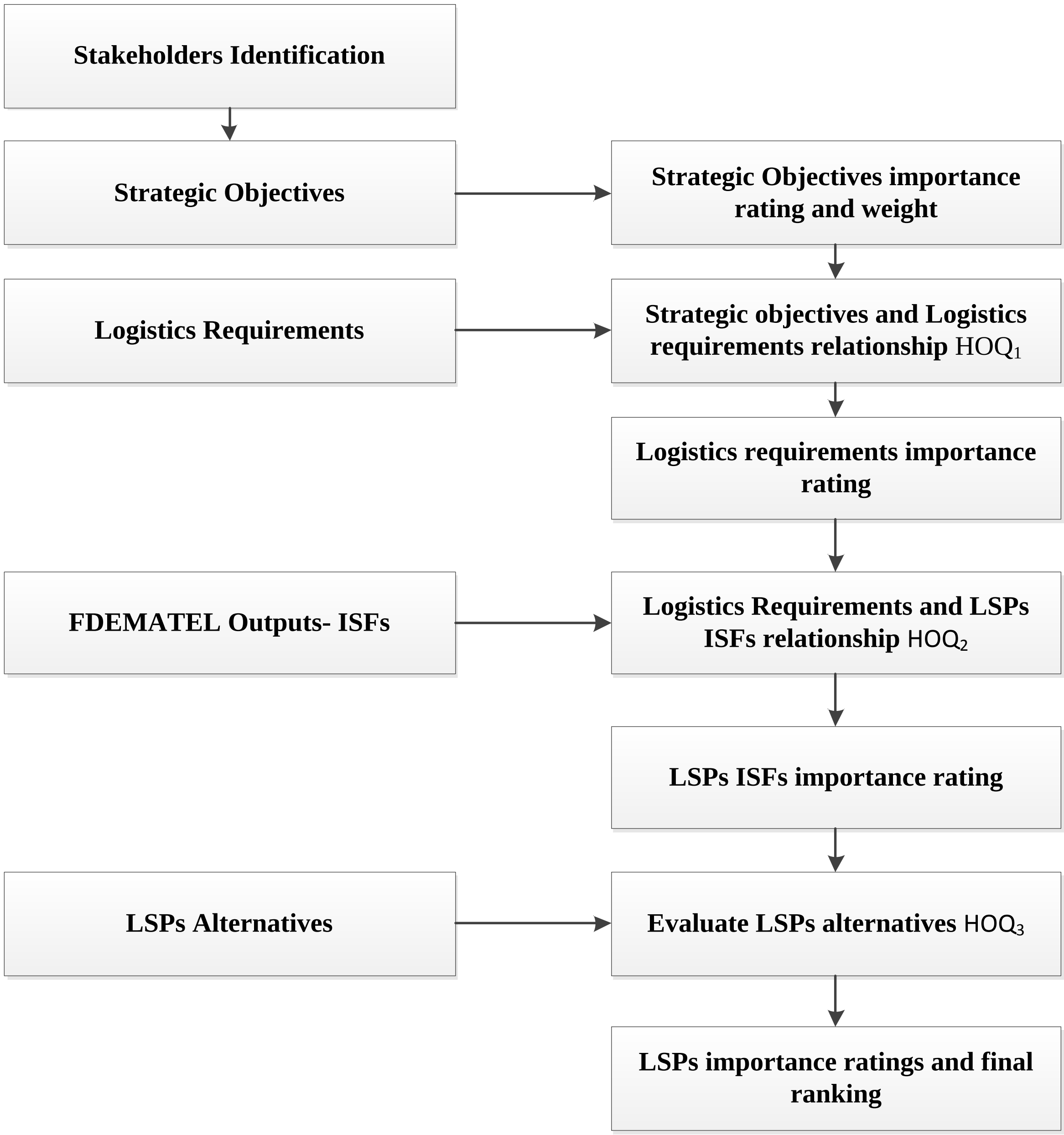

Figure 8- 5: FDEMATEL-FQFD Approach

Step 1: Stakeholder Identification

Managers and DMs from different departments that shall participate in the LSP evaluation and selection process and/or affected by the LSPs performance must be identified first. The stakeholders are those who evaluate the LSP alternatives in the strategic logistics outsourcing process and/or they are affected by the LSPs performance. Normally, financial, operational, marketing, purchasing, inventory/transportation and customer relation mangers are involved in such a process.

Step 2: Strategic Objectives

Stakeholders are asked to list their strategic objectives. According to Peter Drucker (Drucker 1974; 2011), strategic objectives fall into eight areas representing the base of the strategic objectives list. Stakeholders can add/change these areas to fit with their own strategic objectives.

Step 3: Strategic Objectives importance rating and weight

Stakeholders are asked to determine the strategic objectives' relative importance using linguistic variables (Table 8-3). Then Equation 8-1 and Equation 8-2 are used to find $\boldsymbol{W1_i}$.

Step 4: Logistics Requirements

The same stakeholders are asked to identify logistics requirements that are crucial to achieve the firm's strategic objectives. A list of 13 logistics requirements has been provided as a starting point to help stakeholders in their mission (Ho et al., 2012, Ho et al., 2011, Rajesh et al., 2011). Stakeholders have the right to select the appropriate requirements that fit with their strategic objectives. Moreover, they have the opportunity to add other logistics requirements.

Step 5: Strategic objectives and Logistics requirements relationship HOQ_1

Stakeholders are asked to evaluate the relationship between each strategic objective and logistics requirements using five linguistic variables (Table 8-4). The averages of the stakeholders' evaluations (e_{ij}^{RQ}) are used in the HOQ_1 as is shown in Figure 8-6.

Strategic Objective - Logistics Requirements

#	Strategic Objectives	Weight	Logistics Requirements: Reduce Total Logistics Costs	Reduce Cycle Time	Assure Quality in Distribution - Delivery	Acquire the Needed Logistics Resources and Capabilities	Possess State-of-the Art Hardware and Software	Provide Customised Logistics Services	Able to Provide Value-added Logistics Services	Increase Customer Satisfaction	Able to Provide Guidance on Time	Able to Resolve Problems Effectively	Able to Assess Logistics Risks	Able to Build and Sustain Long-Term Collaborations
1	Profitability													
2	Financial Resources													
3	Market Position													
4	Innovation and development													
5	Productivity													
6	Physical Resources													
7	Human Resources													
8	Social Responsibilities													
Importance Rating of Logistics Requirements														
Ranking of Logistics Requirements														

Figure 8- 6: HOQ1

Step 6: Logistics requirements importance ratings

Both e_{ij}^{RQ} (step 5), in addition to the $\boldsymbol{W1_i}$ (Step 3) are used to find the $\boldsymbol{R2_i^{fuz}}$ using Equation 8-3. Then, Equation 8-4 is used to find $\boldsymbol{W2_i}$.

Step 7: Logistics Requirements and LSPs ISFs relationships

Stakeholders are asked to evaluate the relationship between each logistics requirement and LSPs ISFs using the linguistic variables in Table 8-4. Each stakeholder is asked to evaluate the relationships between each logistics requirement and LSPs ISFs. The averages of the stakeholders' evaluations (e_{ij}^{Cr}) are used in the HOQ_2, as is shown in Figure 8-7.

Step 8: LSPs ISFs importance ratings

Both, e_{ij}^{Cr} (Step 7) and the $\boldsymbol{W2_i}$ (Step 6) are used to develop the HOQ_2. Then, Equation 8-5 and Equation 8- 6 is used to find the $\boldsymbol{R3_j^{fuz}}$ and $\boldsymbol{W3_i}$ respectively.

Step 9: Evaluate LSP alternatives

The LSPs' ISFs and their importance ratings $(\boldsymbol{W3_i})$ (Step 8) in addition to the LSP alternatives are used to develop the HOQ_3. Here, stakeholders used the linguistic variables (Table 8-5) to evaluate the LSP alternatives against the weighted LSPs ISFs.

Step 10: LSPs importance ratings and final ranking

Equation 8-7 is used to find the LSPs fuzzy total score based on the stakeholders' evaluations and the LSPs ISFs importance ratings. Finally, Equation 3-11 is used to find the final LSPs ranking scores. Figure 8-8 clarifies the HOQ_3 elements.

Logistics Requirements - LSPs Factors

			LSPs Factors																				
#	Logistics Requirements	Weight	Returns	Logistics Costs	Service Quality & Reliability	Service Flexibility	Logistics Processes Quality	Logistics Processes Productivity	Processes Sustainability	LSPs' Human Talent	Physical Warehousing Resources	Physical Production & Packaging Resources	Physical Information Technology Resources	Human Resource Education	Information Sharing	Databases and Software	Flow-Out Warehousing Activities	Outbound Transportation Activities	Labelling Services	Order management and Fulfilment	Help Desk Services	e-Logistics Services	Logistics Risks Assessment
1	Reduce Total Logistics Costs																						
2	Reduce Cycle Time																						
3	Assure Quality in Distribution - Delivery																						
4	Acquire the Needed Logistics Resources and Capabilities																						
5	Possess State-of-the Art Hardware and Software																						
6	Provide Customised Logistics Services																						
7	Able to Provide Value-added Logistics Services																						
8	Increase Customer Satisfaction																						
9	Able to Resolve Problems Effectively																						
10	Able to Assess Logistics Risks																						
11	Able to Build and Sustain Long-term Collaborations																						
Importance Rating of LSPs Factors																							
Ranking of LSPs Factors																							

Figure 8- 7: HOQ2

LSPs Factors - LSPs Alternatives

			LSPs Alternatives									
#	**LSPs Factors**	**Weight**	**LSP1**	**LSP2**	**LSP3**	**LSP4**	**LSP5**	**LSP6**	**LSP7**	**LSP8**	**LSP9**	**LSP10**
1	Returns											
2	Logistics Costs											
3	Service Quality & Reliability											
4	Service Flexibility											
5	Logistics Processes Quality											
6	Logistics Processes Productivity											
7	Processes Sustainability											
8	Human Talent											
9	Physical Warehousing Resources											
10	Physical Production & Packaging											
11	Physical Information Technology											
12	Human Resource Education											
13	Information Sharing											
14	Databases and Software											
15	Flow-Out Warehousing Activities											
16	Outbound Transportation Activities											
17	Labelling Services											
18	Order management and Fulfilment											
19	Help Desk Services											
20	e-Logistics Services											
21	Logistics Risks Assessment											
Importance Rating of LSPs Alternatives												
Ranking of LSPs Alternatives												

Figure 8- 8: HOQ3

8.5. Chapter Contributions

This chapter provides the first integrated strategic logistics outsourcing approach. The new hybrid model integrates the FDEMATEL and FQFD techniques to link the LSUs strategic objectives, logistics requirements and ISFs in one process. Chapter contributions can be summarised by:

- Developing the first logistics performance-resources-services IRM and their weights
- Developing the first FDEMATEL- FQFD strategic logistics outsourcing approach
- Identifying the logistics ISFs to be used in the LSPs integrated approach
- Developing the new approach procedures and equations

Chapter 9: Strategic Logistics Outsourcing Integrated Approach – Case Studies

Summary

This chapter demonstrates the new model of strategic logistics outsourcing process. Two case studies have been presented and analysed. The first case represents the upstream supply chain members, while the second case represents the downstream members. Both cases support the feasibility and the effectiveness of the new model. Finally, differences and similarities between the upstream and downstream LSUs have been clarified.

9.1. Introduction

Logistics outsourcing decisions affect a firm's capability to compete. Successful strategic logistics outsourcing decisions are an effective approach to achieve competitive advantage. Each member in the supply chain may need to outsource different logistics services. Therefore, a strategic logistics outsourcing approach must deal with different supply chain members. As is mentioned in Chapter 8, the supply chain consists of three main streams: upstream, midstream and downstream. Each stream has its own features and characteristics and therefore, LSUs at each stream perform their logistics outsourcing process differently. To demonstrate the effectiveness and robustness of the new hybrid approach, at least two case studies are needed. One case represents the upstream LSUs and another case represents the downstream LSUs. Figure 9-1 clarifies the supply chain streams, their flows, focuses and pinpoints the case study areas.

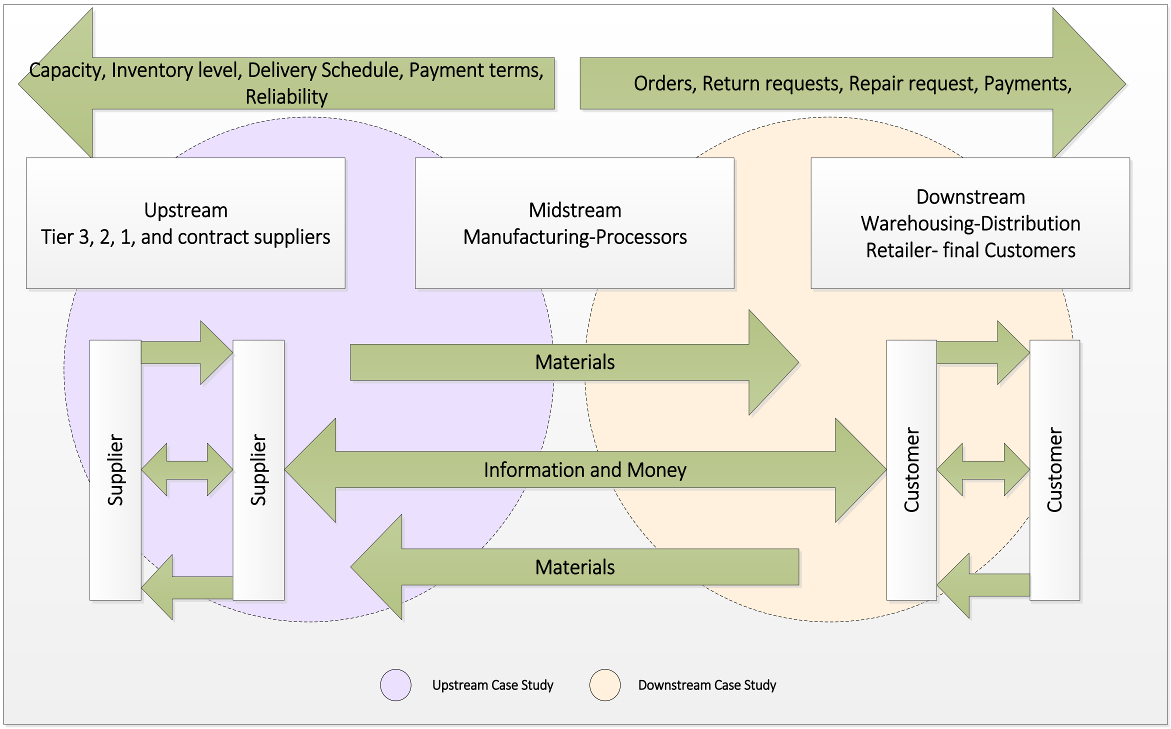

Figure 9- 1: Supply Chain Streams

Upstream flows focus on capacity, inventory level and delivery schedule. Downstream flows focus on orders, return requests, repair and service requests, delivery time/accuracy and payments. Because most of the upstream suppliers perform their logistics activities internally (have their own warehousing and distribution network), upstream outsourcing is focused more on the supplier-selection process than LSPs (Song 2013). According to Aguezzoul (2012), supplier and 3PL selection processes nearly use the same criteria but with different relative weights. The new hybrid approach provides a number of excellent features to work effectively in both cases. These features are:

- ISFs have been identified based on experts' evaluations of the impact-relationship among a large number of factors. Therefore, these factors are highly important for logistics-based decisions.
- The new hybrid approach helps the LSU to prioritise these ISFs based on their needs and/or preferences. Therefore the relative importance of these ISFs can be modified to fit with supplier or LSPs cases.
- The new hybrid approach links the selection process with the LSU's strategic objectives and logistics requirements, which helps firms achieving their strategic objectives.
- The new hybrid approach uses the Peter Drucker strategic objective areas (Drucker 1974; 2011) rather than identifying specific strategic objectives or stakeholders requirements that may or may not fit the LSU's strategic objectives. Therefore, each LSU can find area(s) positioning their objectives in.
- The same thing has been considered with logistics requirements, where LSUs can select/modify the requirement list in a way that fits with their strategic objectives.

A number of Jordanian LSUs were contacted inviting them to be the subject of a case study. Due to data sensitivity, two firms were identified that were happy to provide data for this study, provided their identity was kept anonymous. The first firm is a large manufacturer providing a wide range of petroleum products for all sectors (other manufacturers, governmental, wholesaler and retailer customers). This firm deals with a large number of suppliers and LSPs and most of its operations are within the upstream to midstream flows. The second firm is a regional food manufacturer representing the downstream flow. This firm deals with a large number of suppliers, operates local logistics activities internally and outsources all regional logistics activities through a large number of LSPs.

9.2. First Case Study: Upstream LSU

9.2.1. First Case Background

This firm is a public holding firm listed on Amman stock Exchange (ASE). In addition to its main operations, it has a number of subsidiaries in various industrial areas, such as Liquefied gas manufacturing and filling, Mineral oils manufacturing and Petroleum products marketing. This firm deals with a large network of suppliers and LSPs to provide raw materials and production requirements. Additionally, they perform a wide range of logistics operations to ensure smooth flows of material, products, people and information between departments and units and to satisfy customers' needs. The complex multi-stage production, storage and marketing systems require an effective and efficient logistics network. This firm performs some of its logistics operations internally using tankers, trailers and semi-trailers. The storage capacity amounted to be more than 1,000,000 tons. In order to enhance their storage and transportation capacities, this firm outsources logistics services through contracting with a number of local and international LSPs. Moreover, the firm creates three main sections for marketing & distribution, transportation, supply & trading with special executive directors to manage the internal and external logistics processes. The firm's logistics stakeholders are all the departments that have a say in the LSPs evaluation and selection process and/or are affected by the LSPs performance. First a list of potential managers and DMs from various departments has been developed. Then based on a series of discussions with the firm's managers a list of ten relevant stakeholders was identified. Those stakeholders are:

- Distribution departments
- Warehousing
- Maintenance
- Operations development
- Transportation
- Gas Unit
- Loading Unit
- Administrative Unit
- Laboratories & Quality assurance
- Purchasing

Those stakeholders have a direct contact with the LSPs and have a say in the LSPs evaluation and selection process. Therefore, they identified 10 LSPs to be evaluated.

9.2.2. First Case Strategic Objectives:

Two questions are directed to stakeholders regarding their firms' strategic objectives. The first question asked them to identify the strategic objective areas. The second question asked them to prioritise these areas using linguistic variables (Table 8-3). Due to the different frequencies of the strategic objective areas, the strategic objectives defuzzified average ratings (R_i)have been multiplied by their frequencies before they have been normalised using Equation 8-2. Table 9-1 summarises the strategic objectives with their fuzzy and defuzzified average ratings, frequencies, weights and final rank.

Table 9- 1: Strategic Objectives and their Relative Weights (1st Case Study)

#	Strategic Objective Areas	Fuzzy Average Rating	Defuzzified Rating	Frequency	weight	Rank
1	Profitability	(0.688, 0.938, 1)	0.786	6	0.1131	4
2	Financial Resources	(0.536, 0.786, 0.929)	0.703	7	0.118	3
3	Market Position	(0.528, 0.778, 0.917)	0.692	6	0.0996	5
4	Innovation	(0.375, 0.625, 0.844)	0.601	6	0.0865	8
5	Productivity	(0.611, 0.861, 0.972)	0.753	8	0.1444	1
6	Physical resources	(0.531, 0.75, 0.875)	0.678	6	0.0975	6
7	Human Resources	(0.525, 0.775, 0.9)	0.678	8	0.1301	2
8	Social Responsibility	(0.438, 0.688, 0.875)	0.64	3	0.046	10
9	Excellent Handling process/equipment	(0.6, 0.85, 1)	0.773	5	0.0927	7
10	Customer Satisfaction	(0.75, 1, 1)	0.75	4	0.0719	9

There is a clear interest about "Productivity" and "Human Resources" dimensions, which gives the firm internal consistency. But, more interest about the external dimensions (particularly the customer satisfaction and social responsibility dimensions) is needed to have the long term internal-external strategic balance. Financial resources and Profitability were in the 3th and 4th rankings respectively with nearly the same weight. Then, market position and physical resources in the 5th and 6th rankings followed by excellent handling and innovation objectives. Figure 9-2 shows the strategic objectives relative weights.

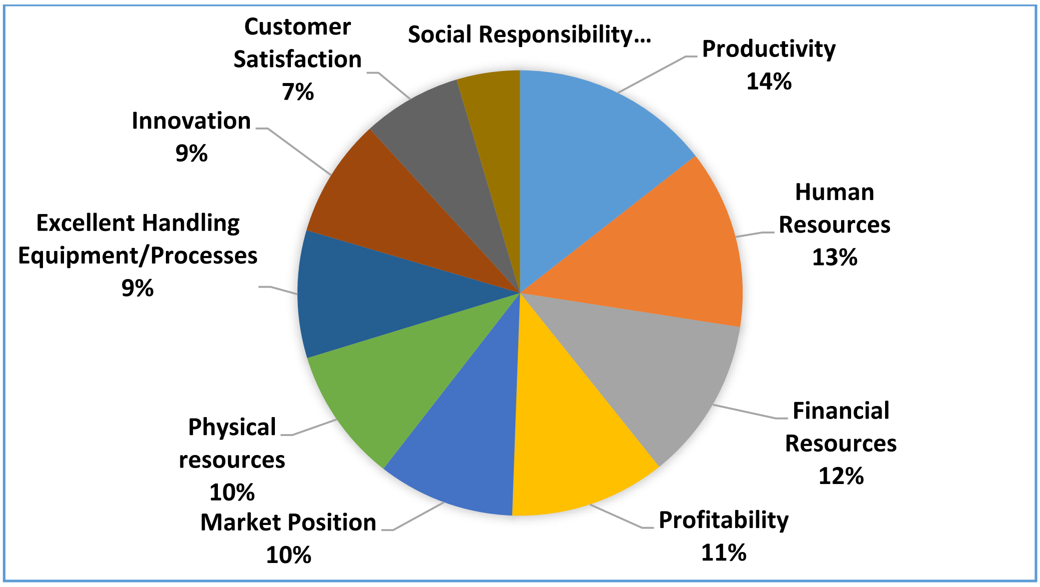

Figure 9- 2: Strategic Objectives Weights (1st Case Study)

There is no clear consensus about the firm's strategic objectives (Table 9-1 Frequencies), which affects the firm's overall performance and capability to achieve these objectives. It would be good if these objectives were reviewed on timescales in line with other strategic activities at the firm to ensure consensus among the firm's managers.

9.2.3. First Case Logistics Requirements

In terms of logistics requirements, stakeholders identified the following logistics requirements to achieve the firm's strategic objectives (Table 9-2):

Table 9- 2: Logistics Requirements and their Rankings (1st Case Study)

#	Logistics Requirements (LR)	Frequency	Rank
1	Increase Customer Satisfaction	10	1
2	Resolve Problems Effectively	10	1
3	Reduce Total Logistics Costs	8	2
4	Possess State-of-the Art Hardware and Software	7	3
5	Provide Guidance on Time	7	3
6	Assess Logistics Risks	7	3
7	Reduce Cycle Time	6	4
8	Assure Quality in Distribution - Delivery	6	4
9	Build and Sustain Long-Term Collaborations	6	4
10	Provide Customised Logistics Services	5	5
11	Provide Value-added Logistics Services	5	5
12	Provide Sustainable Logistics Services	5	5
13	Continuous Measure of Results	4	6
14	Acquire the Needed Logistics Resources and Capabilities	4	6
15	Strategic Compatibility	1	7

Not all logistics requirements are equally important. For this case study 'LSP's capability to satisfy customers' and 'solving problems effectively' are the most frequently identified logistics requirements. This may balance some of the 'customer satisfaction' low ranking in the strategic objective areas. Meanwhile, strategic compatibility came in the last ranking with the lowest frequency, which means that stakeholders did not view LSPs as strategic partners.

9.2.4. First Case HOQs

The FQFD technique is used to find the relative importance of the logistics requirements and the LSPs evaluation criteria (ISFs), which in turn are used to find the final ranking of the LSP alternatives. HOQ1 provided the logistics requirements' weights through analysing the strategic objectives-logistics requirement relationships. Whiles, HOQ2 provided the ISFs weights by analysing the logistics requirements-ISFs relationships. Meanwhile, the final house (HOQ3) provided the final LSPs scores and rankings. Based on further discussion with the firm's managers, five stakeholders have been selected to participate in the HOQs evaluation sessions: Distribution departments, Warehousing, Maintenance planning unit, Operations development and Transportation.

Those stakeholders have a direct contact with the 10 LSPs, are the most affected by the LSPs performance and they have been engaged in LSP evaluation and selection processes before. Therefore, they are in a good position to participate in this process. Linguistic variables (Table 8-4 and 8-5) are used to conduct these evaluations. The following sections provide a systematic description of the first case study HOQs.

HOQ1 – First Matrix

Stakeholders are asked to evaluate the strategic objective-logistics requirements relationships using the linguistic variables (Table 8-4). For each strategic objective, each stakeholder evaluated the extent to which each logistics requirement is significant to achieve this strategic objective (Appendix 9-1). Therefore, for each strategic objective-logistics requirement correlation there are five linguistic evaluations. Table 9-3 shows the stakeholders evaluations of the 'Profitability-logistics requirements relationships.

Table 9- 3: Stakeholders Evaluations Profitability-Requirement Relationship

	Reduce Total Logistics Costs	Reduce Cycle Time	Assure Quality in Distribution - Delivery	Acquire the Needed Logistics Resources and Capabilities	Possess State-of-the Art Hardware and Software	Provide Customised Logistics Services	Provide Value-added Logistics Services	Increase Customer Satisfaction	Provide Guidance on Time	Resolve Problems Effectively	Assess Logistics Risks	Build and Sustain Long-Term Collaborations	Providing Sustainable Logistics Services	Strategic Compatibility	Continuous Measuring of Results
Profitability	S	S	VS	S	S	S	S	VS	S	VS	S	S	S	S	S
	VS	VS	L	M	VS	VS	VS	VS	VS	VS	S	VS	VS	S	VS
	VS	VS	L	M	VS	VS	VS	VS	VS	VS	VS	S	VS	VS	VS
	S	L	L	M	VS	M	M	VS	M	VS	M	VS	S	S	VS
	VS	VS	VS	S	VS	M	VS	S	M	S	S	S	S	VS	VS

VS: very strong relation. S: strong relation. M: moderate relation. L: low relation. No: No relation

In addition to the strategic objectives weights (Table 9-1), the average fuzzy evaluations of the strategic objectives and logistics requirements relationships are used to establish the HOQ1 as is shown in Table 9-4 (Steps 4, 5 and 6 - Chapter 8). Equation 8-3 and Equation 8-4 are used to find the final logistics requirement weights, summarised in Table 9-5.

Table 9- 4: HOQ1 Strategic Objectives– Logistics Requirements Relationships

Strategic Objective - Logistics Requirements			Logistics Requirements														
#	Strategic Objectives	Weight	LR1			LR2			LR3			LR4			LR5		
1	Profitability	0.11	0.65	0.90	1.00	0.55	0.80	0.90	0.30	0.55	0.70	0.35	0.60	0.85	0.70	0.95	1.00
2	Financial Resources	0.12	0.70	0.95	1.00	0.40	0.65	0.90	0.35	0.60	0.85	0.45	0.70	0.85	0.70	0.95	1.00
3	Market Position	0.10	0.20	0.35	0.60	0.15	0.35	0.55	0.50	0.70	0.80	0.55	0.80	0.90	0.65	0.90	1.00
4	Innovation	0.09	0.10	0.15	0.40	0.65	0.90	1.00	0.60	0.85	0.95	0.50	0.75	0.85	0.75	1.00	1.00
5	Productivity	0.14	0.15	0.25	0.45	0.75	1.00	1.00	0.50	0.75	0.85	0.40	0.65	0.80	0.65	0.90	0.95
6	Physical resources	0.10	0.10	0.15	0.40	0.50	0.70	0.80	0.55	0.80	0.95	0.25	0.50	0.75	0.70	0.95	1.00
7	Human Resources	0.13	0.25	0.35	0.55	0.50	0.75	0.90	0.45	0.70	0.85	0.20	0.35	0.60	0.65	0.90	1.00
8	Social Responsibility	0.05	0.10	0.20	0.45	0.05	0.10	0.35	0.40	0.65	0.80	0.35	0.60	0.85	0.35	0.55	0.70
9	Excellent handling process/equip	0.09	0.60	0.85	0.90	0.75	1.00	1.00	0.60	0.85	0.95	0.45	0.70	0.80	0.70	0.95	1.00
10	Customer Satisfaction	0.07	0.10	0.15	0.40	0.65	0.90	0.95	0.60	0.80	0.85	0.05	0.10	0.35	0.65	0.90	1.00
Importance Rating of Logistics Requirements			**0.32**	0.46	0.63	**0.52**	0.75	0.87	**0.48**	0.72	0.85	**0.36**	0.58	0.76	**0.67**	0.91	0.98

#	Strategic Objectives	Weight	LR6			LR7			LR8			LR9			LR10		
1	Profitability	0.11	0.50	0.75	0.90	0.60	0.85	0.95	0.70	0.95	1.00	0.50	0.75	0.90	0.70	0.95	1.00
2	Financial Resources	0.12	0.40	0.60	0.75	0.40	0.65	0.80	0.45	0.70	0.85	0.30	0.50	0.70	0.35	0.55	0.75
3	Market Position	0.10	0.60	0.85	1.00	0.60	0.85	0.95	0.70	0.95	1.00	0.50	0.75	0.90	0.40	0.55	0.70
4	Innovation	0.09	0.50	0.75	0.85	0.60	0.85	1.00	0.65	0.90	1.00	0.65	0.90	1.00	0.65	0.90	1.00
5	Productivity	0.14	0.40	0.55	0.70	0.45	0.70	0.80	0.55	0.80	0.90	0.55	0.75	0.85	0.65	0.90	0.95
6	Physical resources	0.10	0.30	0.55	0.80	0.40	0.65	0.90	0.30	0.55	0.80	0.30	0.55	0.80	0.50	0.75	0.95
7	Human Resources	0.13	0.35	0.60	0.85	0.45	0.70	0.85	0.50	0.75	0.85	0.50	0.70	0.80	0.70	0.95	1.00
8	Social Responsibility	0.05	0.40	0.60	0.75	0.45	0.70	0.85	0.40	0.65	0.80	0.40	0.60	0.75	0.40	0.60	0.80
9	Excellent handling process/equip	0.09	0.55	0.80	0.90	0.60	0.85	0.90	0.55	0.80	0.90	0.35	0.55	0.70	0.55	0.75	0.85
10	Customer Satisfaction	0.07	0.30	0.50	0.70	0.60	0.80	0.85	0.60	0.80	0.85	0.55	0.75	0.85	0.65	0.90	0.95
Importance Rating of Logistics Requirements			**0.43**	0.65	0.82	**0.51**	0.76	0.88	**0.54**	0.79	0.90	**0.46**	0.68	0.83	**0.57**	0.79	0.90

#	Strategic Objectives	Weight	LR11			LR12			LR13			LR14			LR15		
1	Profitability	0.11	0.35	0.60	0.85	0.60	0.85	1.00	0.60	0.85	1.00	0.60	0.85	1.00	0.70	0.95	1.00
2	Financial Resources	0.12	0.40	0.60	0.85	0.45	0.70	0.85	0.45	0.70	0.85	0.45	0.70	0.85	0.45	0.65	0.80
3	Market Position	0.10	0.20	0.30	0.50	0.60	0.85	1.00	0.60	0.85	0.95	0.60	0.85	0.95	0.65	0.90	1.00
4	Innovation	0.09	0.60	0.85	0.95	0.45	0.70	0.85	0.35	0.55	0.70	0.45	0.70	0.85	0.70	0.95	1.00
5	Productivity	0.14	0.40	0.60	0.80	0.55	0.80	0.95	0.35	0.50	0.65	0.45	0.70	0.90	0.75	1.00	1.00
6	Physical resources	0.10	0.35	0.60	0.85	0.30	0.55	0.80	0.40	0.65	0.80	0.40	0.65	0.80	0.50	0.75	0.85
7	Human Resources	0.13	0.55	0.80	0.90	0.70	0.95	1.00	0.55	0.80	0.90	0.50	0.75	0.90	0.55	0.80	0.90
8	Social Responsibility	0.05	0.20	0.35	0.60	0.35	0.60	0.75	0.30	0.55	0.70	0.35	0.60	0.75	0.35	0.50	0.65
9	Excellent handling process/equip	0.09	0.50	0.70	0.85	0.45	0.65	0.80	0.40	0.55	0.70	0.55	0.80	0.90	0.60	0.85	0.90
10	Customer Satisfaction	0.07	0.45	0.65	0.75	0.30	0.55	0.75	0.55	0.80	0.90	0.50	0.75	0.90	0.70	0.95	1.00
Importance Rating of Logistics Requirements			**0.41**	0.62	0.80	**0.50**	0.74	0.89	**0.46**	0.68	0.82	**0.49**	0.74	0.89	**0.61**	0.85	0.92

Table 9- 5: Logistics requirements Weights (1st Case Study)

#	Logistics Requirements	Weighted Average Fuzzy Rating			Defuzz. Rating	Weights
1	Reduce Total Logistics Cost	(0.3161,	0.4569,	0.634)	0.4662	**0.0484**
2	Reduce Cycle Time	(0.5213,	0.7523,	0.866)	0.6614	**0.0686**
3	Assure Quality Distribution-Delivery	(0.4786,	0.720,	0.8534)	0.6367	**0.0661**
4	Acquire the Needed Logistics Resources and Capabilities	(0.3603,	0.5829,	0.7649)	0.5522	**0.0573**
5	Possess State-of-the Art Hardware-Software	(0.6659,	0.9136,	0.979)	0.7671	**0.0796**
6	Provide Customised Logistics Services	(0.4303,	0.6541,	0.8215)	0.6113	**0.0634**
7	Provide Value-added Logistics Services	(0.5088,	0.7552,	0.8806)	0.6615	**0.0687**
8	Increase Customer Satisfaction	(0.5446,	0.791,	0.8996)	0.6834	**0.0709**
9	Provide Guidance on Time	(0.4622,	0.682,	0.826)	0.624	**0.0648**
10	Resolve Problems Effectively	(0.5664,	0.7936,	0.9018)	0.7011	**0.0728**
11	Assess Logistics Risks	(0.41,	0.6191,	0.8044)	0.6011	**0.0624**
12	Build and Sustain Long-Term Collaborations	(0.4988,	0.7442,	0.8946)	0.6713	**0.0697**
13	Providing Sustainable Logistics Services	(0.4626,	0.6846,	0.8195)	0.6178	**0.0641**
14	Strategic Compatibility	(0.4918,	0.7418,	0.8894)	0.6631	**0.0688**
15	Continuous Measuring of Results	(0.6083,	0.8478,	0.9234)	0.7174	**0.0745**

Based on these results, stakeholders' evaluations show that:

- Although all the logistics requirements are important and used in the next HOQ, their contributions in achieving the firm's strategic objectives are not the same.
- 'Possess state-of-the art hardware and software', 'continuous measuring of results' and 'Resolve problems effectively' are the most important logistics requirements that LSPs must provide.
- 'Increase customer satisfaction' and 'Build and sustain long-term collaborations' comes second with relatively high weights.
- 'Reduce total logistics costs' comes in the last ranking with (0.0484) relative weight. Reducing logistics cost is one of the crucial logistics requirements, it's likely the strong negotiation power that this firm have over the LSPs makes logistics costs come in this low ranking. This point reflects flexibility of this approach, where firms can change criteria and their weights according to their preferences and needs.

HOQ2 – Second Matrix

The same five stakeholders participated in the second session to evaluate the logistics requirements and ISFs relationships. Linguistic variables (Table 8-4) are used to evaluate the extent to which these criteria enable LSPs to provide logistics requirements. For each logistics requirement-evaluation criteria correlation there are five linguistic evaluations. Table 9-6 summarises the stakeholders' evaluations of the 'Reduce cycle time' requirement and LSPs criteria relationships.

Table 9- 6: Stakeholders' Evaluations 'Reduce cycle time' Relationships (1st Case Study)

	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C 10**	**C 11**	**C 12**	**C 13**	**C 14**	**C 15**	**C 16**	**C 17**	**C 18**	**C 19**	**C 20**	**C 21**
Reduce Cycle Time	VS	L	S	S	VS	VS	S	VS	S	S	M	S	M	M	S	M	M	M	M	M	M
	S	L	S	L	VS	VS	S	VS	S	S	M	S	M	M	S	M	M	M	M	M	M
	VS	L	S	S	VS	VS	S	VS	S	S	M	S	M	M	S	M	M	M	M	M	M
	L	No	L	No	VS	VS	S	VS	L	M	S	S	L	S	VS	S	L	VS	S	VS	VS
	S	L	S	S	S	S	VS	VS	S	M	S	VS	M	S	S	S	M	S	S	S	S

VS: very strong relation. S: strong relation. M: moderate relation. L: low relation. No: No relation

In addition to the logistics requirements weights (Table 9-5), the average fuzzy evaluations of the logistics requirements and LSPs evaluation criteria relationships are used to establish the HOQ2 (Steps 7 and 8). Equation 8-5 and Equation 8-6 are used to find the final LSPs evaluation criteria weights which are summarised in Table 9-7.

Based on stakeholders' evaluations, 'Human talent' and 'Human resources – Education' are the most important criteria which complement the firm's strategic objectives (Table 9-1). Then, operations-based criteria (processes sustainability, logistics processes quality and logistics processes productivity) and IT-based criteria such as 'physical information technology resources' are in the second rankings. Meanwhile, e-logistics services, information sharing and labelling services have the lowest rankings, 19, 20 and 21 respectively. All the ISFs will be used in the HOQ3.

Table 9- 7: ISFs Weights (1st Case Study)

#	Evaluation Criteria (ISFs)	Weighted Average Fuzzy Rating	Defuzzify Rating	Weights	Rank
C1	Returns	(0.4683, 0.7046, 0.8588)	0.6418	0.0501	**8**
C2	Logistics Costs	(0.3769, 0.5982, 0.7924)	0.5777	0.0451	**15**
C3	Service Quality & Reliability	(0.4599, 0.7033, 0.8817)	0.6539	0.051	**7**
C4	Service Flexibility	(0.3675, 0.6077, 0.847)	0.607	0.0473	**12**
C5	Logistics Processes Quality	(0.4786, 0.7254, 0.9101)	0.6782	0.0529	**4**
C6	Logistics Processes Productivity	(0.453, 0.6928, 0.8821)	0.6546	0.051	**6**
C7	Processes Sustainability	(0.4822, 0.7322, 0.9328)	0.6948	0.0542	**3**
C8	Human Talent	(0.5834, 0.8334, 0.9769)	0.7514	0.0586	**1**
C9	Physical Warehousing Resources	(0.4154, 0.6349, 0.85)	0.6316	0.0493	**9**
C10	Physical Production & Packaging Resources	(0.37, 0.6131, 0.8461)	0.6055	0.0472	**13**
C11	Physical Information Technology Resources	(0.4146, 0.6646, 0.9014)	0.6546	0.0511	**5**
C12	Human Resource Education	(0.4653, 0.7153, 0.9359)	0.72	0.0562	**2**
C13	Information Sharing	(0.2305, 0.4756, 0.7163)	0.4723	0.0368	**20**
C14	Databases and Software	(0.3179, 0.5679, 0.8041)	0.5575	0.0435	**17**
C15	Flow-Out Warehousing Activities	(0.3841, 0.6305, 0.8735)	0.628	0.049	**10**
C16	Outbound Transportation Activities	(0.3388, 0.5888, 0.8317)	0.5834	0.0455	**14**
C17	Labelling Services	(0.1969, 0.413, 0.6559)	0.4198	0.0327	**21**
C18	Order management and Fulfilment	(0.3302, 0.5651, 0.8014)	0.5655	0.0441	**16**
C19	Help Desk Services	(0.3247, 0.5634, 0.7923)	0.556	0.0434	**18**
C20	e-Logistics Services	(0.324, 0.5637, 0.7901)	0.5537	0.0432	**19**
C21	Logistics Risks Assessment	(0.381, 0.631, 0.8613)	0.6162	0.0481	**11**

HOQ3 – Third Matrix

Finally, in HOQ3 stakeholders evaluated the LSP alternatives against the weighted 21 ISFs (Table 9-7) using the linguistic variables (Table 8-5). For each LSP alternative under each criterion there are five linguistic evaluations. The fuzzy averages of the stakeholders' evaluations (e_{ij}^{LSP}) and the evaluation ISFs are used to establish the HOQ3 and in turn the LSPs weighted fuzzy evaluations. Table 9-9 summarised the HOQ3 and the LSPs' weighted fuzzy evaluations. Equations 8-7 is used to find the final LSPs fuzzy total scores which in turn are defuzzified by Equation 3-11. Table 9-8 summarises the final fuzzy and defuzzified LSP alternatives scores and their final rank. Figure 9-3 shows the final LSP alternatives ranking based on their final defuzzified scores.

Table 9- 8: LSPs Fuzzy and Defuzzified Scores and their Final Rankings (1st Case Study)

#	LSP Alternatives	Average Fuzzy Rating	Defuzz. Rating	Weights	Rank
1	LSP1	(0.3329, 0.583, 0.8097)	0.5654	0.0836	9
2	LSP2	(0.4987, 0.749, 0.9665)	0.7244	0.1071	4
3	LSP3	(0.4866, 0.737, 0.9573)	0.7145	0.1056	5
4	LSP4	(0.4703, 0.714, 0.9487)	0.7074	0.1046	7
5	LSP5	(0.5807, 0.831, 1.0)	0.7691	0.1137	1
6	LSP6	(0.5799, 0.83, 1.0)	0.7689	0.1137	2
7	LSP7	(0.5738, 0.824, 1.0)	0.7675	0.1135	3
8	LSP8	(0.3735, 0.624, 0.8613)	0.6143	0.0908	8
9	LSP9	(0.1722, 0.422, 0.6697)	0.4203	0.0621	10
10	LSP10	(0.4756, 0.726, 0.958)	0.7123	0.1053	6

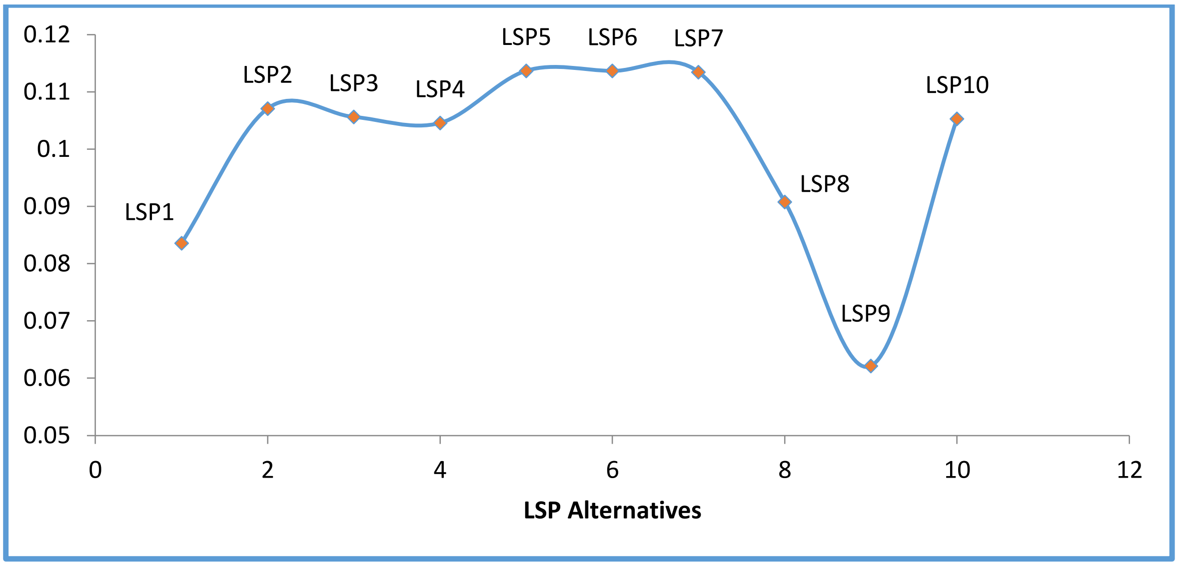

Figure 9- 3: LSPs Final Rankings, FQFD technique (1st Case Study)

Based on their final scores, LSP alternatives are classified into four main groups:

- Good score alternatives: LSP5, 6 and 7
- Moderate score alternatives: LSPs2, 3, 4 and 10
- Acceptable score alternatives: LSP1 and 8
- Low score alternative: LSP9

Table 9- 9: HOQ3 (1st Case Study)

Strategic Objective - Logistics Requirements			LSPs																													
#	ISF	Weight	1			2			3			4			5			6			7			8			9			10		
1	Returns	0.0500	0.65	0.90	1.00	0.55	0.80	1.00	0.70	0.95	1.00	0.55	0.80	0.95	0.60	0.85	1.00	0.60	0.85	1.00	0.65	0.90	1.00	0.45	0.70	0.90	0.35	0.60	0.80	0.55	0.80	1.00
2	Logistics Costs	0.0451	0.45	0.70	0.90	0.55	0.80	1.00	0.50	0.75	0.95	0.45	0.70	0.95	0.50	0.75	1.00	0.55	0.80	1.00	0.55	0.80	1.00	0.35	0.60	0.85	0.15	0.40	0.65	0.55	0.80	1.00
3	Service Quality & Reliability	0.0510	0.45	0.70	0.95	0.55	0.80	1.00	0.50	0.75	1.00	0.45	0.70	0.95	0.55	0.80	1.00	0.55	0.80	1.00	0.55	0.80	1.00	0.40	0.65	0.90	0.10	0.35	0.60	0.50	0.75	1.00
4	Service Flexibility	0.0473	0.30	0.55	0.80	0.50	0.75	0.95	0.50	0.75	1.00	0.45	0.70	0.95	0.60	0.85	1.00	0.55	0.80	1.00	0.55	0.80	1.00	0.40	0.65	0.90	0.30	0.55	0.80	0.50	0.75	1.00
5	Logistics Processes Quality	0.0529	0.40	0.65	0.90	0.55	0.80	1.00	0.50	0.75	1.00	0.50	0.75	1.00	0.60	0.85	1.00	0.60	0.85	1.00	0.60	0.85	1.00	0.35	0.60	0.85	0.20	0.45	0.70	0.45	0.70	0.95
6	Logistics Processes Productivity	0.0510	0.50	0.75	1.00	0.50	0.75	1.00	0.50	0.75	1.00	0.50	0.75	1.00	0.60	0.85	1.00	0.60	0.85	1.00	0.60	0.85	1.00	0.40	0.65	0.90	0.10	0.35	0.60	0.50	0.75	1.00
7	Processes Sustainability	0.0542	0.40	0.65	0.85	0.50	0.75	0.95	0.50	0.75	1.00	0.50	0.75	1.00	0.55	0.80	1.00	0.55	0.80	1.00	0.55	0.80	1.00	0.50	0.75	0.95	0.10	0.35	0.60	0.35	0.60	0.85
8	Human Talent	0.0586	0.15	0.40	0.60	0.45	0.70	0.90	0.40	0.65	0.85	0.45	0.70	0.95	0.60	0.85	1.00	0.55	0.80	1.00	0.55	0.80	1.00	0.35	0.60	0.85	0.10	0.35	0.60	0.35	0.60	0.85
9	Physical Warehousing Resources	0.0493	0.45	0.70	0.90	0.50	0.75	1.00	0.55	0.80	1.00	0.35	0.55	0.80	0.55	0.80	1.00	0.55	0.80	1.00	0.55	0.80	1.00	0.40	0.65	0.85	0.15	0.40	0.65	0.50	0.75	1.00
10	Physical Production & Packaging Resources	0.0472	0.25	0.50	0.75	0.55	0.80	0.95	0.55	0.80	1.00	0.35	0.55	0.80	0.55	0.80	1.00	0.55	0.80	1.00	0.55	0.80	1.00	0.30	0.55	0.80	0.15	0.40	0.65	0.35	0.60	0.85
11	Physical Information Technology Resources	0.0511	0.25	0.50	0.70	0.45	0.70	0.95	0.50	0.75	1.00	0.50	0.75	0.95	0.60	0.85	1.00	0.60	0.85	1.00	0.55	0.80	1.00	0.35	0.60	0.85	0.15	0.40	0.65	0.50	0.75	1.00
12	Human Resource Education	0.0561	0.25	0.50	0.70	0.50	0.75	1.00	0.40	0.65	0.85	0.55	0.80	1.00	0.60	0.85	1.00	0.60	0.85	1.00	0.55	0.80	1.00	0.35	0.60	0.85	0.20	0.45	0.70	0.50	0.75	1.00
13	Information Sharing	0.0368	0.20	0.45	0.70	0.55	0.80	1.00	0.55	0.80	1.00	0.40	0.60	0.85	0.60	0.85	1.00	0.60	0.85	1.00	0.55	0.80	1.00	0.30	0.55	0.80	0.30	0.55	0.80	0.45	0.70	0.95
14	Databases and Software	0.0435	0.20	0.45	0.70	0.45	0.70	0.95	0.50	0.75	1.00	0.50	0.75	0.95	0.55	0.80	1.00	0.60	0.85	1.00	0.55	0.80	1.00	0.35	0.60	0.85	0.25	0.50	0.75	0.50	0.75	1.00
15	Flow-Out Warehousing Activities	0.0490	0.30	0.55	0.80	0.45	0.70	0.95	0.35	0.60	0.80	0.55	0.80	1.00	0.55	0.80	1.00	0.55	0.80	1.00	0.60	0.85	1.00	0.30	0.55	0.80	0.15	0.40	0.65	0.45	0.70	0.95
16	Outbound Transportation Activities	0.0455	0.35	0.60	0.85	0.40	0.65	0.90	0.45	0.70	0.95	0.50	0.75	1.00	0.60	0.85	1.00	0.60	0.85	1.00	0.60	0.85	1.00	0.35	0.60	0.85	0.15	0.40	0.65	0.55	0.80	1.00
17	Labelling Services	0.0327	0.35	0.60	0.85	0.55	0.80	0.95	0.50	0.75	1.00	0.50	0.75	1.00	0.60	0.85	1.00	0.60	0.85	1.00	0.55	0.80	1.00	0.30	0.55	0.80	0.10	0.35	0.60	0.55	0.80	1.00
18	Order management and Fulfilment	0.0441	0.35	0.60	0.85	0.55	0.80	0.95	0.50	0.75	0.95	0.50	0.75	1.00	0.60	0.85	1.00	0.60	0.85	1.00	0.60	0.85	1.00	0.50	0.75	1.00	0.20	0.45	0.70	0.55	0.80	1.00
19	Help Desk Services	0.0434	0.35	0.60	0.85	0.50	0.75	1.00	0.45	0.70	0.95	0.50	0.75	1.00	0.60	0.85	1.00	0.60	0.85	1.00	0.60	0.85	1.00	0.40	0.65	0.90	0.15	0.40	0.65	0.55	0.80	1.00
20	e-Logistics Services	0.0432	0.10	0.35	0.60	0.45	0.70	0.95	0.40	0.65	0.90	0.40	0.65	0.90	0.60	0.85	1.00	0.60	0.85	1.00	0.60	0.85	1.00	0.35	0.60	0.80	0.15	0.40	0.65	0.35	0.60	0.80
21	Logistics Risks Assessment	0.0480	0.25	0.50	0.75	0.45	0.70	0.95	0.45	0.70	0.95	0.40	0.65	0.90	0.60	0.85	1.00	0.60	0.85	1.00	0.60	0.85	1.00	0.35	0.60	0.80	0.15	0.40	0.65	0.50	0.75	0.95
Importance Rating of Logistics Requirements			0.33	0.58	0.81	0.50	0.75	0.97	0.49	0.74	0.96	0.47	0.71	0.95	0.58	0.83	1.00	0.58	0.83	1.00	0.57	0.82	1.00	0.37	0.62	0.86	0.17	0.42	0.67	0.48	0.73	0.96

9.2.5. FTOPSIS for the First Case

In addition to the general evaluation scores, FTOPSIS technique helps DMs to compare alternatives and analyse differences against each criterion and between alternatives and aspiration level. These comparisons help DMs to point out strength and weakness for each LSP alternative and therefore to identify improvement opportunities. Stakeholders' evaluations in the HOQ3 in addition to criteria weights (Table 9-7) are used to establish the FTOPSIS matrices. Table 9-10 compares the LSPs scores and rankings based on the FQFD and FTOPSIS techniques. While, Figure 9-4 shows the final LSP alternatives ranking based on the FTOPSIS technique.

Table 9- 10: Comparison of the LSPs Scores (FQFD and FTOPSIS) (1st Case Study)

LSP Alternatives	FQFD Score	FQFD Rank	FTOPSIS Score	FTOPSIS Rank
LSP1	0.083586	**9**	0.0350	**9**
LSP2	0.107096	**4**	0.0421	**4**
LSP3	0.105633	**5**	0.0415	**6**
LSP4	0.104581	**7**	0.0410	**7**
LSP5	0.113694	**1**	0.0438	**1**
LSP6	0.113666	**2**	0.0438	**2**
LSP7	0.113468	**3**	0.0436	**3**
LSP8	0.090818	**8**	0.0369	**8**
LSP9	0.062143	**10**	0.0278	**10**
LSP10	0.105308	**6**	0.0418	**5**

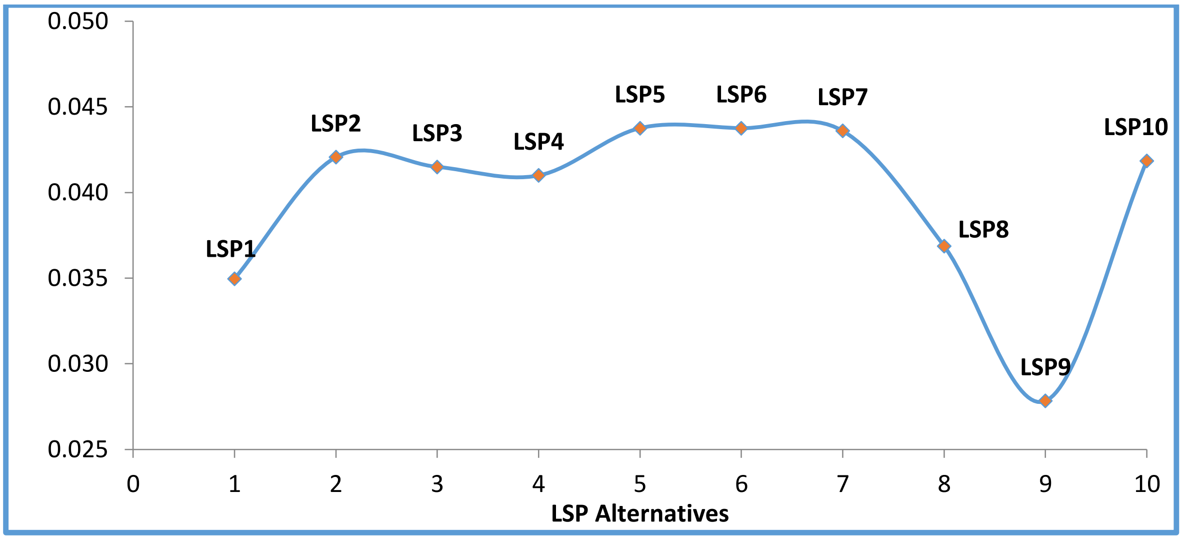

Figure 9- 4: LSPs Final Ranking (FTOPSIS technique) (1st Case Study)

Both, FQFD and FTOPSIS techniques provide the same LSPs final rank, but FTOPSIS technique through comparing alternatives with the aspiration level can provide more detail regarding development areas that each LSP alternative needs to consider. LSPs rankings under each criterion (dimension) give the DMs another opportunity to classify LSP alternatives based on their ranking frequencies. Giving the first ranking 10 points weight, the second one 9 points and so on produces a total score out of 210. Table 9-11 and Figure 9-5 summarise the total scores of the LSPs based on their weighted frequencies.

Table 9- 11: LSPs Total Scores based on their Weighted Ranking Frequencies (1st Case Study)

#	LSP Alternatives	First	Second	Third	Fourth	Fifth	Sixth	Seventh	Eighth	Ninth	Tenth	Total Score
1	**LSP1**	0	1	0	1	0	0	2	6	8	3	**61**
2	**LSP2**	2	0	1	2	8	3	5	0	0	0	**125**
3	**LSP3**	3	0	0	5	4	5	3	1	0	0	**129**
4	**LSP4**	0	1	1	1	3	6	6	2	1	0	**104**
5	**LSP5**	14	4	1	1	1	0	0	0	0	0	**197**
6	**LSP6**	1	15	3	1	1	0	0	0	0	0	**182**
7	**LSP7**	1	0	15	4	1	0	0	0	0	0	**164**
8	**LSP8**	0	0	0	0	0	1	3	9	8	0	**60**
9	**LSP9**	0	0	0	0	0	0	0	0	3	18	**24**
10	**LSP10**	0	0	0	6	3	6	2	3	1	0	**109**

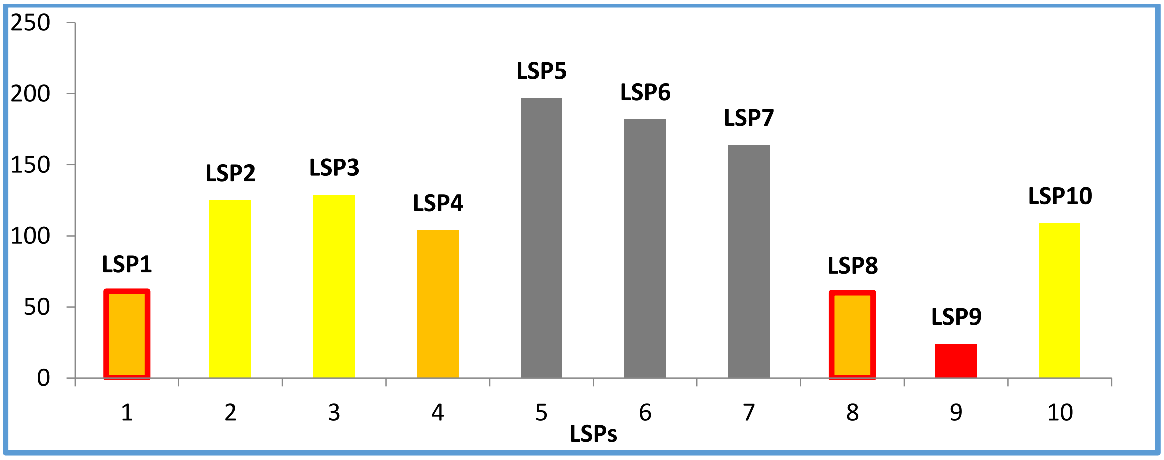

Figure 9- 5: First Case Study LSPs Rankings (Weighted Ranking Frequencies)

This case study helped to demonstrate the applicability of the new hybrid model and showed some of its potential to evaluate and select the best LSPs that are capable of helping and supporting firms to achieve their strategic objectives effectively and efficiently. Moreover, this analysis helped the firm to recognise their LSPs' strengths and weaknesses strategically. Based on the case study findings, a special report has been developed and presented to the board of directors to be used in their logistics outsourcing processes. The following sections provide a gap analysis of the framework and case study weights.

9.2.6. First Case-Study Gap analysis

Based on the stakeholders' evaluations of the firm's strategic objectives, logistics requirements and ISFs, there are some differences in the final rankings and relative weights of the 21 ISFs. Table 9-12 summarises the differences between the case study and the general framework weights. Figure 9-6 clarifies their gaps. Taking 40% as the threshold of acceptable variance can classify gaps into three groups: acceptable, overestimated and underestimated.

Table 9- 12: Weights Differences of the First Case and the General Framework

#	LSPs Evaluation Criteria (ISFs)	Case study	Framework	Deviation	%	Deviation Acceptance
1	Returns	0.05005	0.0418	0.0083	0.1655	Good
2	Logistics Costs	0.0451	0.0408	0.0043	0.0948	Good
3	Service Quality & Reliability	0.0510	0.0433	0.0077	0.1502	Good
4	Service Flexibility	0.0473	0.0417	0.0056	0.1193	Good
5	Logistics Processes Quality	0.0529	0.0291	0.0238	0.4507	Over est.
6	Logistics Processes Productivity	0.0510	0.0283	0.0227	0.4450	Over est.
7	Processes Sustainability	0.0542	0.0281	0.0261	0.4811	Over est.
8	Human Talent	0.0586	0.0848	-0.0262	0.4470	Under est.
9	Physical Warehousing Resources	0.0493	0.0430	0.0062	0.1262	Good
10	Production & Packaging Resources	0.0472	0.0396	0.0076	0.1618	Good
11	Information Technology Resources	0.0511	0.0826	-0.0316	0.6183	Under est.
12	Human Resource Education	0.0562	0.0590	-0.0028	0.0505	Good
13	Information Sharing	0.0368	0.0568	-0.0199	0.5414	Under est.
14	Databases and Software	0.0435	0.0495	-0.0060	0.1381	Good
15	Flow-Out Warehousing Activities	0.0490	0.0561	-0.0071	0.1458	Good
16	Outbound Transportation Activities	0.0455	0.0578	-0.0123	0.2709	Good
17	Labelling Services	0.0327	0.0548	-0.0220	0.6731	Under est.
18	Order management and Fulfilment	0.0441	0.0299	0.0142	0.3209	Good
19	Help Desk Services	0.0434	0.0270	0.0164	0.3782	Good
20	e-Logistics Services	0.0432	0.0525	-0.0094	0.2168	Good
21	Logistics Risks Assessment	0.0481	0.0535	-0.0055	0.1142	Good

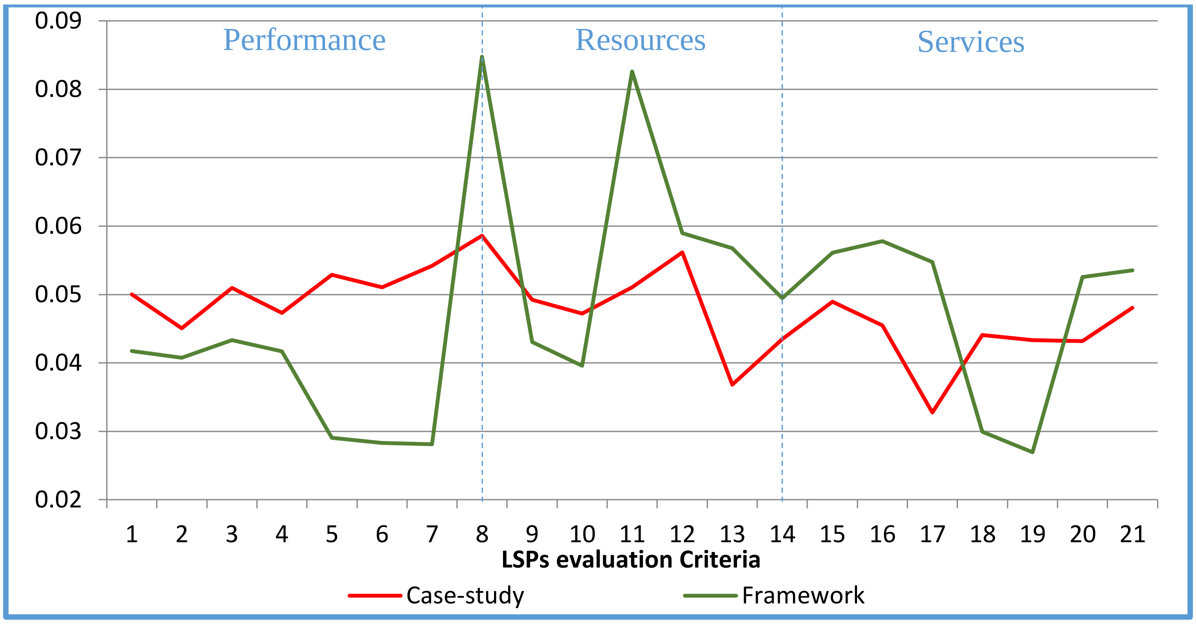

Figure 9- 6: Criteria Weights - Gap Analysis (1st Case Study)

In general, most of the case study's performance criteria weights (C1:C8) are higher than the framework weights. In addition, most of the service criteria weights (C15:C21) are lower than the framework weights, meanwhile resources and capabilities criteria weights (C9:C14) are interchangeable. However, not all these gaps are significant. Individually, there are some significant gaps between the case study weights and the general framework weights. The fifth, sixth and the seventh criteria are overestimated by the case study, whiles, the eighth, eleventh, thirteenth and the seventeenth criteria are underestimated. Weight differences between the general experts and stakeholders' evaluations are explained by:

- In the general framework, Experts group provided general evaluations that weren't based on a specific case-study context.
- Experts group used both, LSUs and LSPs perspectives, while the case study represents the LSUs perspective only.
- Experts group provided evaluations based on their experiences and preferences without linking them with specific strategic objectives and logistics requirements.
- Each firm (case study) has different strategic objectives and logistics requirements and in turn it is not expected to have the same evaluations and weights.
- Even in some cases if firms have similar strategic objectives and/or logistics requirements, the relative weights cannot be the same and in turn, the final criteria weights are different too.

- This case study is a manufacturing firm, which can explain the overestimated weights of the process-based criteria (C5, C6 and C7). While experts' evaluations are based on a general view that can be used in various situations and for various firms, that's why they give high weights for human and information based criteria (C8, C11, C13 and C17) that important for all.
- Framework general weights represent the general case that can fit with most firms, where each firm can customise weights according to their strategic objectives and/or logistics requirements, which increases the framework flexibility and its usage potentials.

Therefore the general experts' weights based on accumulated experiences without linking them to specific strategic objectives and/or logistics requirements are more generalizable and can be used in various situations.

9.3. Second Case Study: Downstream LSU

9.3.1. Second Case Background

The second case specialises in food manufacturing with a wide range of frozen and chilled products. With nine production lines and more than 70 years of experience, this firm is considered among the biggest food companies in the Middle East. All products are manufactured according to a number of international standards and specifications such as Food safety management system (ISO22000:2005), Quality management system (ISO9001:2000) and European food safety inspection services (EFSIS). Huge production quantities and high quality standards requirements required world-class logistics networks. This firm deals with a number of non-genetically modified raw materials suppliers. Therefore, for safety and health issues each supplier takes the logistics responsibilities for its raw materials. For the same health and safety issues, the case study performs all the logistics activities and services inside Jordan internally. In addition to the local market, the firm deals with a huge network of dealers and agents in most of the Middle East countries.

After a series of communications with the firm's managers, the company accepted to participate in this research. They asked to use the new hybrid model to evaluate the 'logistics' side for some of their suppliers and to evaluate some of their LSPs outside Jordan. A number of managers that have a say in evaluating and selecting suppliers and LSPs were invited to participate in a special meeting for this study. Based on the meeting outputs, a single response has been provided regarding the needed information. The following sections provide more detail regarding the case study strategic objective, logistics requirements and LSPs evaluation. The firm's response is considered as the average of experts' evaluations. The managers (Stakeholders) who participated in this meeting are: Financial manager, Regional Marketing Manager, Operations Manager and Purchase Manager.

9.3.2. Second Case Strategic Objectives:

The stakeholders use the main Peter Drucker strategic objective areas (Drucker 1974; 2011) to identify their strategic objectives and their relative importance. Nearly all the strategic areas are equally important. Table 9-13 summarises the fuzzy and defuzzified rating of these objectives and their final weight. Although all the areas have the same final weight, the fuzzy rating shows more interest about Market position, Innovation, Productivity and social responsibility. The strategic objectives' equal weight reflects a balanced strategic-view and supports the firm's efforts to strength their competitive advantage and market position.

Table 9- 13: Strategic Objectives (2nd Case Study)

#	Strategic Objective Areas	Fuzzy Rating	Defuzzified Rating	weight
1	Profitability	(0.5, 0.75, 1)	0.75	0.125
2	Financial Resources	(0.5, 0.75, 1)	0.75	0.125
3	Market Position	(0.75, 1, 1)	0.75	0.125
4	Innovation	(0.75, 1, 1)	0.75	0.125
5	Productivity	(0.75, 1, 1)	0.75	0.125
6	Physical resources	(0.5, 0.75, 1)	0.75	0.125
7	Human Resources	(0.5, 0.75, 1)	0.75	0.125
8	Social Responsibility	(0.75, 1, 1)	0.75	0.125
9	Excellent Handling process/equipment	(0.5, 0.75, 1)	0.75	0.125
10	Customer Satisfaction	(0.5, 0.75, 1)	0.75	0.125

9.3.3. Second Case Logistics Requirements

In terms of logistic requirements, the same list used in the first case study has been used here. The stakeholders accepted all the requirements except 'Providing guidance on time'. Table 9-14 lists the logistics requirements used in this case study. The relative importance of these requirements is evaluated based on their contribution to achieve the firm's strategic objectives. The next section applies the FQFD techniques to link the second case study strategic objectives with the logistics requirements and ISFs.

Table 9- 14: Logistics Requirements (2nd Case Study)

#	Logistics Requirements
1	Reduce Total Logistics Costs
2	Reduce Cycle Time
3	Assure Quality in Distribution Delivery
4	Acquire the Needed Logistics Resources and Capabilities
5	Possess State-of-the Art Hardware and Software
6	Provide Customised Logistics Services
7	Able to Provide Value-added Logistics Services
8	Increase Customer Satisfaction
9	Able to Resolve Problems Effectively
10	Able to Assess Logistics Risks
11	Able to Build and Sustain Long-term Collaborations

9.3.4. Second Case HOQs

The FQFD technique is used to find the relative importance of the logistics requirements and the LSPs evaluation criteria (ISFs), which in turn are used to find the final ranking of the LSP alternatives. The weighted ‘WHATs’ and ‘HOWs’ relationships are used to find the ‘HOWs’ relative weights. The first HOQ’s outputs are used as the next HOQ’s inputs. HOQ1 provides the logistics requirements’ weights through analysing the strategic objectives-logistics requirement relationships, while, HOQ2 provides the LSPs evaluation criteria by analysing the logistics requirements-LSPs evaluation criteria relationships. The final house (HOQ3) provides the LSP alternatives scores and rankings.

HOQ1 – First Matrix

Stakeholders are asked to evaluate the strategic objective-logistics requirements relationships using the linguistic variables (Table 8-4). For each strategic objective, each stakeholder evaluated the extent to which each logistics requirement is important to achieve each strategic objective. At the end, stakeholders agreed upon one evaluation for each strategic objective-logistics requirement relationship. Table 9-15 shows the stakeholders’ evaluations of the ‘Profitability-logistics requirements relationships.

Table 9- 15: Strategic Objective-Logistics Requirement Relationships (2nd Case Study)

#	Strategic Objectives	Logistics Requirement										
		1	2	3	4	5	6	7	8	9	10	11
1	Profitability	SR	Mo	Mo	Mo	Low	Mo	Mo	SR	VSR	Low	SR
2	Financial Resources	Mo	Mo	Low	No	Mo	No	VSR	SR	Mo	Mo	Mo
3	Market Position	Low	SR	SR	VSR	SR	Mo	Low	SR	SR	Mo	Mo
4	Innovation &	Mo	VSR	SR	Low	Low	Mo	Low	Low	Low	No	Mo
5	Productivity	SR	VSR	Mo	Mo	VSR	SR	SR	Mo	Mo	Low	Low
6	Physical Resources	Mo	Mo	VSR	Mo	Mo	VSR	Mo	SR	Mo	Mo	Low
7	Human Resources	Mo	Low	Mo	SR	VSR	VSR	SR	VSR	VSR	Mo	SR
8	Social Responsibilities	Mo	Mo	Low	Mo	No	Mo	Mo	Mo	No	SR	Mo

VSR: very strong relation. SR: strong relation. Mo: moderate relation. Low: low relation. No: No relation

In addition to the strategic objectives weights (9-13), the average fuzzy evaluations of the strategic objectives and logistics requirements relationships are used to establish the HOQ1 (Steps 4, 5 and 6 of the FQFD procedures). Equation 8-3 and Equation 8-4 are used find the final logistics requirement weights, summarised in Table 9-16.

Table 9- 16: Logistics Requirements Weights (2nd Case Study)

#	Logistics Requirements	Fuzzy importance Rating			Defuzzified	Weight
1	Reduce Total Logistics Costs	(0.2813,	0.53125,	0.7813)	0.5313	0.0904
2	Reduce Cycle Time	(0.375,	0.625,	0.8125)	0.5775	0.0983
3	Assure Quality in Distribution -	(0.3125,	0.5625,	0.7813)	0.5389	0.0918
4	Acquire the Needed Logistics	(0.2813,	0.5,	0.7188)	0.500	0.0851
5	Possess State-of-the Art	(0.3125,	0.53125,	0.7188)	0.5077	0.0864
6	Provide Customised Logistics	(0.375,	0.59375,	0.7813)	0.5702	0.0971
7	Able to Provide Value-added	(0.3125,	0.5625,	0.7813)	0.5389	0.0918
8	Increase Customer Satisfaction	(0.4063,	0.65625,	0.875)	0.6327	0.1077
9	Able to Resolve Problems	(0.3438,	0.5625,	0.75)	0.5389	0.0917
10	Able to Assess Logistics Risks	(0.1875,	0.40625,	0.6563)	0.4142	0.0707
11	Able to Build and Sustain Long-	(0.250,	0.500,	0.750)	0.500	0.0851

It is clear that logistics requirements are not equally important for this firm. ‘Increase customer satisfaction’, ‘Reduce cycle time’ and ‘Provide customised logistics services’ have the biggest contribution in achieving the firm’s strategic objectives. Meanwhile, the LSP capability to assess logistics risk has the lowest weight and therefore, the lowest contribution to achieve the firm’s strategic objectives.

HOQ2 – Second Matrix

In addition to the logistics requirement weights (Table 9-16), Stakeholders use the linguistic variables in Table 8-4 to evaluate the logistics requirement-LSP ISFs relationships (HOQ2) as is shown in Table 9-17. Steps 7, 8 and 9 of the FQFD procedures are applied using Equation 8-5 and Equation 8-6 to find the final LSPs ISFs. Table 9-18 summarised the weights of the second case ISFs.

Based on stakeholders’ evaluations, ‘Logistics services’ dimension is more important than logistics performance and logistics resources dimensions. ‘Order management & fulfilment’ and ‘Labelling services’ are the most important criteria, followed by ‘Outbound transportation’ and ‘Flow-out warehousing activities’. Meanwhile, ‘Help desk’ and ‘Physical production & Packaging resources’ have the fifth and sixth ranking respectively.

Table 9- 17: HOQ2 (2nd Case Study)

#	Logistics Requirements	LSPs ISFs																				
		C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**	**C12**	**C13**	**C14**	**C15**	**C16**	**C17**	**C18**	**C19**	**C20**	**C21**
1	Reduce Total Logistics Costs	SR	VSR	VSR	LOW	MO	MO	MO	LOW	SR	MO	VSR	MO	MO	VSR	SR	SR	SR	SR	SR	VSR	VSR
2	Reduce Cycle Time	LOW	VSR	MO	MO	MO	VSR	SR	SR	MO	VSR	MO	MO	MO	MO	SR	SR	SR	SR	MO	MO	SR
3	Assure Quality in Distribution	LOW	VSR	MO	LOW	NO	SR	MO	NO	LOW	SR	MO	MO	MO	MO	SR	MO	SR	SR	MO	SR	SR
4	Acquire the Needed Logistics	SR	VSR	SR	VSR	MO	MO	SR	LOW	SR	SR	MO	VSR	SR	VSR	MO	MO	SR	VSR	VSR	LOW	VSR
5	Possess State-of-the Art Hardware	SR	MO	LOW	SR	MO	MO	MO	MO	MO	VSR	SR	SR	SR	SR	MO	SR	SR	SR	VSR	MO	LOW
6	Provide Customised	MO	MO	MO	LOW	SR	VSR	VSR	SR	LOW	SR	SR	MO	MO	SR	MO	SR	SR	SR	MO	MO	MO
7	Able to Provide Value-added	MO	SR	SR	LOW	SR	MO	SR	SR	VSR	SR	MO	SR	MO	MO	VSR	VSR	SR	SR	SR	MO	MO
8	Increase Customer Satisfaction	MO	MO	VSR	SR	LOW	LOW	MO	LOW	SR	SR	SR	SR	MO	LOW	SR	MO	SR	SR	SR	LOW	MO
9	Able to Resolve Problems	VSR	SR	LOW	MO	MO	SR	LOW	SR	SR	MO	MO	SR	MO	SR	SR	VSR	MO	SR	SR	MO	MO
10	Able to Assess Logistics Risks	SR	SR	MO	MO	VSR	SR	LOW	MO	SR	MO	SR	SR	SR	SR	SR	SR	MO	SR	MO	LOW	MO
11	Able to Build and Sustain Long-term	VSR	SR	SR	MO	MO	VSR	MO	LOW	SR	VSR	MO	LOW	MO	MO	SR	VSR	SR	SR	MO	MO	LOW

VSR: very strong relation. SR: strong relation. MO: moderate relation. LOW: low relation. NO: NO relation

Table 9- 18: ISFs Weights (2nd Case Study)

#	ISFs	Fuzzy importance Rating	Defuzzified	Weight
1	Returns	(0.3750, 0.6250, 0.8308)	0.5916	0.0463
2	Logistics Costs	(0.5186, 0.7686, 0.9272)	0.6986	0.0546
3	Service Quality & Reliability	(0.3700, 0.6200, 0.8205)	0.5825	0.0456
4	Service Flexibility	(0.2483, 0.4983, 0.7271)	0.4823	0.0377
5	Logistics Processes Quality	(0.2846, 0.5117, 0.7430)	0.5127	0.0401
6	Logistics Processes Productivity	(0.4278, 0.6778, 0.8577)	0.6245	0.0488
7	Processes Sustainability	(0.3258, 0.5758, 0.8015)	0.5575	0.0436
8	Human Talent	(0.2297, 0.4567, 0.7067)	0.4625	0.0362
9	Physical Warehousing Resources	(0.3823, 0.6323, 0.8594)	0.6151	0.0481
10	Physical Production & Packaging Resources	(0.5033, 0.7533, 0.9358)	0.7020	0.0549
11	Physical Information Technology Resources	(0.3867, 0.6367, 0.8640)	0.6196	0.0485
12	Human Resource Education	(0.3843, 0.6343, 0.8630)	0.6183	0.0484
13	Information Sharing	(0.3115, 0.5615, 0.8115)	0.5615	0.0439
14	Databases and Software	(0.3983, 0.6483, 0.8544)	0.6151	0.0481
15	Flow-Out Warehousing Activities	(0.4558, 0.7058, 0.9328)	0.6885	0.0539
16	Outbound Transportation Activities	(0.4960, 0.7460, 0.9289)	0.6949	0.0544
17	Labelling Services	(0.4584, 0.7084, 0.9584)	0.7084	0.0554
18	Order management and Fulfilment	(0.5213, 0.7713, 1.0000)	0.7553	0.0591
19	Help Desk Services	(0.4312, 0.6812, 0.8883)	0.6488	0.0508
20	e-Logistics Services	(0.2513, 0.5013, 0.7287)	0.4843	0.0379
21	Logistics Risks Assessment	(0.3424, 0.5924, 0.7985)	0.5592	0.0437

HOQ3 – Third Matrix

In HOQ3, stakeholders use the weighted ISFs (Table 9-18) to evaluate ten logistics partners. The first five partners are the main suppliers of this firm, meanwhile the second five partners are the firm's agents network and LSPs who store, distribute and deliver the firm's product in the Middle East region. The fuzzy average of the stakeholders' evaluations in addition to the ISFs weights are used to establish the HOQ3, meanwhile, Equation 7-7 is used to find the final LSPs fuzzy total scores and then defuzzified by Equation 3-11. Table 9-19 summarises the final scores and rankings of the second case study LSPs. Meanwhile Figure 9-7 shows their final rankings of the second case study logistics partners (suppliers and LSPs).

Table 9- 19: LSPs Scores and Rankings (2nd Case Study)

#	Type	Fuzzy Rating	Defuzzified	Final Score	Overall Rank	Type Rank
1	Supplier	(0.2781, 0.5025, 0.7415)	0.5062	0.0855	9	5
2	Supplier	(0.4471, 0.6851, 0.8817)	0.6538	0.1104	2	1
3	Supplier	(0.4655, 0.6898, 0.8536)	0.6438	0.1087	4	2
4	Supplier	(0.3631, 0.6016, 0.8402)	0.6016	0.1016	6	4
5	Supplier	(0.3988, 0.6488, 0.8673)	0.6250	0.1055	5	3
6	LSP	(0.4229, 0.6729, 0.8980)	0.6541	0.1105	1	1
7	LSP	(0.3652, 0.6152, 0.8124)	0.5752	0.0971	7	3
8	LSP	(0.4264, 0.6764, 0.8898)	0.6488	0.1096	3	2
9	LSP	(0.2556, 0.4725, 0.7036)	0.4760	0.0804	10	5
10	LSP	(0.2869, 0.5369, 0.7869)	0.5369	0.0907	8	4

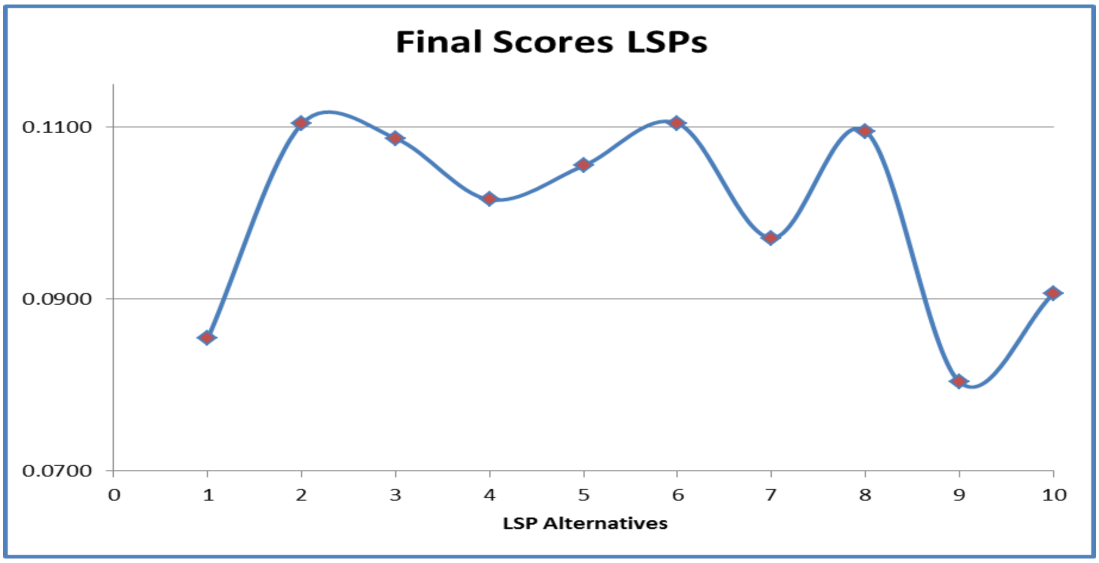

Figure 9- 7: LSPs Scores – FQFD (2nd Case Study)

9.3.5. Second Case Gap analysis

According to the second case study stakeholders' evaluations of the firm's strategic objectives, logistics requirements and LSPs ISFs, there are some differences in the final rankings and relative weights of the 21 ISFs compared with FDEMATEL outputs. Table 9-20 summarises the differences between the second case study and the general framework weights. Comparing these results with the first case study gap analysis shows that, both case studies overestimate the importance of the C5, 6 and 7 (logistics process quality, productivity and sustainability criteria respectively) which confirms the idea that most firms focus on the operational factors in their logistics outsourcing process. Additionally, both case studies underestimate the high importance of the 'Human talent' and 'Information sharing' criteria. Figure 9-8 clarifies gaps between the case study and the framework weights.

Table 9- 20: Differences between the Second Case and the FDEMATEL Outputs

#	LSPs Evaluation Criteria (ISFs)	Case study	Framework	Deviation	%	Deviation Acceptance
1	Returns	0.04628	0.0418	0.005	0.108	Good
2	Logistics Costs	0.05465	0.0408	0.014	0.340	Good
3	Service Quality & Reliability	0.04557	0.0433	0.002	0.052	Good
4	Service Flexibility	0.03773	0.0417	-0.004	0.095	Good
5	Logistics Processes Quality	0.04011	0.0291	0.011	0.381	Good
6	Logistics Processes Productivity	0.04885	0.0283	0.021	0.724	Over est.
7	Processes Sustainability	0.04361	0.0281	0.015	0.551	Over est.
8	Human Talent	0.03618	0.0848	-0.049	0.573	Under est.
9	Physical Warehousing Resources	0.04811	0.0430	0.005	0.118	Good
10	Production & Packaging Resources	0.05491	0.0396	0.015	0.387	Good
11	Information Technology Resources	0.04847	0.0826	-0.034	0.413	Under est.
12	Human Resource Education	0.04837	0.0590	-0.011	0.180	Good
13	Information Sharing	0.04393	0.0568	-0.013	0.226	Good
14	Databases and Software	0.04812	0.0495	-0.001	0.028	Good
15	Flow-Out Warehousing Activities	0.05386	0.0561	-0.002	0.040	Good
16	Outbound Transportation Activities	0.05436	0.0578	-0.003	0.060	Good
17	Labelling Services	0.05542	0.0548	0.001	0.012	Good
18	Order management and Fulfilment	0.05908	0.0299	0.029	0.973	Over est.
19	Help Desk Services	0.05075	0.0270	0.024	0.883	Over est.
20	e-Logistics Services	0.03789	0.0525	-0.015	0.279	Good
21	Logistics Risks Assessment	0.04375	0.0535	-0.010	0.183	Good

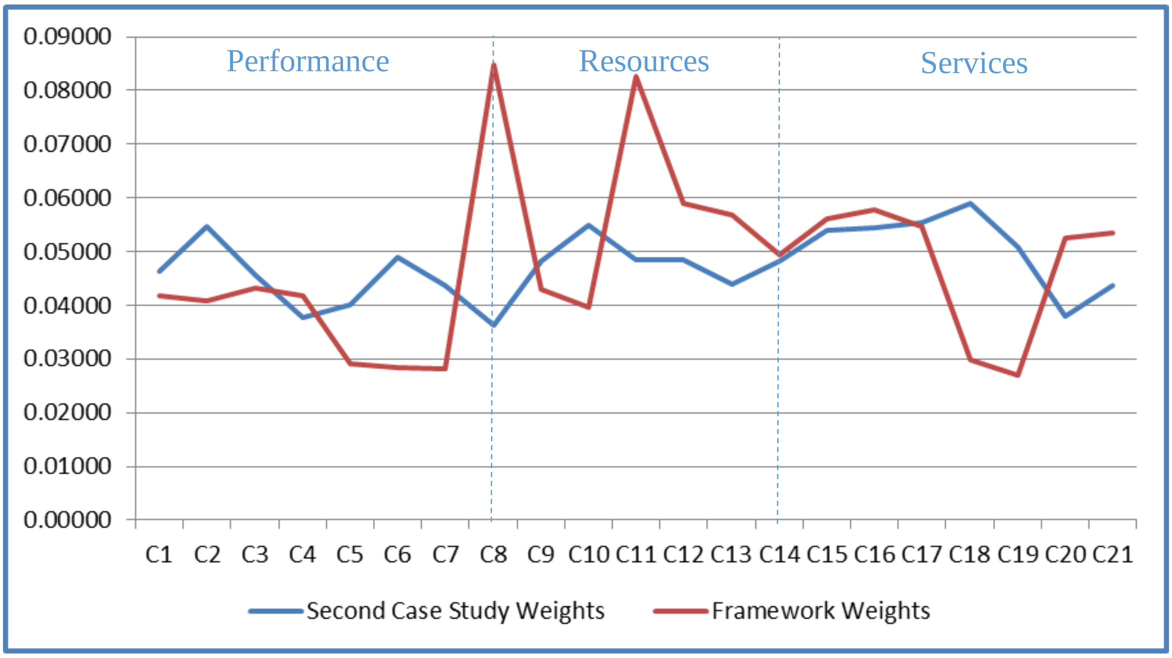

Figure 9- 8: Gap Analysis (2nd Case Study)

9.4. Comparison of the Upstream/Downstream Cases

Taking the HOQs' outputs together helps to identify impact-relationships between the firm's strategic objectives, logistics requirements and the LSPs' ISFs for the two case studies.

9.4.1. Case 1 Strategic Objective-Logistics Requirements-ISFs Relationships

Back to HOQ1 of the first case study, by defuzzifying the DMs' evaluations of the strategic objectives - logistics requirements relationships and taking the average as a threshold for each strategic objective, one can identify exactly which logistics requirements are crucial to achieve which strategic objective. The shaded cells in Appendix 9-2 represent these crucial requirements. It is clear that, the logistics requirements 5, 8, 10, 14 and 15 are the most important ones, which complements the case study logistics requirement weights (9-16). Crucial logistics requirements for each strategic objective are:

- For 'Profitability', crucial logistics requirements are 1, 5, 7, 8, 9, 10, 12, 13, 14 and 15. While the top five logistics requirements are: Possess state-of-the art hardware & software, Increase customer satisfaction, resolve problems effectively, continuous measuring of results and reduce total logistics costs.
- For 'Financial Resources', crucial logistics requirements are 1, 2, 4, 5, 8, 12, 13 and 14. While the top requirements are: Reduce total logistics costs and acquiring the needed logistics resources and capabilities.

- For 'Market position', crucial logistics requirements are 4, 5, 6, 7, 8, 9, 12, 13, 14 and 15. While the top requirement is 'Increase customer satisfaction' followed by possess state-of-the art hardware & software and continuous measuring of results.
- For 'Innovation', crucial logistics requirements are 2, 3, 5, 7, 8, 9, 10, 11 and 15. While the top requirement is 'continuous measuring of results' followed by reduce cycle time, increase customer satisfaction, provide guidance on time and resolve problems effectively.
- For 'Productivity', crucial logistics requirements are 2, 3, 5, 8, 9, 10, 12, 14 and 15. While the top requirements are 'reduce cycle time' and 'continuous measuring of results'.
- For 'Physical resources', crucial logistics requirements are 2, 3, 5, 7, 10, 11 and 15. The top logistics requirement is 'Possess state-of-the art hardware & software'.
- For 'Human resources', logistics requirements 2, 5, 10, 11, 12, 13, 14 and 15 are crucial, particularly 'Resolve problems effectively' and 'Build and sustain long-term collaborations'.
- Meanwhile, 'Acquiring the needed logistics resources and capabilities' and 'Resolve problems effectively' are the top logistics requirements for 'Social responsibility'.

In HOQ2, taking the average of defuzzified DMs' evaluations of the logistics requirements-LSPs criteria relationships as a threshold helps to identify which LSPs criteria are crucial to provide which logistics requirements. Shaded cells in Appendix 9-3 summarise these crucial criteria for each logistics requirement. Some of the LSPs' evaluation criteria are crucial for most of the logistics requirements, such as C8 (Human Talent), C12 (Human resources), C5 (Processes quality), C6 (Processes productivity) and C7 (Processes sustainability). While, C13 (Information sharing) is somehow crucial for three logistics requirements (Resolve problems effectively, Assess logistics risks and Build and sustain long-term collaborations) and C17 is somehow crucial for 'Customer satisfaction'. Understanding these relations helps DMs to identify 'Key' factors under each dimension and therefore, support them in their strategic logistics outsourcing decisions. Table 9-21 summarises the strategic objectives with some of their most crucial logistics requirements and evaluation criteria.

Table 9- 21: Strategic Objectives, Crucial Logistics Requirements and ISFs (1st Cast Study)

#	Strategic Objectives	Crucial Logistics Requirements	Crucial ISFs
1	**Profitability**	Possess state-of-the art (hardware & software)	Human Talent
			Flow-Out Warehousing Activities
			Processes Sustainability and Physical Information Technology Resources
		Increase customer satisfaction	Human Resource Education
			Order management and Fulfilment
			Logistics Risks Assessment
		Resolve problems effectively	Logistics Processes Quality, Processes Sustainability, Human Talent, Human Resource Education and Logistics Risks Assessment
		Continuous measuring of results	Human Talent
			Physical Information Technology Resources
			Service Quality & Reliability
		Reduce total logistics costs	Logistics Processes Quality
			Processes Sustainability
			Human Talent
2	**Financial Resources**	Reduce total logistics costs	See ‘Reduce total logistics cost’ under ‘Profitability’
		Acquiring the needed logistics resources and capabilities	Logistics Costs
			Returns
			Human Talent
3	**Market Position**	Increase customer satisfaction	See ‘Increase customer satisfaction’ under ‘Profitability’
		Possess state-of-the art hardware & software	See ‘Possess state of art…’ under ‘Profitability’
		Continuous measuring of results	See ‘Continuous measuring …’ under ‘Profitability’
4	**Innovation**	Continuous measuring of results	See ‘Continuous measuring …’ under ‘Profitability’
		Reduce cycle time	Logistics Processes Quality and Logistics Processes Productivity
			Processes Sustainability, Human Resource-Education and Flow-Out Warehousing Activities
		Increase customer satisfaction	See ‘Increase customer satisfaction’ under ‘Profitability’
		Provide guidance on time	Human Talent
			Logistics Processes Quality
			Outbound Transportation Activities and Logistics Risks Assessment
		Resolve problems effectively	See ‘Resolve problems effectively’ under ‘Profitability’

Continue ➔

#	Strategic Objectives	Crucial Logistics Requirements	Crucial ISFs
5	**Productivity**	Reduce cycle time	See ‘Reduce cycle time’ under ‘Innovation’
		Continuous measuring of results	See ‘Continuous measuring …’ under ‘Profitability’
6	**Physical resources**	Possess state-of-the art hardware & software	See ‘Possess state of art …’ under ‘Profitability’
7	**Human Resources**	Resolve problems effectively	See ‘Resolve problems effectively’ under ‘Profitability’
		Build and sustain long-term collaborations	Human Resource Education
			Processes Sustainability
			Order management and Fulfilment
8	**Social Responsibility**	Acquiring the needed logistics resources and capabilities	See ‘Acquiring the needed…’ under ‘financial resources’
		Resolve problems effectively	See ‘Resolve problems effectively’ under ‘Profitability’

9.4.2. Case 2 Strategic Objective-Logistics Requirements-ISFs Relationships

Back to the first case study HOQ1, by defuzzifying the DMs’ evaluations of the strategic objectives - logistics requirements relationships and taking the average as a threshold for each strategic objective, crucial logistics requirements can be identified. The shaded cells in Appendix 9-4 represent these crucial requirements. It is clear that, the logistics requirement #8 (Increase customer satisfaction) are the most important ones followed by requirements # 1, 2, 5, 6, 9 and 11. Each strategic objective has various logistics requirements:

- For ‘Profitability’, crucial logistics requirements are # 1, 8, 9 and 11 with the same level of influence and importance.
- For ‘Financial Resources’, crucial logistics requirements are # 1, 2, 5, 7, 8, 9, 10 and 11. While the top requirements are: #7 (Able to provide value-added logistics services) and #8 (Increase customer satisfaction).
- For ‘Market position’, crucial logistics requirements are # 2, 3, 4, 5, 8 and 9 with the same level of influence and importance.
- For ‘Innovation’, crucial logistics requirements are # 1, 2, 3, 6 and 11. While the top requirements are: # 2 (Reduce cycle time) and #3 (Assure quality in distribution/delivery).
- For ‘Productivity’, crucial logistics requirements are # 1, 2, 5, 6 and 7 with nearly the same level of influence and importance.
- For ‘Physical resources’, crucial logistics requirements are # 3, 6 and 8 with the same level of influence and importance.

- For ‘Human resources’, logistics requirements # 4, 5, 6, 7, 8, 9 and 11 are most crucial ones with the same level of influence and importance.
- For ‘Social responsibility’, logistics requirements # 1, 2, 4, 6, 7, 8, 10 and 11 are the most crucial ones. The top requirement is #10 (Able to assess logistics risks).

In HOQ2, taking the average of defuzzified DMs’ evaluations of the logistics requirements-ISFs relationships as a threshold helps to identify which LSPs criteria are crucial to provide which logistics requirements for this case study. Shaded cells in Appendix 9-5 summarise these crucial criteria for each logistics requirement. C18 (Order management and fulfilment) is crucial for all the logistics requirements. Meanwhile, C20 (e-logistics services) is important for two requirements (#1 reduce total logistics costs and #3 assure quality in distribution and delivery). In addition to C18, C16 and C17 are highly important ISFs that support a large number of the logistics requirements. C16 (Outbound transportation) is crucial for all the logistics requirements except requirements # 4 and 8. Meanwhile C17 (Labelling services) is crucial for all the logistics requirements except requirements # 9 and 10. Moreover, C2, C10 and C15 are important ISFs for eight logistics requirements, followed by C9, C11, C12 and C13 which are important for seven logistics requirements. In this case study, ‘Increase customer satisfaction’ is the most important logistics requirement. For this requirement, ISFs # 3, 4, 9-12, 15 and 17-19 (Service quality and reliability, Service flexibility, Physical warehousing resources, production & packaging resources, Information technology resources, Human resources/education, Flow-out warehousing activities, Labelling services, Order management and fulfilment and Help desk) are the most important ones. Therefore, downstream LSUs need to contract with an LSP that has good records in these factors to satisfy their customers well. Table 9-22 summarises the strategic objectives with their most crucial logistics requirements and evaluation criteria (>0.5) for the second case study.

Table 9- 22: Strategic Objectives, Crucial Logistics Requirements and ISFs (2nd Cast Study)

#	Strategic Objectives	Crucial Logistics Requirements	Crucial ISFs
1	**Profitability**	R1: Reduce total logistics costs	C1, C2, C3, C9, C11, C14-C21
		R8: Increase customer satisfaction	C3, C4, C9-C12, C15, C17-19
		R9: Able to resolve problems effectively	C1, C2, C6, C8, C9, C12, C14-C16, C18, C19
		R11: Able to build and sustain long-term collaborations	C1-C3, C6, C9-C11, C15-C18
2	**Financial Resources**	R7: Able to provide value-added logistics services	C2, C3, C5, C7-C10, C12, C15-C19
		R8: Increase customer satisfaction	C3, C4, C9-C12, C15, C17-19
3	**Market Position**	R2: Reduce cycle time	C2, C6-8, C10, C15-C18, C21
		R3: Assure quality in distribution delivery	C2, C6, C7, C10, C15, C17, C18, C20, C21
		R4: Acquire the needed logistics resources and capabilities	C1-C4, C7, C9, C10, C12-C14, C17-C19, C21
		R5: Possess state-of-the art hardware and software	C1, C4, C10-C14, C16-C19
		R8: Increase customer satisfaction	C3, C4, C9-C12, C15, C17-19
		R9: Able to resolve problems effectively	C1, C2, C6, C8, C9, C12, C14-C16, C18, C19
4	**Innovation**	R2: Reduce cycle time	C2, C6-8, C10, C15-C18, C21
		R3: Assure quality in distribution delivery	C2, C6, C7, C10, C15, C17, C18, C20, C21
5	**Productivity**	R1: Reduce total logistics costs	C1, C2, C3, C9, C11, C14-C21
		R2: Reduce cycle time	C2, C6-8, C10, C15-C18, C21
		R5: Possess state-of-the art hardware and software	C1, C4, C10-C14, C16-C19
		R6: Provide customised logistics services	C5-C8, C10, C11, C14, C16-C18
		R7: Able to provide value-added logistics services	C2, C3, C5, C7-C10, C12, C15-C19
6	**Physical resources**	R3: Assure quality in distribution – delivery	C2, C6, C7, C10, C15, C17, C18, C20, C21
		R6: Provide customised logistics services	C5-C8, C10, C11, C14, C16-C18
		R8: Increase customer satisfaction	C3, C4, C9-C12, C15, C17-19

Continue ➔

#	Strategic Objectives	Crucial Logistics Requirements	Crucial ISFs
7	**Human Resources**	R4: Acquire the needed logistics resources and capabilities	C1-C4, C7, C9, C10, C12-C14, C17-C19, C21
		R5: Possess state-of-the art hardware and software	C1, C4, C10-C14, C16-C19
		R6: Provide customised logistics services	C5-C8, C10, C11, C14, C16-C18
		R7: Able to provide value-added logistics services	C2, C3, C5, C7-C10, C12, C15-C19
		R8: Increase customer satisfaction	C3, C4, C9-C12, C15, C17-19
		R9: Able to resolve problems effectively	C1, C2, C6, C8, C9, C12, C14-C16, C18, C19
		R11: Able to build and sustain long-term collaborations	C1-C3, C6, C9-C11, C15-C18
8	**Social Responsibility**	R10: Able to assess logistics risks	C1, C2, C5, C6, C9, C11-C16, C18

9.4.3. Results Comparison

Based on the outputs of the two case studies, comparing the upstream LSUs (First case) and downstream LSUs (second case) outputs provides more insights regarding the logistics outsourcing differences across the supply chain.

9.4.3.1. Strategic Objectives:

In term of strategic objectives, both upstream and downstream LSUs focus on the Peter Drucker eight strategic areas (Drucker 1974; 2011). Downstream LSUs treat these areas equally (9-13). Upstream LSUs give different weights and add new areas related to customer satisfaction and handling abilities (Table 9-1). The most important objectives for the upstream LSUs are productivity and human resources followed by financial resources and Profitability. Downstream LSUs deal with both, ultimately customers and suppliers directly. They try to balance between the eight strategic objective areas to achieve a kind of strategic balance that satisfies most of their stakeholders. Upstream LSUs are mainly suppliers and manufacturing firms that focused on productivity levels as the most important strategic area followed by ‘human resources’ to support the achievement of these productivity levels effectively and efficiently. Table 9-23 compares the strategic objectives importance for upstream and downstream supply chain.

Table 9- 23: Upstream-Downstream Strategic Objectives Importance

Importance for Upstream	Strategic Objective Areas	Importance for Downstream
0.1131	**Profitability**	0.1250
0.1180	**Financial Resources**	0.1250
0.0996	**Market Position**	0.1250
0.0865	**Innovation**	0.1250
0.1444	**Productivity**	0.1250
0.0975	**Physical resources**	0.1250
0.1301	**Human Resources**	0.1250
0.0460	**Social Responsibility**	0.1250
0.0927	**Excellent Handling process/equipment**	0.1250
0.0719	**Customer Satisfaction**	0.1250

9.4.3.2. Logistics Requirements:

Both case studies agree upon the listed logistics requirement to achieve the strategic objectives effectively and efficiently except 'Providing guidance on time' that was rejected by the downstream LSUs. The relative importance of these requirements is not the same. Upstream LSUs deal with 'Possess state-of-the art hardware and software', 'Continuous measuring of results', 'Increase customer satisfaction', 'Resolve problems effectively' and 'Strategic compatibility' as the most important requirements (Table 9-5). Meanwhile, downstream LSUs focus on 'Increase Customer Satisfaction' as the most important logistics requirement that LSPs must provide, followed by 'Reduce Cycle Time', 'Assure Quality in Distribution – Delivery', 'Provide Customised Logistics Services' and 'Able to Provide Value-added Logistics Services' (Table 9-16). It's clear that the upstream LSUs have a wider range of requirements that LSPs must possess to be considered as a strategic logistics partner. Both case studies share the interest of customer satisfaction as a crucial logistics requirement that any LSP should acquire. Table 9-24 compares the crucial logistics requirements for each strategic objective of the upstream and downstream supply chain.

Table 9- 24: Upstream-Downstream Crucial Logistics Requirements

Crucial Requirements for Upstream	Strategic Objective Areas	Crucial Requirements for Downstream
Possess state-of-the art hardware & software Increase customer satisfaction Resolve problems effectively Continuous measuring of results Reduce total logistics costs	**Profitability**	Reduce total logistics costs Increase customer satisfaction Able to resolve problems effectively Able to build and sustain long-term collaborations
Reduce total logistics costs Acquiring the needed logistics resources and capabilities	**Financial Resources**	Able to provide value-added logistics services Increase customer satisfaction
Increase customer satisfaction Possess state-of-the art hardware & software Continuous measuring of results	**Market Position**	Reduce cycle time Assure quality in distribution – delivery Acquire the needed logistics resources and capabilities Possess state-of-the art hardware and software Increase customer satisfaction Able to resolve problems effectively
Continuous measuring of results Reduce cycle time Increase customer satisfaction Provide guidance on time Resolve problems effectively	**Innovation**	Reduce cycle time Assure quality in distribution - delivery
Reduce cycle time Continuous measuring of results	**Productivity**	Reduce total logistics costs Reduce cycle time Possess state-of-the art hardware and software Provide customised logistics services Able to provide value-added logistics services

Continue ➔

Crucial Requirements for Upstream	Strategic Objective Areas	Crucial Requirements for Downstream
Possess state-of-the art hardware & software	**Physical resources**	Assure quality in distribution – delivery Provide customised logistics services Increase customer satisfaction
Resolve problems effectively Build and sustain long-term collaborations	**Human Resources**	Acquire the needed logistics resources and capabilities Possess state-of-the art hardware and software Provide customised logistics services Able to provide value-added logistics services Increase customer satisfaction Able to resolve problems effectively Able to build and sustain long-term collaborations
Acquiring the needed logistics resources and capabilities Resolve problems effectively	**Social Responsibility**	Able to assess logistics risks

9.4.3.3. ISFs

In terms of the evaluation and selection criteria (ISFs), both up and down streams agreed upon the 21 ISFs to identify the extent to which each LSP is capable of providing logistics requirements or not, and the extent to which each LSP is a good alternative to be a strategic logistics partner. Although both cases overestimate the importance of the fifth, sixth and seventh ISFs, the relative importance of other ISFs is not the same (Table 9-7 and Table 9-18). Upstream LSUs focus on the logistics performance and logistics resource ISFs (Logistics Processes Quality, Processes Sustainability, Human Talent, Human Resource Education and Physical Information Technology Resources). Downstream LSUs focus on the logistics service ISFs (Physical Production & Packaging Resources, Flow-Out Warehousing Activities, Outbound Transportation Activities, Labelling Services, Order management and Fulfilment and Help Desk Services). Figure 9-9 summarises the similarities and differences between up and down streams regarding the ISFs relative importance.

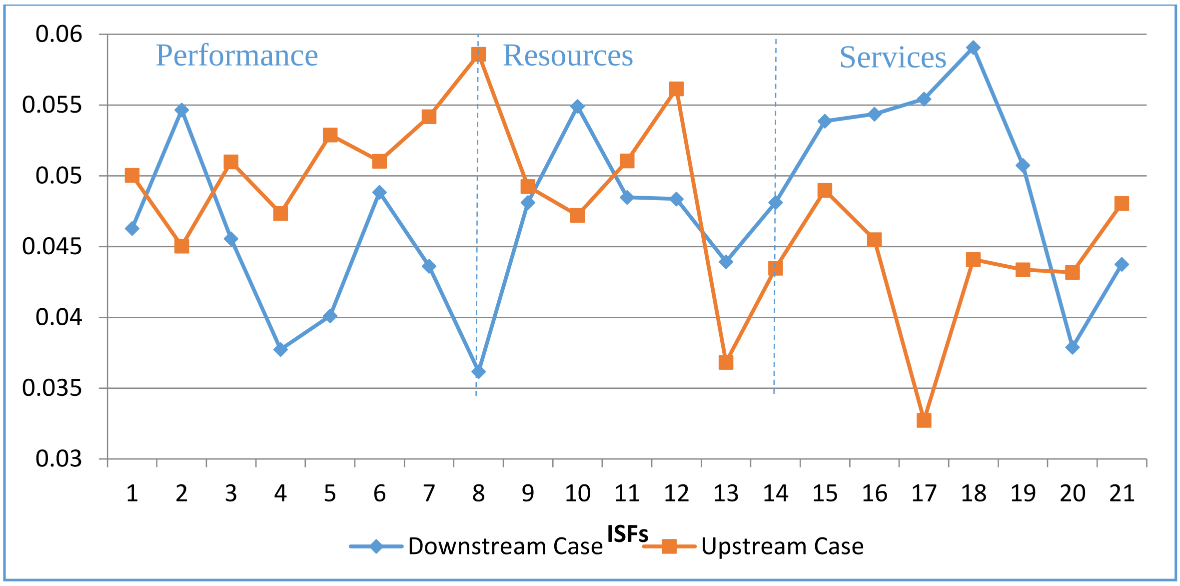

Figure 9- 9: Upstream and Downstream ISFs Weights

Adding the FDEMATEL outputs of the 21 ISFs to Figure 9-9 helps to understand the differences between both case studies and to clarify which one is closer to the general weights. Figure 9-10 summarises the three outputs together.

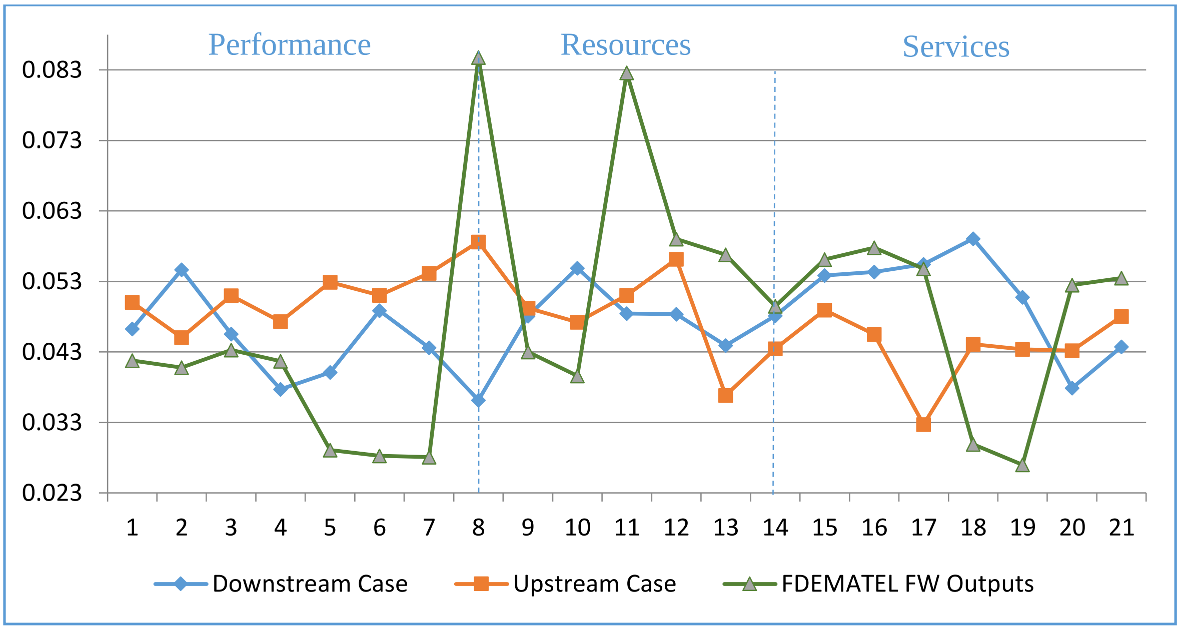

Figure 9- 10: ISFs Weights in the FDEMATEL, Upstream and Downstream

9.4.4. Case Study Feedback

Study findings have been discussed with the firm's stakeholders. Each LSP's strengths and weaknesses have been reviewed in detail. The stakeholders were so happy with these discussions and results and asked for some suggestions and improvements potential. Then, a special report was developed and presented to the board of directors to be used in the firm's logistics outsourcing, LSP performance appraisal and development processes. Based on the case study findings, the firm's managers are going to evaluate their relationships with some LSPs and ask others for more improvements in some areas. Moreover, they are going to apply the same approach in their future logistics and suppliers outsourcing processes to ensure that they fit with their strategic objectives.

9.5. Chapter Contributions

In this chapter two case studies have been conducted to validate the feasibility and effectiveness of the new hybrid approach presented in Chapter 8. The outputs of both case studies improve the effectiveness of the new approach in the strategic logistics outsourcing process. The following points summarise the main contributions of this chapter.

- Validates the effectiveness of the new approach in both case studies (the upstream and downstream supply chain logistics outsourcing) under uncertain decision-making environments.
- Identifies the strategic objectives, logistics requirements and the relative weight of the ISFs for both case studies.
- Identifies similarities and differences between the supply chain upstream and downstream actors in terms of strategic objectives, logistics requirements and ISFs.
- Provides a number of recommendations for both case studies to improve their logistics outsourcing processes (to make it strategic), to help them to be more confident about their decisions and to help them to monitor, manage and improve their LSPs.

Chapter 10: Thesis Conclusions and Future Research

Summary

The main aim of this research was to explore the validity of developing a number of integrated models for the logistics outsourcing process under high uncertainty. This chapter concludes the thesis findings and contributions and clarifies the extent that they satisfied the research aim. Different LSP-evaluation and selection models that are valuable for an effective and strategic outsourcing process are summarised. Additionally, improvement suggestions and future research areas with limitations are outlined too.

10.1. Thesis Contributions

Logistics outsourcing is considered among the most common outsourcing forms. The growing demand for logistics services and the increasing number of LSPs highlight the increasing importance of logistics outsourcing. The complexity of the decision and the large number of criteria involved increase the attractiveness of the MCDM approaches. Moreover, data uncertainty problems make it difficult for experts and DMs to provide a crisp value to quantify the precise rankings of LSPs. Therefore, the concept of fuzzy sets is integrated with the MCDM methods to handle the uncertainty of the data. This thesis sets out to solve these problems through developing a new LSP framework and a number of integrated models to help DMs perform effective logistics outsourcing processes under high uncertainties. Each integrated model has been developed based on a well-known theory using a new hybrid approach to be applied in real decision-making situations. Therefore, for each integrated model a test case has been used to demonstrate its effectiveness. Additionally, the ISFs that were identified in each model, have been integrated in one new approach to perform a strategic logistics outsourcing process. Two case studies representing the supply chain upstream and downstream have been used to demonstrate the new integrated and strategic approach. The main contributions of each chapter and how they contribute in achieving the thesis objectives can be summarised by the following points:

In chapter 2, a comparative literature review was conducted to study existing LSP evaluation and selection papers since 2008 and to compare results with previous literature studies to identify any possible shift in the way that LSPs are evaluated and selected. Several problems in current LSPs literature have been identified. Literature review results reveal that the usage and importance of evaluation and selection criteria fluctuate during different periods; increasing the importance of specific selection methods; increasing the importance of integrated models and fuzzy logic in logistics literature; and the need for more research in specific logistics outsourcing area

Chapter 3 presents the new LSPs' framework. Dimensions, factors and theories that were used to develop the framework are presented too. The second part of this chapter summarises the research methodology, data collection and analysis tools, experts selection and impact relationships and ranking techniques were summarised too. Moreover, systematic implementation procedures for the integrated FDEMATEL-FTOPSIS approach are presented to be used in the new logistics outsourcing models.

Chapter 4 provides the first Jordanian logistics study using both primary and secondary data. Moreover, JLSPs and JLSUs perspectives are used to verify the LSP framework dimensions. Additionally, this chapter provides the conceptual definitions of the LSP evaluation and selection framework. ***The contributions of these three chapters satisfy the first two research objectives*****:**

1. To identify the most important/used LSPs evaluation and selection criteria to model a new multi-dimension framework that covers the LSPs' performance; resources & capabilities; and logistics services dimensions.
2. To develop a fuzzy logic-DEMATEL methodology to analyse the impact-relationship among the LSPs framework elements and therefore to identify dependent and independent factors to use.

The first model (Chapter 5) proposes an integrated logistics outsourcing approach for evaluating and selecting LSPs based on their logistics resources and capabilities. This approach combines a FDEMATEL and FTOPSIS techniques. The new integrated model addresses the impact-relationship between decision criteria and ranks LSP alternatives against weighted resources and capabilities. The second model (Chapter 6) proposes a new hybrid model to quantify LSPs’ performance measures and evaluation. The new hybrid model helps LSUs in their logistics outsourcing decisions under uncertain environments and supports LSPs to manage their performance effectively. The new model integrates the FDEMATEL and FTOPSIS techniques to address the impact-relationship between the LKPIs, identifies independent factors and ranks LSPs against the weighted LKPIs to select the most appropriate one. The third model (Chapter 7) proposes a new hybrid model to evaluate the logistics services value-added and in turn to evaluate and select the best LSP. The new model helps LSPs and LSUs to analyse the value-added of the provided logistics services. This model integrates the FDEMATEL and FTOPSIS techniques to address the impact-relationship between logistics services, identifies independent services and rank LSPs based on their value-added scores. ***The contributions of these three chapters satisfy the third research objective*****:**

3. To develop a fuzzy DEMATEL-TOPSIS methodology for evaluating and selecting LSPs based on their logistics performance, resources, and services:

- To develop a novel technique for evaluating and selecting LSPs' based on their logistics resources and capabilities
- To develop an advanced model for quantifying LSPs' performance measurement and evaluation based on the LKPIs
- To develop a new model for evaluating and selecting LSPs' based on their value-added logistics services

Chapter 8 is based on the three models outcome to identify the ISFs and in turn to develop a new integrated approach to link the LSU's strategic objectives with the logistics requirements with the ISFs to perform an effective strategic logistics outsourcing process. This new approach enables the DMs to be more confident about the suitability of their LSPs to their strategic objectives. ***The contributions of this chapter satisfy the fourth research objective:***

4. To integrate the three models' outcomes into one comprehensive strategic logistics outsourcing approach using fuzzy logic and QFD approach

The new approach has been demonstrated by two supply chain test case studies (Chapter 9). The upstream and downstream case studies support the effectiveness of the new approach and show its real capabilities. Moreover, these two case studies help to clarify the upstream and downstream differences in terms of their strategic objectives, logistics requirements and the ISFs relative importance. The case study's outputs were used to develop a special report presented to the board of directors to improve their logistics outsourcing processes. ***The contributions of these case studies satisfy the fifth research objective:***

5. To conduct real case studies to verify the proposed methods and to show how these models can help DMs to take effective and efficient strategic logistics outsourcing process

The new four models represent a generic practical sense to be used in real logistics outsourcing situations under a high level of uncertainty. The DMs can choose the best model that fit with their needs, preferences and/or availability of resources:

1. The first integrated model is suitable for the cases in which the LSUs try to support their operations by contracting with a strong LSP that has acquired the right logistics resources and capabilities.
2. The second integrated model is suitable for the cases in which the LSUs try to improve their logistics performance levels by contracting with a superior performance records LSP.
3. The third integrated model is suitable for the cases in which the LSUs try to improve their customer service levels by providing more value-added logistics services.
4. The fourth integrated approach is suitable for the cases where LSUs try to perform a strategic logistics outsourcing process to support their strategic objectives through selecting the most appropriate LSP that is capable of providing logistics requirements.

10.2. Research Opportunities and Future Work

A good thesis opens the door for new research opportunities and directs researchers toward crucial future work. Therefore, a number of direct applications and research opportunities have been identified.

10.2.1. Research Opportunities

Research findings can be used to build on for further research. In terms of logistics management process, this research covers the evaluation and selection stage. Further research related to other stages pre and post this stage are highly needed. There is a crucial need for new research to help LSUs evaluate their need for outsourcing, to identify which activities need to be outsourced and which ones to be performed internally. Moreover, further developments are needed to help LSUs and LSPs to manage and sustain a long-term and healthy relationship. In terms of experts involved in this study, between three and seven experts were used to conduct different evaluations, for further investigations, the experts' number can be increased and they can be diversified to include other areas within the supply chain. Although the employed expert groups are from different developed and developing countries, increasing the experts number from those countries to conduct a comparative study is an important research area that has not been extensively studied yet. The same comparative sense can be used to conduct a LSP-LSU comparative study too.

Additionally, integrating this work with the whole SCM process is another crucial research opportunity. The strategic logistics outsourcing process has to work in harmony with other SCM processes such as relationships management, demand management, product development and advanced manufacturing. Considering research's findings and conclusions in any future SCM research, surely can facilitate and support them.

10.2.2. Applications

In addition to the logistics outsourcing process, the models, approaches and findings of the work can be used for different purposes:

In terms of self-evaluation, LSPs can utilise this work to analyse their strengths and weaknesses, to identify areas for development and to measure progress levels. In terms of continuous improvement and benchmarking, applying these models by LSPs can provide a huge logistics database that can help to identify best practices/actors in the industry to benchmark. In terms of decision-making process, each model in this study can be developed as a decision support tool (DST) to help and guide LSPs and LSUs in their logistics-based decision. For LSUs, these models are useful to evaluate, select and contract with LSPs. Additionally, case studies findings provide crucial information about the LSPs performance levels that in turn help them to evaluate their LSPs' relationships, identify which one to continue and which one to stop.

This work is grounding for a big SCM platform that connects all the supply chain members in real-time information sharing and decision making applications. Ideally, connecting the supply chain members in a real-time base using clouding technologies can help to improve all the SCM processes and support members to achieve their objectives effectively and efficiently. Appendix 10-1 presents a general flowchart of such platform with a special focus on LSP outsourcing process. The benefits of such integrations and applications are obvious, but the challenges are plenty.

10.2.3. Research Limitations and Challenges

There are a number of challenges faces these applications and research opportunities. Some of these challenges are presented in section (2.2.3 CSCG**)** such as willingness to share information, confidentiality and trust, availability and compatibility of IT hardware and software resources. In addition, the organisation that it will own and manage such CSCG is a big challenge to face. Therefore, participation and commitment of supply chain members in such integration, sharing information in a real-time base, participating in a real-time decision-making processes, trust and openness are some of these challenges.

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PUBLICATIONS

1. **Logistics Service Providers (LSPs) evaluation and selection: Literature review and framework development.** *Strategic Outsourcing: An International Journal*, 8 (1), pp. 102-134, 2015. doi.org/10.1108/SO-12-2014-0028

This paper provides an insight to the outsourcing decision-making through investigating if the old evaluation/selection criteria and methods still fit with current business priorities or not and in turn to identify the appropriate criteria and methods to develop a new selection framework. A focused literature review is prepared after analysing 56 articles related to the LSP evaluation and selection methods and criteria during 2008-2013. The review result is compared with previous literature studies for the periods (1991-2008) to identify any possible shifts. Several problems in current LSPs literature have been identified. Then, a comprehensive LSPs' evaluation and selection framework has been developed. **Strategic Outsourcing journal** includes several novel features. In addition to the best new journal award-2011, the Industry Viewpoint section invites industrial practitioners from around the world to present their point of view on a relevant subject area.

2. **A novel technique for evaluating and selecting logistics service providers based on the logistics resource view.** *Expert Systems with Application*, 42 (20), pp. 6976-6989, (2015) **doi:10.1016/j.eswa.2015.05.010**

This paper proposes an integrated logistics outsourcing approach to evaluate and select LSPs based on their logistics resources and capabilities. This novel approach combines FDEMATEL and FTOPSIS techniques. The new MCDM model addresses the impact-relationships between decision criteria and ranks LSP alternatives against weighted resources and capabilities. The effectiveness of this approach is demonstrated through a case study and a two-phase sensitivity analysis confirms its robustness. **Expert Systems with Application** is a well-known applications journal that focuses on exchanging information relating to expert and intelligent systems applied in industry, government and universities worldwide.

3. **A hybrid model to quantify LSPs' performance measurement and evaluation.** *IJPE*, (2015) under review.

This paper presents a new hybrid approach to quantify LSPs' performance measures and evaluation. Both, LSUs and LSPs perspectives have been used to identify the most important LKPIs and their relative metric(s) to form the framework. This framework is based on the SBSC perspectives to structure its hierarchy. This approach combines the FDEMATEL and FTOPSIS techniques to address the LKPIs impact-relationships, find their weights and to evaluate, rank and select LSPs. Data from a case-study were used to demonstrate the new hybrid model's effectiveness and a sensitivity analysis confirms its strength. A comparison between the LKPIs and independent LKPIs was conducted as well.

Under preparation

4. **Logistics Services Value-added: An advanced Multi-criteria approach for logistics outsourcing.**
5. **An Advanced Strategic Logistics Outsourcing Approach: Upstream-Downstream Perspectives.**

APPENDICES

Appendix 2-1: LSPs selection and elevation studies during 2008-2013

#	Author(s)/ Year	Interest	Methods	Main Criteria/Dimensions
1	**Chen and Wu (2011)**	LSP selection in southeast Asia	ANP-Delphi	Service cost, operational performance, company performance, logistics technology and service quality
2	**Shan (2012)**	Green LSP selection	Intuitionistic Language fuzzy entropy	Compatibility cost of service, quality of service, service capability and adaptation with environment
3	**Falsini et al. (2012)**	LSP evaluation and selection	AHP, DEA, Linear programming	Quality and reliability, speed of service, flexibility, costs, equipment, operations' safety, environmental safeguard
4	**Rajesh et al. (2011)**	3PL evaluation and selection	AHP, QFD	Using aqua model (QFD with AHP), including three phases of evaluation, 3PL evaluation phase includes 17 selection criteria, such as price, flexibility, image, delivery
5	**Cooper et al. (2012)**	3PL selection	ANP, statistics	Income order management, transportation to regional distribution centre (RDC), inventory management, transportation from RDC and delivery management
6	**Rajesh et al. (2012)**	LSP selection for cement industry	Fuzzy PROMETHEE	Price, reliability, flexibility and economic conditions
7	**Tang (2013)**	Health care provider selection	ANP	Five attributes: market, activity, regulatory, criteria and strategic

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Appendix 2-1

#	Author(s)/ Year	Interest	Methods	Main Criteria/Dimensions
8	**Chang et al. (2011)**	Supplier Selection	Fuzzy DEMATEL	Quality, service, flexibility, price, delivery, lead-time, reaction on demand change, production capability, technical capability and reliability
9	**Rajesh et al. (2009)**	3PL selection	AHP, Fuzzy Logic, TOPSIS	Cost, financial viability, risk mitigation, IT capability and on-time delivery
10	**Kasture et al. (2008)**	3PL selection	FAHP, sensitivity analysis	Five main criteria with 20 sub-criteria: logistics capacity, logistics service quality, logistics information capacity, potential for development and flexibility
11	**Qureshi et al. (2009)**	LSP selection	FAHP, Graph-theoretic	Digraph and matrix approach, evaluation and selection index derived from selection attributes, which obtained from digraph of LSP selection attributes
12	**Shiau et al. (2011)**	Hub location selection for 3PL	FAHP	Facility aspects, management aspects, level of inland transport service, compliance of policy and rules, effects of location's social environment
13	**Rujikietkumjorn et al. (2012)**	3PL selection for online retailer	Study the effects of 3PL selection	Open-ended interview questions, regarding motivation to outsource, influence of 3PL usage, relationship between 3PL and online retailer, quality and improvement opportunities
14	**Yang et al. (2010)**	LSP selection for Air Cargo	ANP	Performance, features, reliability, conformance, serviceability, perceived quality
15	**Dubey and Shah (2010)**	Value-added services on LSP	Statistical	Strategic attributes and value-added services, with a number of sub-criteria

Continue ➔

#	Author(s)/ Year	Interest	Methods	Main Criteria/Dimensions
16	**Wong (2012)**	DSS for 3PL selection	FANP, Fuzzy integer GP MOOM with experts' opinion.	Globalisation considerations (non-tariff trade and global scope), Quality (reliability of delivery and quality of service)
17	**Banomyong and Supatn (2011)**	LSP selection in Thailand.	Regression analysis	Key attributes of freight-logistics service quality identified based on literature review and interview and used to select 3PL. 24 attributes categorised into: reliability, assurance, tangibility, empathy, responsiveness and cost
18	**Vijayvargiya and Dey (2010)**	LSP selection in India	AHP	Cost (inland transportation and ocean/air freight), Delivery (port licensing and schedule flexibility), Value-added services (clearing & forwarding and IT-track & trace)
19	**Liu and Wang (2009)**	3PL evaluation and selection	Fuzzy Delphi, Fuzzy inference, Fuzzy linear assignment	26 evaluation criteria such as price, location, growth, etc. without classification
20	**Govindan et al. (2012)**	Analysis of 3PRLP	ISM	3PLservices, impact of using 3PL, organisational role, user satisfaction, reverse logistics functions, IT applications and organisational performance criteria
21	**Tian et al. (2009)**	4PL selection	AHP, LP.	Number of criteria used to evaluate integrative logistics providers, or 4PL includes Price, Service quality, Customer service quality and Service capability

Continue ➔

#	Author(s)/ Year	Interest	Methods	Main Criteria/Dimensions
22	**Kabir (2012)**	3PL selection	FAHP, TOPSIS	Number of criteria such as, quality, cost and delivery time
23	**Ho et al. (2012)**	Strategic logistic outsourcing	QFD, FAHP	Cost, delivery, flexibility, quality, technology and risk
24	**Aloini et al. (2010)**	LSP selection	Fuzzy PROMETHEE	Freight costs, delivery time and reliability of delivery, quality and response
25	**Bhatti et al. (2010)**	LLP (4PL) selection in India	AHP	Four main criteria with a number of sub-criteria: vendor status, logistics competence, quality of service and IT-based competence
26	**Qureshi et al. (2008)**	3PL selection	Fuzzy Synthetic, TOPSIS	IT capability, flexibility, quality of management, financial stability, compatibility, reputation, long-term relationship, surge capacity, size and quality of assets, geographical reach and range of service
27	**Gotzamani et al. (2010)**	LS outsourcing dilemma	Chi-Squared Test	Quality management and financial performance criteria and their relationship
28	**Guoyi and Xiaohua (2012)**	3PL selection	AHP	Evaluation index system, combining subjective and objective evaluation, include five main dimensions: Operational capability, Service level, Price level, Development potential and Green level
29	**Fachao et al. (2012)**	3PL selection	Fuzzy sets, Centralized quantification, Synthesis effect	Four main indices: management success, business strength, service quality and business growth, with a number of sub-indices under each one
30	**Daim et al. (2013)**	3PL selection	AHP, TOPSIS	Cost, service, global, IT, industry experience and local presence.

Continue ➔

#	Author(s)/ Year	Interest	Methods	Main Criteria/Dimensions
31	**Chang et al. (2008)**	Port selection	Exploratory and Confirmatory Factor Analysis	21 criteria such as location, cargo volume and profitability, reliability of services and IT ability
32	**Efendigil et al. (2008)**	3PL selection under vagueness	ANN, FAHP	On-time delivery, confirmation fill rate, service quality, unit operation cost, capacity usage ratio, total order cycle time, system flexibility index, integration level index, R&D, environmental expenditures and customer satisfaction index
33	**Qureshi et al. (2009a)**	3PL assessment	Interpretive Structure Modelling **(ISM)**: a structural analysis tool used to describe a system using a matrix with combines the constituent components of the system	Quality of service, fixed assets and management, IT capabilities, delivery performance, information sharing, operational performance, compatibility, financial stability, geographical spread and range, long term relationship, reputation, optimum cost, capacity flexibility in operation and delivery.
34	**Büyüközkan et al. (2008)**	Strategic Alliance Partner Selection	FAHP, FTOPSIS	Two main dimensions: Strategic (similar value-goal, similar size, finance stability, comparable culture, successful track records and sustainable relationship) and Business excellence (technical experience, performance, market knowledge and managerial experience)
35	**Tuzkaya and Önüt (2008)**	Transportation Model selection Turkey-Germany	Fuzzy Algorithms	Cost, flexibility, product characteristics, reliability, risks, safety problems, speed and traceability

Continue ➔

#	Author(s)/ Year	Interest	Methods	Main Criteria/Dimensions
36	**Qureshi et al. (2009b)**	3PL selection	AHP, Graph Theory	IT capability, compatibility, flexibility in operation and delivery, financial stability and geographic spread and range of services
37	**Gadde and Hulthén (2009)**	Improving logistics outsourcing through buyer-provider interaction	Framework	Improve the logistics outsourcing process through increasing the interaction in four main stages: - Selection of the 3PL - Decision regarding the scope of outsourcing - Development of the relationship - Assessment of the outsourcing arrangement
38	**Wang et al. (2010b)**	Logistics distribution centre selection	FAHP	Select the best logistics distribution centre that maximises profits and minimises costs through using FAHP to help DMs express their preferences
39	**Govindan and Murugesan (2011)**	3PRL selection	Fuzzy extent analysis	3PL services, reverse logistics functions, organisational role, user satisfaction, impact of use of 3PL, organisational performance criteria and IT applications
40	**Liou et al. (2011)**	Outsourcing Provider Selection	Fuzzy, DEMATEL, ANP	Transportation cost, frequency of shipments, IT communication, quality performance and order shop time
41	**Cheng and Lee (2010)**	Reverse Logistics for High-Tech in Taiwan	ANP	Warehousing management, transportation management, IT management and value-added services

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Appendix 2-1

#	Author(s)/ Year	Interest	Methods	Main Criteria/Dimensions
42	**Kannan et al. (2009a)**	3PRLP selection	AHP, Linear programming	Different Attributes from various dimensions: 3PL's, Reverse logistics functions, Organisational role, User satisfaction, Impact of use 3PL, Organisational performance criteria and Application IT
43	**Bansal et al. (2008)**	3PL selection for chemical logistic	Mixed-integer LP	Using mixed integer LP to reduce the transportation costs for a chemical firm, evaluating number of choices based on the transportation costs
44	**Kannan et al. (2009b)**	RLSP selection	ISM, FTOPSIS	Quality, deliverability, reverse logistics cost, rejection rate, technology/engineering capability, inability to meet future requirement and willingness and attitude
45	**Büyüközkan et al. (2009)**	4PL operating models	MCDM, Hierarchy model with CHOQUET integral	Three main performances (service, IT and management) with 4 sub-criteria under each performance
46	**Kumar et al. (2012)**	Analysing logistics outsourcing	Cost effectiveness, CFPR, VIKOR (consistent fuzzy performance relation)	Two levels of analysis: First: outsourcing success (core competence, order fulfilling, total sales volume, increase in time to market, threat to security, customer location and service level requirement) Second: flexibility, supplier profit and relationship, service quality, risk and cost effective
47	**Perçin (2009)**	3PL evaluation	Two-phase AHP and TOPSIS	Three main factors with a number of sub-criteria: Strategic factors: such as similarity in size Business factors: such as technical ability Risk factors: such as loss of control see article # 34

Continue ➔

#	Author(s)/ Year	Interest	Methods	Main Criteria/Dimensions
48	**Routroy (2009)**	3PL selection	AHP, performance value analysis	Number of performance indicators in a hierarchy model. Five main dimensions: Cost, Time, Customer service, Organisation and Information.
49	**Onut et al. (2011)**	Selecting Container port	FANP	Different criteria such as; location, cost, physical features, efficiency, etc.
50	**Saen (2010)**	Ranking 3PL	DEA	Efficiency score, unit operation cost (input) and recycling capacity (output), solid waste stream (dual-role factor)
51	**Yang and Tzeng (2011)**	Vendor Selection	DEMATEL, ANP	Quality, price and terms, supply chain support and technology
52	**Chang (2011)**	Factors of introducing RFID and its efficiency in supply chain systems	AHP, DEMATEL	Try to discover the factors with significant effect to the RFID in Taiwan. AHP employed to conduct pairwise comparisons while DEMATEL used to examine the cause and effect in every criterion.
53	**Amiri et al. (2011)**	Prioritise distribution centres in supply chain	DEMATEL	BSC perspectives (finance, customer, internal processes and learning and growth) with 22 criteria.
54	**Baykasoğlu et al. (2013)**	Truck Selection for logistics providers firms	DEMATEL, FTOPSIS	17 criteria related to truck features and usage, such as reliability, fuel consumption, cost of spare parts, maintenance cost, etc.
55	**Najmi and Makui (2010)**	Measuring supply chain performance	AHP, DEMATEL	Flexibility, reliability, responsiveness, quality, asset management. With a number of metrics for each criterion.
56	**Hsu et al. (2012)**	Vendor Selection process	DEMATEL-ANP-VIKOR	Quality, delivery, risk, cost, service and environmental collaboration.

Appendix 3-1: DEMATEL and TOPSIS Methodologies

DEMATEL methodology

The DEMATEL method can be summarised in the following steps (Yang and Tzeng, 2011**;** Dalalah et al. 2011**;** Shieh et al. 2010**;** Wu 2008**;** Tzeng et al., 2007**;** Tamura et al., 2002**;** Baykasoğlu 2013**)**:

1. Find the Average Matrix ***(A)*** of the initial direct-relation matrix

If there are *H* experts and *n* factors to consider, then, each expert is asked to indicate the degree to which he/she believes a factor *i* affects factor *j*. These pairwise comparisons between any two factors are denoted by a_{ij} and are given an integer score ranging from 0, 1, 2, 3 and 4, representing 'No influence (0),' 'Low influence (1),' 'Medium influence (2),' 'High influence (3),' and 'Very high influence (4),' respectively. The scores by each expert provide a $n \times n$ non-negative answer matrix A^k=[X^k_{il}], with $1 \leq k \leq H$. The diagonal elements of each answer matrix A^k are all set to zero. The $n \times n$ average matrix ***A*** for all expert opinions can be computed by averaging the *H* experts' scores. The average matrix **A=[** a_{ij}] is also called the initial direct-relation matrix.

2. Calculate the normalised initial direct-relation matrix ***(X)***

The *X* matrix can be obtained by normalising the average matrix ***A*** by dividing each a_{ij} by the maximum sum of the columns and rows; each x_{ij} element of matrix ***X*** is between zero and less than 1.

3. Compute the total-relation matrix ***(T)***. The total-relation matrix ***T*** is an $n \times n$ matrix and can be established by multiplying normalised matrix ***X*** by $(I-X)^{-1}$, where *I* is the $n \times n$ identity matrix.

4. Identify the Cause and Effect Groups. Let R_i be the sum of the i^{th} row and let C_j denote the sum of the *j*th column in matrix ***T***. R_i shows the total effects, both direct and indirect, given by factor *i* to the other factors and C_j shows the total effects, both direct and indirect, received by factor *j* from the other factors. Therefore, (R_i + C_j) provides an index representing the total effects both given and received by factor *i*. (R_i + C_j) shows the degree of importance that factor *i* plays in the system. Meanwhile, (R_i - C_j) shows the net effect that factor *i* contributes to the system. When (R_i - C_j) is positive, factor *i* is a *net causer* and belongs to the '*Cause Group*' and when (R_i - C_j) is negative, factor *i* is a *net receiver* and belongs to the '*Effect Group*' (Dalalah et al. 2011**;** Tzeng et al. 2007**;** Tamura et al., 2002).

5. Set a threshold value and obtain the IRM. DMs must set a threshold value to reduce the complexity of the structural relationship model implicit in matrix ***T***. Only factors with effects greater than the threshold value should be chosen and shown in the IRM (Tzeng et al., 2007; Wu 2008; Shieh et al. 2010).

6. Criteria importance and weights. In the IRM, the horizontal axis (R_i+C_j) is called "Importance" and the vertical axis (R_i-C_j) is called "Relation". The importance of each criterion ω_i can be measured using the length of the vector from the origin to each criterion (Dalalah et al. 2011; Baykasoğlu 2013; Pamucar and Cirovic 2015) Equation 3-1:

$$\boldsymbol{\omega_i} = \{(R_i + C_j)^2 + (R_i - C_j)^2\}^{1/2} \text{ ....(3-1)}$$

The final criterion weight W_i is the normalised importance (Equation 3-2):

$$W_i = \frac{w_i}{\sum_{i=1}^{n} w_i}, \quad i = 1,2,\ldots,n. \text{ ....(3-2)}$$

Fuzzy DEMATEL methodology

According to Ding and Liang (2005), fuzzy subset A is defined by membership function $\mu_A(x)$, which maps each element x in X to a real number in the interval [0,1]. Fuzzy number A is a TFN if its membership function is $0 < l \leq m \leq u \leq \infty$.

$$\boldsymbol{\mu_A(x)} = \begin{cases} \frac{(x-l)}{(m-l)}, & l \leq x \leq m, \\ \frac{(u-x)}{(u-m)}, & m \leq x \leq u, \\ 0, & Otherwise \end{cases} \text{ ....(3-3)}$$

Where l, m and u are the lower, moderate and upper limits of the TFN.

Start with the fuzzy initial direct-relation matrix $\hat{A}$, where each $\hat{a}_{ij} = (l_{ij}, m_{ij}, u_{ij})$ is a TFN and $\hat{a}_{ij}$ (i-1,2,…,n) is the average of experts' evaluations of the i^{th} and j^{th} factors impact-relationship and it is regarded as a TFN (0,0,0) where necessary.

$$\hat{A} = \begin{bmatrix} \hat{a}_{11} & \cdots & \hat{a}_{1n} \\ \vdots & \ddots & \vdots \\ \hat{a}_{n1} & \cdots & \hat{a}_{nn} \end{bmatrix} \text{ ....(3-4)}$$

By normalising matrix $\hat{A}$, the normalised fuzzy initial matrix X (direct-relation matrix) can be acquired:

$$X = \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{n1} & \cdots & x_{nn} \end{bmatrix} \quad \textbf{.....................(3-5)}$$

$$\text{Where, } x_{ij} = \frac{\hat{a}_{ij}}{r} \quad \textbf{.........................(3-6)}$$

$$r = max_{l \leq i \leq n}\left(\sum_{j=1}^{n} u_{ij}\right) \quad \textbf{..............(3-7)}$$

The fuzzy total-relation matrix $\check{T}$ is computed based on the following definition (Lin and Wu 2008**,** Hosseini and Tarohk 2013)

$$\check{T} \lim_{k \to \infty} X^1 + X^2 + \cdots + X^k \quad \textbf{..............(3-8)}$$

$$\check{T} \begin{bmatrix} t_{11} & \cdots & t_{1n} \\ \vdots & \ddots & \vdots \\ t_{n1} & \cdots & t_{nn} \end{bmatrix} \quad \textbf{........................(3-9)}$$

in which t_{ij} is TFN, $\check{T}$ matrix is produced based by

$$\check{T} = X \times (I - X)^{-1} \quad \textbf{.....................(3-10)}$$

Where, (I) is the identity fuzzy matrix (Hosseini and Tarohk, 2013).

The fuzzy sum of row $(R_i)^f$ and fuzzy sum of column $(C_i)^f$ and also the fuzzy $(R_i + C_j)^f$ and fuzzy $(R_i - C_j)^f$ of $\check{T}$ matrix can be calculated. The final step is to calculate the defuzzified $(R_i + C_j)^{def}$ and $(R_i - C_j)^{def}$. Defuzzification of any fuzzy number can be performed by finding the point that divides the fuzzy set area into two equal parts (Dalalah et al., 2011).

$$= \begin{cases} \boldsymbol{u} - \sqrt{\dfrac{(\boldsymbol{u}-\boldsymbol{l})(\boldsymbol{u}-\boldsymbol{m})}{\mathbf{2}}}, & \boldsymbol{u} - \boldsymbol{m} > m - l \\ \sqrt{\dfrac{(\boldsymbol{u}-\boldsymbol{l})(\boldsymbol{u}-\boldsymbol{m})}{\mathbf{2}}} + \boldsymbol{l} & \boldsymbol{u} - \boldsymbol{m} < m - l \\ \boldsymbol{m}, & \boldsymbol{otherwise} \end{cases} \quad \textbf{..............(3-11)}$$

The importance and weight of each criterion is obtained using Equations 3-1 and 3-2.

There are local and global weights for each criterion, cluster and level. In order to be convenient to compare the relative importance between levels, global and local weights need to be calculated. For each cluster of criteria, the sum of criteria local weights equal 1. And for any level, the sum of clusters local weights equal 1. Meanwhile the sum of global weights of all the system elements is equal 1.

TOPSIS methodology

The TOPSIS method is divided into the following steps (Dalalah et al., 2011**;** Baykasoğlu 2013):

1. Create an evaluation matrix consisting of *m* alternatives and *n* criteria. Then, a $(x_{ij})_{mxn}$ matrix can be developed, where x_{ij} is the intersection of each alternative and criterion which is the average experts' evaluations of the m^{th} alternative against the n^{th} criterion.

2. Normalise the evaluation matrix through dividing each x_{ij} by the maximum possible value of the indicator v_j, $j= 1,2,\dots,n$.

3. Calculate the weighted normalised decision matrix (***T)*** by multiplying each criterion column by its weight $\boldsymbol{w_j}$.

4. Determine the Positive Ideal Solution (*PIS*) and the Negative Ideal Solution (*NIS*):

(A_w)= max scores with the criteria having a positive impact or benefit and min scores with the criteria having a negative impact or cost.

(A_b)= min scores with the criteria having a positive impact or benefit and max scores with the criteria having a negative impact or cost.

5. Calculate the distance between the target alternative *(i)* and the NIS (d-) and the distance between the alternative *(i)* and the PIS ($d+$).

6. Calculate the **Closeness Coefficient (*CC*)** by dividing (d^-) by the sum of (d^+) and (d^-). Rank the alternatives according to their CC_i values. An alternative to the highest value is the best value (the longest distance from the *NIS* and shortest distance to the *PIS*). These steps are based on the linear normalisation method for dealing with incongruous criteria dimensions (step 2). Some studies use the vector normalisation method:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{j=1}^{n} x_{ij}^2}} \quad i= 1,2,\dots,m,\ j= 1,2,\dots,n \text{..............}\mathbf{(3\text{-}12)}$$

FTOPSIS methodology

1. Choose appropriate linguistic variables (Table 3-7).

2. Construct the fuzzy decision matrix and the normalised fuzzy decision matrix. Let *B* and *C* be the sets of benefits and cost criteria, respectively. The normalised fuzzy decision matrix $R = [r_{ij}]_{m\times n}$ can be obtained using Equation 3 -13.

$r_{ij}= \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right), \quad J \in B$ where $c_j^* = \max c_{ij}$ (max upper limit)

$r_{ij}= \left(\frac{a_j^-}{c_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{a_j^-}{a_{ij}}\right), \quad J \in C$ where $a_j^- = \min a_{ij}$ (min lower limit) **……………(3-13)**

Where *B* and *C* are the set of benefit and cost criteria respectively

3. Construct the weighted normalised fuzzy decision matrix (*T*) using criteria weight w_j

$(T) = [v_{ij}]_{m\times n}$

$v_{ij} = r_{ij} \times w_j$ **……………(3-14)**

4. Determine the FPIS (A^*) and fuzzy negative-ideal solution (FNIS) (A^-)

$A^* = v_1^*, v_2^*, \dots, v_n^*$ and $A^- = v_1^-, v_2^-, \dots, v_n^-$

$v_j^* = (1,1,1)$ and $v_j^- = (0,0,0)$ for all $j = 1,2,..,n$ **……………(3-15)**

5. Calculate distances (d_i^*, d_i^-) for each alternative from A^* *and* A^-

$d_i^* = \sum_{j=1}^{n} d(v_j^*, v_{ij})$ and $d_i^- = \sum_{j=1}^{n} d(v_{ij}, v_j^-)$ for all i=1,2,…,m, **………(3-16)**

Where $d(v_j^*, v_{ij})$ *and* $d(v_{ij}, v_j^-)$ are calculated by the area compensation method. In this method, if a value is compared to two fuzzy numbers A and B, then the distance between these two fuzzy numbers, *d(A,B)*, is the maximum difference between A and B

$$d(A,B) = max\{|u_i - u_j|, |l_i - l_j|\} \text{……………}\textbf{(3-17)}$$

6. Calculate the closeness coefficient (CCi) for each alternative (Equation 3-18) and rank the alternatives according to their CC_i. The alternative with the highest *CCi* is the best alternative (shortest distance to the best condition and longest distance to the worst condition):

$$CC_i = \frac{d_i^-}{d_i^* + d_i^-}, \quad i = 1,2,\dots,m \text{ ……………}\textbf{(3-18)}$$

Appendix 3-2: Examples of used Questionnaires

1- Jordanian LSPs Data Collection Tool

LIVERPOOL JOHN MOORES UNIVERSITY

Logistics service provider (LSP) evaluation and Selection

A research project at Liverpool John Moores University is currently being carried out to develop an advanced LSP's evaluation and selection framework. This project aims at providing a comprehensive framework to help managers and decision makers in business, governments and NGOs to take their logistics-based decision effectively and efficiently. This subject is considered among the critical topics on the international agenda due to the logistics crucial role in today business world.

My name is **SALEH AL-KHATIB** and I am a Postgraduate student at LJMU, because you are an expert in this field, I am inviting you to contribute to this research study by completing the attached surveys.

Thank you for taking the time to assist me in my educational endeavours. The data collected will provide useful information regarding improving LSPs' performance, and increase the effectiveness and efficiency of LSP evaluation and selection process; in addition it will help to build the first database of the Jordanian logistics industry.

The following questionnaire will require approximately 20-30 minutes to complete. There is no compensation for responding nor is there any identified risk. In order to ensure that all information will remain confidential, please ***do not*** include your name.

If you choose to participate in this project, please answer all questions as honestly as possible and we will collect it back. Participation is strictly voluntary and you may refuse to participate at any time.

Any refusal or incomplete questionnaire will be excluded without any responsibility on the participant.

Completion and return of the questionnaire will indicate your willingness to participate in this study. If you require additional information or have questions, please contact me at the addresses listed below.

If you are not satisfied with the manner in which this study is being conducted, you may report any complaints to the LJMU-LOOM research centre. (www.ljmu.ac.uk/ENG/Researchgroups/MORG/)

LOOM Director: Professor Jin Wang email: j.wang@ljmu.ac.uk

Supervisor: Dr. Robert Darlington email: R.I.Darlington@ljmu.ac.uk

Researcher: Saleh Al-Khatib email: s.f.alkhatib@2013.ljmu.ac.uk

This study has received ethical approval from LJMU's Research Ethics Committee

(13/ENR/002- 24/April/2013)

Part One: Logistics Services:

The following lists represent the most commonly known logistics services worldwide.

If you please, Which **of these Services do you provide now?**

Check the box where it applicable, if you have any other logistics services you can add it.

Services		Brief Description	Yes	No
1-1 Inventory and Warehousing Services:			☐	☐
a. Flow-In	**a-1 Receiving and Sorting items**	The basic function of inventory centres is to receive and store items for the time they will be needed	☐	☐
	a-2 Handling	All the movement of the items inside the centres (manually or automatically	☐	☐
	a-3 Quality assurance	All inspection activities about an item's type, time, place, and features	☐	☐
	a-4 Documenting and inventory control	Activities related to data entry and record documentation of all items across all stages	☐	☐
	a-5 Monitoring and tracking activities	Internal monitoring and controlling system inside the inventory centres to ensure the smooth flow, right sequence and high quality of logistics activities.	☐	☐
	a-6 Maintaining and optimising activities	Activities related to development and optimisation of logistics activities to provide more efficient logistics services	☐	☐
	a-7 Barcoding and radio frequency	Item barcoding to facilitate storage, handling and monitoring activities, RFID system use for internal and external communication to facilitate logistics activities	☐	☐
	a-8 Cross Docking services	Receiving and directly transferring shipments between vehicles within 12hours, to reduce time and cost of inventory	☐	☐
	a-9 Refrigerate warehousing	Cooling and Refrigerating warehouses	☐	☐
b. Flow-Out	**b-1 Order filling**	Is the first step in preparing outgoing shipments	☐	☐
	b-2 Preparing shipments shipment planning	planning, preparing, and monitoring an order's items	☐	☐
	b-3 Picking items	Pre-allocation of inventory before the items are picked and grouping shipment's items in one place for transfer	☐	☐
	b-4 Consolidating shipments	Receiving customer's request for products from different sources and delivering them together to the customer	☐	☐
	b-5 Shipping items	Loading ordered items to vehicles	☐	☐

Service		Brief Description	Yes	No
1-2 Transportation:		**Land-Transportation** **Air-Transportation** **Maritime-Transportation**	☐ ☐ ☐	☐ ☐ ☐
a. Inbound transportation	**a-1 Putting away received items**	Moving received items to the right storage places	☐	☐
b. Outbound transportation	**b-1 Customised transportation**	dedicated logistics employees with vehicles for a specific customer to provide a customised logistic services	☐	☐
	b-2 Consolidated transportation	Receiving customer's request for products from different sources and delivering them together to the customer	☐	☐
	b-3 Frequent operations	Providing fixed schedules of transportation services on a daily, weekly or monthly basis	☐	☐
	b-4 Product return Reveres-Logistics	All activities related to moving back returned items	☐	☐
	b-5 Freight forward	Purchasing long-distance transport services from carriers and reselling them to outsourcers	☐	☐
	b-6 Fleet management	Includes all vehicle related activities: financing, moving to maintenance, tracking and diagnostics, speed and fuel management, driver management, traffic management and health and safety management.	☐	☐

Service		Brief Description	Yes	No
1-3 Production and Packaging Services:			☐	☐
a. Packaging	Packaging logistics is an approach aimed at developing package and packaging systems in order to support the logistics process and to meet customer/user demand		☐	☐
b. Labelling	The labelling function comes after the items have been packaged. An item's label is any type of communication (written, electronic, and graphic) used to inform the user about the item's specifications		☐	☐
c. Postponement	**c-1 Geographical Postponement**	Aims to hold item inventory in a central point to delay its commitment to target markets as long as possible until customers' orders are received	☐	☐
	c-2 Production Postponement	Product postponement occurs when the outsourcer delays the last production stages as late as possible until a customer's needs and preferences are known	☐	☐

Service	Brief Description	Yes	No
1-4 Customer Services:		☐	☐
a. Freight Payment and Auditing	May include freight audit, information reporting for logistics, and work with a combination of both EDI and paper freight bills	☐	☐
b. Order management	Order management integrated system includes: item information, inventory availability, order entry, financial processing, order processing, and data analysis and reporting	☐	☐
c. Order fulfilment	The way LSPs respond to customer orders, starting from item inquiry to order configuration, order booking, invoicing, processing, shipment and delivery. It may include order sourcing, planning and changing if necessary	☐	☐
d. Help desk	Help desk provides the outsourcers with information and support related to orders, shipments, prices, inventory levels, shipments' location/stages etc.	☐	☐
e. Carrier selection	In the case of freight forward, "carrier selection services" give the outsourcer the chance to select the suitable carrier	☐	☐
f. Rate negotiation	Collecting and analysing logistics information and shipping characteristics in the industry to provide freight rate structure to negotiate the best price/service combination	☐	☐
g. e-logistics	Providing a real-time global visibility of logistics assets, inventory and vehicles through using advanced software and communication tools	☐	☐

Part Two: Logistics Resources & capabilities

The following lists represent the most needed logistics resources and capabilities that enable LSPs to perform their duties. If you please, as you one of the Jordanian Logistics firms,

Which of the following Resources do you have <u>now</u>?

Check the box where it applicable, if you have any other logistics resources you can add it under each category.

Resources and Capabilities		**Brief Description**	**Yes**	**No**	**If Yes**	
2-1 Tangible Resources			**Total Fixed Assets =___________________JD**			
a. Physical Resources	**a-1 Internal Vehicles**	Small trucks, cranes, etc.	☐	☐	Total # _____________	Total Capacity _____________
	a-2 Transportation facilities	Trucks, trains, planes, ships, etc.	☐	☐	#_____________ #_____________ #_____________	Average age_________ Average age_________ Average age_________
	a-3 Warehouse Facilities	Storage area, handling equipment, etc.	☐	☐	Total Storage Area of all Warehouses ______________m^3	
	a-4 Production and Packaging Facilities		☐	☐	Annual Capacity:	
	a-5 Physical IT Resources	Infrastructure components such as computes, communication tools, databases, etc.	☐	☐	Infrastructure components:	Database storage capacity:
	a-6 Improvement and maintenance	Periodic maintenance, update and improvement	☐	☐	What is the nature and frequency of these improvements? total or partial/ yearly etc. For Trucks: For IT and PCs: For logistics Tools:	
b. Technology Resources	**b-1 Communication systems**		☐	☐	Internal and External coverage:	
	b-2 Internet-based technology and Information systems		☐	☐	Full-function website with up-to-date information:	
	b-3 Hardware and Software		☐	☐	Special hardware/software such as:	
	b-4 Tracking and Tracing tools (EDI, Cargo tracking, etc.)		☐	☐	Type and coverage of Tracking technology:	
	b-5 Cloud Computing Technology		☐	☐	Real-time information sharing and participative decision-making	

Resources and Capabilities			Specifications
2-2 Intangible Resources			
Human Resources, Capabilities	**Total number of workers:__________________,**		
	Qualified Human Resources in terms of:	**Education:** # of workers with	High school ___________, Diploma_______________ Bachelor_____________, Post-Bachelor___________
		Skills level	# of workers with specialized Logistics certificate
		Ability to solve problems	# of workers with Authority to take decisions
		Ability to use technology	# of workers able to use different logistics systems and tools of communications
		Ability to share knowledge	# of workers with authority to share information with customers and other parities
		Training	Average Number of logistics training courses/worker/year_________________
		Experience : # of workers with	Less than 5 years________, from 5 to 10__________ More than 10 years ___________.
Relational Resources	**b-1 Relationships with Customers/Suppliers**		% of loyal customers/Suppliers who work with you for more than a year:
	b-2 Relationships with other LSP		# of other LSPs with over five years cooperation
	b-3 Trademark and trade names that have value as a result of customer relationships. **Licences and Franchises**		Trademark(s):_______________ Trade name(S):_______________ Licences and Franchises:_____________

Follow Part c: Structural Resources and Capabilities ➔

Resources and Capabilities			Specifications
2-2 Intangible Resources			
Structural Resources and Capabilities	**c-1 Database and Software**	Include all the software used in data processing (collecting, organizing, storing, maintaining, mining and sending)	JD invest in logistics Software JD invest in Database JD invest in Automation
	c-2 Image and Reputation	Age of the firm, Rank in the industry, Market Share,	Years________ Your Rank in the Jordanian industry is _________ Estimate your market share percentage
	c-3 Firm's Culture	Attention to details Teamwork levels Aggressiveness Focus on Worker Focus on Output Accept Change Motivate Innovation	High ☐ Moderate ☐ Low ☐ High ☐ Moderate ☐ Low ☐ High ☐ Moderate ☐ Low ☐ High ☐ Moderate ☐ Low ☐ High ☐ Moderate ☐ Low ☐ High ☐ Moderate ☐ Low ☐ High ☐ Moderate ☐ Low ☐

Part Three: Logistics Performance

In order to have a comprehensive and balanced performance evaluation; we need to take different measures related to different areas. The following sections ask you to provide your firm measures regarding four main performance perspectives: **Financial Performance, Customers Satisfaction, Logistics Processes, and finally Learning and Development**. The measures of these four perspectives help us to estimate the overall Jordanian Logistics Sector indicators; which could be used as a reference to evaluate the performance of each LSP firm.

If you please, based on your firm's up-to-date actual records answer the following financial measurers **If it Available**. Wherever the data is not available your responses still valuable contributions, please write "not available (**N/A**)".

Logistics Performance		
3-1 Customer Satisfaction Performance:		
Service Quality and Reliability	**a-1 Order Delivery Time**	
	a-2 Percentage of orders with On-Time Delivery	
	a-3 Average # of Customers' Complaints/year	
	a-4 Percentage of Order Delivery to Correct Destination	
	a-5 Percentage of Orders with the Right Price Calculation	
	a-6 Average # of Units Damaged through transportation	
	a-7 Average Losses Cases during Transportation	
Service Flexibility	**b-1 Ability to add additional Manpower whenever needed**	Yes ☐ No ☐
	b-2 Ability to deal with Expedite Urgent Shipment	Yes ☐ No ☐
	b-3 Ability to Increase/Decrease Delivery Volume	Yes ☐ No ☐
	b-4 Ability to Increase/Decrease Shipment Volume	Yes ☐ No ☐
	b-5 Ability to deal with Special Cargo/customised services	Yes ☐ No ☐
Customer Sustainability	**c-1 Customer Growth Ratio**	**(#of orders this year -#of orders last year)/# of orders last year =**
	c-2 Market Share (estimated)	
	c-3 Customer health and Safety	**# of customers' accidents**

Logistics Performance			
3-2 Logistics Processes		**For Example**	**Your Firm's Measures**
Logistics Quality	a-1 Percentage of Complete Order Delivery	80% of total orders	
	a-2 Percentage of Serious Deliveries (as chemical, petroleum, governmental etc.	20% of total orders	
	a-3 Delay Rate: Percentage of Out-of-date orders	10% of total orders	
	a-4 Percentage of Inventory/internal Damage	2% of total inventory items	
	a-5 Percentage of Inventory Record Errors	0% of total records	
Logistics Productivity	b-1 Complete Order Fill Rate	90% of total received orders	
	b-2 Warehouse Utilization rate	In average 70% of the storage area are used during the year	
	b-3 Truck Space Utilization	In average 80% of Turk spaces are used during the year	
	b-4 Percentage of Faultless Delivery (orders without errors)	83% of total orders are without faults	
	b-5 Total # of Order/Year	In Average we deal with 250 order/year	
Timeliness	c-1 Order Cycle time (average)	In average each order takes 3 working days.	
	c-2 Order Response time (Average Order Lead time)	Response time after receiving the order is 2.3 working days	
	c-3 Percentage of On-Time Pick-Up	We pick-up 94% of customers' ships on time	
	c-4 Average Response time for Customers Complaints	Average time needed to solve a customer's complaints?	
Process Sustainability	d-1 Employee Turn-over Rate	# of employee leave the work/year:	
	d-2 Internal Accident Rate (# of work accident/year)	Office Accidents: Warehouse Accidents: Transport Accidents:	
	d-3 Green/environmental/ sustainable Design	Percentage of the Environmental Offices and Warehouses	
	d-4 Green Purchase (recyclable paper, reusable packages, etc.)	Percentage of green purchase to total firm's purchase	

Logistics Performance		
3-3 Financial Performance (Strength)		
Return and Cash. Which of the current measures your firm apply?	**Total Return (TR)__________________________ Total Assets_________________________**	
	Cash to Cash cycle time (Average days cash is available to use)	**= days cash is locked-up (as inventory and Receivables) – days cash is free=**
	Economic Value added (EVA)	**Rate of return – capital cost =**
Costs (Operational Costs) Average	**Transport Cost**	**Average cost to transport one unit form your warehouse to your customer:**
	Packaging Cost	**Average cost to package one unit:**
	Inventory Cost/Unit	**Average cost to keep one unit at your warehouse for an average inventory time:**
	Handling cost	**Average cost to receive, sort, store, move, etc. one unit for an average inventory time:**
	Waste handling	**Average cost to handle one ton of waste**
	Greening Cost	**Average cost/year to be more environment-friendly firm**
Flexibility	**Flexible Billing system**	**Ability to customise bills based on the customer's preferences:** Yes ☐ For some customers ☐ N/A ☐
	Discount Opportunities (different prices for different situations)	**Do you have Quantity Discount:** Yes ☐ No ☐ **Do you have Time Discount :** Yes ☐ No ☐
Total Value.	**Firm's Book-Value**	
	Firm's Market-Value	
	Total Salaries/year	
Profitability	**Net Profit**	
	Gross Profit	
	Profit Margin	

Logistics Performance			
3-4 Learning and Growth Perspective			
Employee Training and Education	**# of training courses in general/year**		
	# of logistics courses /year		
	#of administrative and decision-making courses/year		
	# of workers trained/year		
	Training budget/year		
Innovation and Development	**Investment in R&D**		
	Innovation Rate of new product/services per year		
Resources Sustainability	**Resources Productivity**	**Average JDs obtained through the expenditure of unit of resource (fuel)**	
	Waste Volume/Year	**Average waste volume during the year**	
	Corporate Sustainability Report	**Annual report gives information about economic, environmental, social and governance performance**	Yes ☐ No ☐ **If Yes, could you attach a copy of it?**
	Energy Consumption JD/Year	**Fuel, Oil, gas, electricity.. etc. with total cost of e.g. JD25,000.**	**Fuel:** **Utilities:**
	Percentage of Renewable Resources (sustainable Energy)	**Natural resource which can replenish with time (Solar, Wind,,, etc.**	

Additional Information:

Dimension	Your Notices
Logistics Services	
Logistics Resources	
Logistics Performance	

2- FDEMATEL - Logistics service provider evaluation and Selection

LSPs' Resources & Capabilities

A research project at Liverpool John Moores University is currently being carried out to develop an advanced LSP's evaluation and selection framework. This project aims at providing a comprehensive framework to help managers and decision makers in business, governments and NGOs to take their logistics-based decision effectively and efficiently. This subject is considered among the critical topics on the international agenda due to the logistics crucial role in today business world.

My name is SALEH AL-KHATIB and I am a Postgraduate student at LJMU, because you are an expert in this field, I am inviting you to contribute to this research study by completing the attached surveys. Thank you for taking the time to assist me in my educational endeavours. An advanced framework to evaluate and select an appropriate LSP has been developed through integrating the three value-added sources: resources and capabilities, performance, and logistics services.

The following questionnaire covers the first part of the framework (Logistics Resources and Capabilities) which based on the RBL theory, will require approximately 20-30 minutes to complete. There is no compensation for responding nor is there any identified risk. If you choose to participate in this project, please answer all questions as honestly as possible. Participation is strictly voluntary and you may refuse to participate at any time. Any refusal or incomplete questionnaire will be excluded without any responsibility on the participant. Completion of the questionnaire will indicate your willingness to participate in this study. If you require additional information or have questions, please contact me at the addresses listed below.

If you are not satisfied with the manner in which this study is being conducted, you may report any complaints to the LJMU-LOOM research centre.

(www.ljmu.ac.uk/ENG/Researchgroups/MORG/)
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This study has received ethical approval from LJMU's Research Ethics Committee
(13/ENR/002- 24/April/2013)

The General Dimensions

The following questions based on pairwise comparisons, if you please, based on your experience, use the following linguistic scale to estimate to what extent each left-side factor affects the opposite factor; where:

No Influence
Very Low Influence
Low Influence
High Influence
Very High Influence

This part aims to evaluate the causal relationships among the main three dimensions of the LSP evaluation and selection framework (Logistics Performance, Logistics Resources and Capabilities, and Logistics Services)

Logistics Performance, includes: Financial, Customer, Processes, and learning and growth perspectives
Logistics Resources, includes: All the Tangible and Intangible logistics resources and capabilities
Logistics Services include: Warehousing and inventory, Transportation, Postponement and e-Logistic Services. *

	No Influence	Very Low Influence	Low Influence	High Influence	Very High Influence	
Logistics Performance	◯	◯	◯	◯	◯	Logistics Resources and Capabilities
Logistics Performance	◯	◯	◯	◯	◯	Logistics Services
Logistics Resources and Capabilities	◯	◯	◯	◯	◯	Logistics Performance
Logistics Resources and Capabilities	◯	◯	◯	◯	◯	Logistics Services
Logistics Services	◯	◯	◯	◯	◯	Logistics Performance
Logistics Services	◯	◯	◯	◯	◯	Logistics Resources and Capabilities

LSPs Resources and Capabilities Evaluation

Tangible Logistics Resources & Facilities include physical logistics Resources & Facilities and Technology-based Resources.

Intangible Logistics Resources and Facilities include: Human resources, Relational resources, and Structural resources. *

	No Influence	Very Low Influence	Low Influence	High Influence	Very High Influence	
Tangible Resources & Facilities						Intangible Resources & Facilities
Intangible Resources & Facilities						Tangible Resources & Facilities

General Tangible Dimensions

Physical Resources & Facilities include: Warehousing, Transportation, Production and Packaging Resources & Facilities, and Improvements and Maintenance of these Resources & Facilities.

IT-based Resources & Facilities include: Physical IT, Communication, Tracking and Tracing tools, Internet-based technology and IS. *

	No Influence	Very Low Influence	Low Influence	High Influence	Very High Influence	
Physical Resources & Facilities						IT-based Resources & Facilities
IT-based Resources & Facilities						Physical Resources & Facilities

Tangible Resources: Physical Resources & Facilities

Warehousing Resources & Facilities: All tools, machines and equipment used to receive, sort, store and handle shipments

Transportation Resources & Facilities: All logistics physical resources used to transport shipments from /to warehouses, Trucks, Train, Planes and Ships

Production and Packaging Resources & Facilities: Tools and machines used in partial-production, assembly processes, packaging and labelling activities.

Improvements and Maintenance: Investment in acquiring, improving, and updating logistics resources and technologies to increase the firm's ability to perform logistics activities effectively and efficiently. *

	No Influence	Very Low Influence	Low Influence	High Influence	Very High Influence	
Warehousing Resources & Facilities	○	○	○	○	○	Transportation Resources & Facilities
Warehousing Resources & Facilities	○	○	○	○	○	Production & Packaging
Warehousing Resources & Facilities	○	○	○	○	○	Resources & Facilities Improvement & Maintenance
Transportation Resources & Facilities	○	○	○	○	○	Warehousing Resources & Facilities
Transportation Resources & Facilities	○	○	○	○	○	Production & Packaging
Transportation Resources & Facilities	○	○	○	○	○	Resources & Facilities Improvement & Maintenance
Production & Packaging Resources & Facilities	○	○	○	○	○	Warehousing Resources & Facilities
Production & Packaging Resources & Facilities	○	○	○	○	○	Transportation Resources & Facilities
Production & Packaging Resources & Facilities	○	○	○	○	○	Resources & Facilities Improvement & Maintenance
Resources & Facilities Improvement & Maintenance	○	○	○	○	○	Warehousing Resources & Facilities
Resources & Facilities Improvement & Maintenance	○	○	○	○	○	Transportation Resources & Facilities
Resources & Facilities Improvement & Maintenance	○	○	○	○	○	Production & Packaging Resources & Facilities

If you please, Rank the following lists based on the relative importance of each element under each category. Number '1' is the lowest importance.

1- Warehousing and Inventory: *

	Inventory Area
	Warehousing/Inventory facilities and equipment
	Handling equipment
	Automated Material Handling equipment
	Cranes, Winches, etc.
	Special Inventory tools/area: Refrigeration storage, chemical containers, etc.
	Inventory Records/Management

2- Transportation: *

	Types of Trucks, Trains, Planes, Ships etc.
	Sizes of Trucks, Trains, Planes, Ships etc.
	Ages of Trucks, Trains, Planes, Ships etc.
	Amount of Investment in Transportation Facilities.
	Availability/Appropriateness of Transportation Facilities.

3- Production and Packaging *

	Assembly Lines
	Packaging equipment
	Labelling equipment
	Availability/Appropriateness of these facilities.

4- Improvement and Maintenance *

	Amount of Investment in Improvement and Maintenance
	Number of Periodic maintenance/Year
	Nature of Improvement Actions (minor or major)
	Availability and Sufficiency of Improvement and maintenance Actions

Tangible Resources & Facilities: IT-based Resources

Physical IT includes: All hardware components and IT infrastructures such as computers, networks and barcode readers used to provide effective logistics activities through facilitate communication and data sharing among the logistics network parities.

Communication and Tracking and Tracing systems: Systems and tools used to enhance communication inside and outside LSP firms to provide smooth monitoring of shipments and inventory throughout all stages within the logistics network worldwide.

IS and Internet-base technology: Web-based IS using computers, networking and other software systems to support and control logistics activities, and to facilitate information access by different parities in the logistics network to support decision-making process. *

	No Influence	Very Low Influence	Low Influence	High Influence	Very High Influence	
Physical IT	○	○	○	○	○	Communication & Tracking-Tracing Tools
Physical IT	○	○	○	○	○	IS and Internet-based Resources & Facilities
Communication & Tracking-Tracing Tools	○	○	○	○	○	Physical IT
Communication & Tracking-Tracing Tools	○	○	○	○	○	IS and Internet-based Resources & Facilities
IS and Internet-based Resources & Facilities	○	○	○	○	○	Physical IT
IS and Internet-based Resources & Facilities	○	○	○	○	○	Communication & Tracking-Tracing Tools

If you please, Rank the following lists based on the relative importance of each element under each category. Number '1' is the lowest importance.

1- Physical IT Resources and Capabilities: *

- [▾] Computers and Platforms
- [▾] Networks equipment
- [▾] Database equipment
- [▾] Mobile data entry equipment

2- Communication, Tracking, and Tracing Equipment: *

	RFID
	GPS
	GPD
	GIS
	Internal connectivity coverage
	External connectivity coverage
	Availability and Appropriateness of these facilities

3- IS AND Internet-based technology: *

	Amount Invested in IS and internet-based technology
	Internet services facilities (servers)
	Availability and Appropriateness of web-based/ IS networking

Intangible Resources and Capabilities

Human Resources include: education and training, knowledge and experience, skills and capabilities.

Relational Resources include: collaborations, long-term relationships, and information sharing.

Structural Resources include: databases and software, image and reputation, and LSPs' culture. *

	No Influence	Very Low Influence	Low Influence	High Influence	Very High Influence	
Human Resources	◯	◯	◯	◯	◯	Relational Resources
Human Resources	◯	◯	◯	◯	◯	Structural Resources
Relational Resources	◯	◯	◯	◯	◯	Human Resources
Relational Resources	◯	◯	◯	◯	◯	Structural Resources
Structural Resources	◯	◯	◯	◯	◯	Human Resources
Structural Resources	◯	◯	◯	◯	◯	Relational Resources

If you please, Rank the following lists based on the relative importance of each element under each category. Number '1' is the lowest importance.

1- Education and Training: *

[▾]	Number of courses/year
[▾]	Number of Certificates
[▾]	% of employees participate in these courses
[▾]	Type of these courses and certificates

2- Knowledge and Experience: *

[▾]	Years of managerial experience
[▾]	Years of logistics experience
[▾]	Level of managerial experience
[▾]	Level of logistics experience

3- Skills and Capabilities: *

[▾]	Employees' Salaries and Wages
[▾]	% of employees with decision making authority
[▾]	% of employees with multi skills capabilities
[▾]	Quality/Level of employees' skills

Intangible Logistics Resources: Relational Resources

Collaboration and Cooperation: LSP ability and experience to cooperate with other SC's members in group decision-making processes

Long-term Relationships: LSP ability to build and sustain long-term relationships with customers and suppliers

Information Sharing: LSP ability and willingness to share right information at the right time for the right partner. *

	No Influence	Very Low Influence	Low Influence	High Influence	Very High Influence	
Collaboration and Cooperation	◯	◯	◯	◯	◯	Long-term Relationships
Collaboration and Cooperation	◯	◯	◯	◯	◯	Information Sharing
Long-term Relationships	◯	◯	◯	◯	◯	Collaboration and Cooperation
Long-term Relationships	◯	◯	◯	◯	◯	Information Sharing
Information Sharing	◯	◯	◯	◯	◯	Collaboration and Cooperation
Information Sharing	◯	◯	◯	◯	◯	Long-term Relationships

If you please, Rank the following lists based on the relative importance of each element under each category. Number '1' is the lowest importance.

1- Collaboration: *

- [ ] Number of Supply Chains that you work with (grid network technology)
- [ ] Number or % of firms you collaborate with them
- [ ] Ability/Willingness to collaborate with other SCs and/or Firms

2- Long-term Relationships: *

- [ ] Number or % of SCs that you work with for more than 2 years
- [ ] Number or % of firms that you work with them for more than 2 years
- [ ] Ability/Willingness to build a healthy long-term relationships

3- Information Sharing: *

- [ ] Number or % of firms that have direct access to your database
- [ ] Number or % of firms that share with you POS and Inventory level Data
- [ ] Ability/ Willingness to share information (EDI)

Intangible Logistics Resources: Structural Resources

Database and Software: Include all the software used in data processing (collecting, organizing, storing, maintaining, mining and sending and distribution) effectively and accurately.
Image and Reputation: Opinion of the public about the firm's image, services reputation and satisfaction level.
Cultural and management Commitment: The shared values, principles and firm's philosophy about different topics such as trust, openness, participation and interaction, TQM, and sustainability. *

	No Influence	Very Low Influence	Low Influence	High Influence	Very High Influence	
Database & Software Resources & Capabilities	○	○	○	○	○	Image & Reputation Resources & Capabilities
Database & Software Resources & Capabilities	○	○	○	○	○	Cultural & Management Commitment
Image & Reputation Resources & Capabilities	○	○	○	○	○	Database & Software Resources & Capabilities
Image & Reputation Resources & Capabilities	○	○	○	○	○	Cultural & Management Commitment
Cultural & Management Commitment	○	○	○	○	○	Database & Software Resources & Capabilities
Cultural & Management Commitment	○	○	○	○	○	Image & Reputation Resources & Capabilities

If you please, Rank the following lists based on the relative importance of each element under each category. Number '1' is the lowest importance.

1- Databases and Software: *

▾	Amount Investment in Databases and logistics software
▾	Availability of warehousing, inventory, transport management ...software
▾	Databases and Software Updating

2- Image and Reputation: *

▾	Firm's local rank
▾	Market share
▾	% of loyal Customers (stay with the firm > 2years)

3- Firm's Culture: *

▾	Number of conflicts/problems with customers per year
▾	% of employees with decision making Authority
▾	Appropriateness of Values, norms, and Principles
▾	Participation and Empowerment
▾	Innovation, Risk taking, and change acceptance

Personal Information

Position / Title *

- [ ] Academic
- [ ] Researcher
- [ ] Administrative - logistics
- [ ] Administrative - Others
- [ ] Other

If Academic and/or Researcher *

Number of published papers

Number of PhD students

Number of Conferences

Years of Experience *

Notices

3- FTOPSIS - Logistics service provider evaluation and Selection

LSPs' Resources & Capabilities

A research project at Liverpool John Moores University is currently being carried out to develop an advanced LSP's evaluation and selection framework. This project aims to provide a comprehensive framework to help managers and decision makers in business, governments and NGOs to take their logistics-based decision effectively and efficiently. This subject is considered among the critical topics on the international agenda due to the logistics crucial role in today business world.

An advanced framework to evaluate and select an appropriate LSP has been developed through integrating the three value-added sources: resources and capabilities, performance, and logistics services. I am a Postgraduate student at LJMU, because you are an expert in this field, I am inviting you to contribute to this research study by completing the attached surveys. Thank you for taking the time to assist me in my educational endeavours.

This questionnaire tries to evaluate a number of LSPs based on the first part of the framework (Logistics Resources and Capabilities) which based on the RBL theory. There is no compensation for responding nor is there any identified risk. If you choose to participate in this project, please answer all questions as honestly as possible. Participation is strictly voluntary and you may refuse to participate at any time.

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(www.ljmu.ac.uk/ENG/Researchgroups/MORG/)

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Researcher: Saleh Al-Khatib email: s.f.alkhatib@2013.ljmu.ac.uk

This study has received ethical approval from LJMU's Research Ethics Committee
(13/ENR/002- 24/April/2013)

Introduction:

The following questions are based on pairwise comparisons technique. Based on your experience in this field, each question asks you to rank the LSPs based on their resources and capabilities. Information about the LSPs resources and capabilities are available in each section. Your answer at any point shows the performance of i^{th} LSP with response to j^{th} resources.

The following linguistic rating variables could be used to evaluate LSPs alternatives with respect to each criterion:

- Very Good (V.G)
- Good (G)
- Fair (F)
- Poor (P)
- Very Poor (VP)

Example:

The following data represent number, average age, and total load of three LSPs' Trucks.

LSP alternatives	# of Trucks	Average Age - years	Total Load - Tons
LSP1	35	12.5 year	700
LSP2	20	8	500
LSP3	27	5	675

Based on these data we can rate transportation resources and facilities of these three LSPs as follows:

LSP alternatives	Transportation Resources and facilities
LSP1	F
LSP2	F
LSP3	G

Part One: Tangible Logistics Resources and Capabilities

This part includes the 'Physical resources' and 'IT-based resources'. Under the 'Physical resources' there are: warehousing & inventory resources and facilities; transportation resources; production & packaging; and maintenance & improvement. Whiles, under the 'IT-based resources' there are: physical IT resources, communication tools, and IS and internet-based resources.

Physical Logistics Resources

Based on the following data, could you please rate the LSP alternatives using the linguistic rating variables (VG, G, F, P, and VP).

LSP	Total fixed assets	# of internal vehicles	Capacity	# of transportation vehicle	Avg. age	Storage area
1	N/A	N/A	N/A	N/A	N/A	N/A
2	N/A	2	10 ton	4vans, 1forklift, 3cars	5,5,2 years	1000 m^2
3	1,600,000JD	N/A	N/A	24cars, 3trucks,	3 years	800 m^2
4	300,000JD	11	N/A	42trucks (16 refrigerated)	8 years	9500 m^2
5	400,000JD	3	N/A	18big and 6small	3 to 4 years	1200 m^2
6	10,000,000JD	15	multi	60 truck	5 years	20,000 m^2
7	150,000JD	2	N/A	22 truck	N/A	3000 m^2

N/A: not announced and/or not available.

LSP	Database storage	Improvement & maintenance
1	N/A	YES
2	N/A	YES - monthly
3	go daddy/ dedicated servers	YES
4	high performance server	YES, trucks-weekly, firm-monthly
5	able to expand	YES as it needed
6	cloud system	YES monthly/weekly
7	N/A	YES for-trucks

Rating of LSP alternatives based on the 'Physical resources'

LSP	Warehousing & Inventory	Transportation	Production & Packaging	Improvement & Maintenance
1				
2				
3				
4				
5				
6				
7				

IT-based Logistics Resources

Based on the following data, could you please rate the LSP alternatives using the linguistic rating variables (VG, G, F, P, and VP).

LSP	Communication systems	Internal coverage	external coverage	IT & IS	Website	Examples	CLOUD SYSTEMS	EDI, RFID, CARGO TRACKING
1	YES	N/A	N/A	YES	N/A	N/A	YES	NO
2	YES	N/A	N/A	YES	N/A	WH. SYS & SECURITY	YES	YES
3	YES	N/A	N/A	YES	YES	EXPIDITORS TRACKING	YES	YEs
4	YES	N/A	N/A	YES	YES	TRACKING	NO	YES
5	YES	100%	N/A	YES	YES	Tracking IIS	NO	YES - IIS
6	YES	100%	N/A	YES	YES	Tracking/ shipments	YES	special SW
7	YES	YES	YES	YES	YES	YES	NO	YES

Rating of LSP alternatives based on the 'IT-based' resources

LSP	Physical IT	Communication	IS & Internet-based facilities
1			
2			
3			
4			
5			
6			
7			

Part Two: Intangible Logistics Resources and Capabilities

This part includes the 'Human', 'Relational', and 'Structural' resources and capabilities. Under the 'Human' there are: knowledge & experience; education & training; and skills. Under 'Relational resources' there are: collaboration, long-term relationships, and information sharing. While, 'Structural resources' include: databases & software, image & reputation, and firm's culture.

Human Resources

Based on the following data, could you please rate the LSP alternatives using the linguistic rating variables (VG, G, F, P, and VP).

LSP	# of employees	Diploma	BA	Grad.	Others	Logistics certificate
1	35	6	22	4	3	8
2	40	5	30		5	DGR-COMPUTER-IATA
3	38	12	15		11	32
4	113	54	38	2	9	18
5	65	30	8	3	24	42
6	220	86	42	12	80	128
7	35	13	22			6

LSP	# of employees with DM authority	able to use logistics tech	share info	# of training courses	5 years' experience.	5 to 10 years	more than 10 years
1	6	24	24	8	N/A	N/A	N/A
2	6	all	10	2	5	30	5
3	4	32	4	6	38	N/A	N/A
4	5	all	13	8	N/A	N/A	N/A
5	3	42	7	4	16	37	12
6	14	100	45	12	88	65	67
7	3	4	5	1	35	N/A	N/A

Rating of LSP alternatives based on the 'Human' resources

LSP	Knowledge & Experience	Education & Training	Skills capabilities
1			
2			
3			
4			
5			
6			
7			

Relational Resources

Based on the following data, could you please rate the LSP alternatives using the linguistic rating variables (VG, G, F, P, and VP).

LSP	Relationships with customers	Relationships with suppliers	Relationships with other LSP	TRADEMARKS/TRADE NAMES
1	8	10	2	N/A
2	95%	95%	2	UPS-FIDI-ISO-CONSOLIDATED MARKETING AND LOG.
3	432 FIRMS WW	34-35	34	EXPIDITORS
4	40%	20% AS DHL	12	DIONEX
5	60%	50 to 60%	27	N/A
6	70%	75%	13	MALTRANSE SHIPPING / AL WASAT WAREHOUSING
7	60%	80%	3	MEDICNE TRANS

Rating of LSP alternatives based on the 'Relational' resources

LSP	Collaboration	Long-term Relationships	Information sharing
1			
2			
3			
4			
5			
6			
7			

Structural Resources

Based on the following data, could you please rate the LSP alternatives using the linguistic rating variables (VG, G, F, P, and VP).

LSP	Investment in database & software	Firm age	Local rank /profits	Market share	Attention to details	Team work	Aggressive	People oriented	Output oriented	Risk Taking	Innovation & change
1	N/A	25	2	20%	H	H	M	M	H	M	H
2	20,000JD	15	5	15%	H	H	M	M	M	H	M
3	N/A	3	N/A	N/A	H	H	H	H	H	H	H
4	N/A	12	5	N/A	H	H	H	H	H	H	H
5	N/A	14	Adequate	2%	H	H	H	H	H	H	H
6	N/A	35	first	50%	H	H	H	H	H	H	H
7	N/A	4	First in medicine	80% of medicine trans	H	H	M	H	H	M	M

Rating of LSP alternatives based on the 'Structural' resources

LSP	Database and Software	Image & Reputation	Firm's Culture
1			
2			
3			
4			
5			
6			
7			

Appendix 4-1 Importance and Usage Rate-Logistics Resources and Capability

Tangible Resources			Intangible Resources		
Factor	**Importance**	**Usage Rate**	**Factor**	**Importance**	**Usage Rate**
Improvement in logistics facilities and technology usage	4.56	0.65	Focusing on customers' requirements and satisfaction	4.56	0.83
Logistics facilities and equipment	4.50	0.79	Management experience	4.38	0.85
Periodic maintenance	4.44	0.77	Coordination and collaboration with customers	4.31	0.73
Continuous improvement	4.44	0.67	Continual improvement for sustainable services	4.31	0.67
Transportation facilities and equipment	4.31	0.77	Skilled and educated workers	4.25	0.67
Facilities and equipment maintenance and improvement	4.31	0.71	Communication	4.19	0.75
Web-based information systems	4.25	0.65	Management commitment, trust, openness	4.13	0.65
New technology advanced equipment	4.19	0.56	TQM and environmental policy for safety and health	4.06	0.65
Communication facilities and equipment	4.13	0.67	Training for managerial and logistics skills	4.06	0.61
Advanced equipment and facilities	4.13	0.59	Attempts to build mutual and long term relationships	4.00	0.71
Warehousing facilities and equipment	4.06	0.69	Organisational	4.00	0.69
IT infrastructure	4.06	0.67	Commitment to recruit experienced workers	4.00	0.56
Electronic Data Interchange (EDI) facilities and equipment	4.00	0.63	Multi-experienced workers	3.94	0.63
Barcode	4.00	0.60	Relational	3.81	0.71
IT facilities and equipment	3.94	0.67	Commitment to information sharing	3.81	0.67
			Practices and routine for providing solutions to	3.81	0.60
			Organisational culture and shared values system	3.81	0.54

Appendix 4-2: Importance and Usage Rate-Logistics Performance Perspectives

Financial Strength			Customer Satisfaction		
Factor	**Importance**	**Usage Rate**	**Factor**	**Importance**	**Usage Rate**
Operational profit	4.56	0.81	Delivery to correct destination	4.44	0.73
Total revenue	4.50	0.75	On-time delivery	4.31	0.79
Profit margin	4.31	0.71	Delivery time	4.19	0.75
Warehousing cost	4.31	0.69	Quality of employee	4.19	0.73
Transportation cost	4.25	0.75	Order response time	4.19	0.71
Logistics cost/unit	4.19	0.65	Days of order late	4.19	0.65
ROE (return on equity)	4.06	0.69	Customer growth	4.13	0.65
ROI (return on investment)	4.06	0.69	Complete order fill rate	4.06	0.60
Handling cost	4.06	0.67	Average order cycle time	4.00	0.52
Cash-to-cash ratio	4.00	0.58	Avoiding customer discrimination	3.88	0.56
Logistics fixed cost	4.00	0.56	Customer health and safety	3.75	0.48
ROA (return on assets)	3.75	0.63	Customer value added	3.50	0.52
Logistics cost as % of sales	3.63	0.54	Cargo space confirmation	3.31	0.52
Economic value added	3.63	0.44			
Flexible billing system	3.44	0.40			
Discount opportunities	3.38	0.46			
Resource productivity	3.38	0.42			
Environmental accounting	2.75	0.38			
Green product/service profit	2.75	0.37			

Continue ➔

Appendix 4-2

Logistics Processes			Learning and Growth		
Factor	**Importance**	**Usage Rate**	**Factor**	**Importance**	**Usage Rate**
Order fulfilment	4.25	0.69	Employee skills and knowledge	4.44	0.71
On-time pick-up	4.19	0.79	Employee training, education	4.44	0.67
Inventory accuracy	4.13	0.73	Employee safety and health	4.44	0.63
Damage due to transportation	4.13	0.69	Rate of costs reduction	4.38	0.58
Health/safety of employees (Work condition)	4.06	0.67	TQM certificates	4.19	0.65
Delay rate	4.06	0.65	Avoiding employee discrimination	4.19	0.63
Internal accident rate	4.00	0.52	Employee satisfaction	4.13	0.56
Delivery complete order	3.94	0.60	new products/services Profit	3.94	0.54
Internal damage	3.88	0.71	R&D budget	3.94	0.50
Shortest lead-time	3.88	0.56	ISO 28000 certificates	3.88	0.56
Waste volume	3.81	0.56	Training budget	3.88	0.50
Thefts during transportation	3.75	0.63	Intellectual capital	3.56	0.50
Expedite urgent shipment	3.75	0.54	ISO 14000 certificates	3.56	0.50
Serious delivery	3.75	0.54	Greening costs	3.00	0.31
Increase/decrease delivery volume	3.69	0.54			
Increase/decrease shipment volume	3.63	0.56			
Packaging cost	3.63	0.56			
Additional manpower at short notice	3.63	0.52			
Ordering cost	3.56	0.61			
Corporate sustainability report	3.50	0.46			
HO, CH and greenhouse gases	3.50	0.40			
Profit/employee	3.44	0.44			
Average age of vehicles	3.38	0.49			
Employee value added	3.38	0.48			
Green design	3.38	0.44			
Green purchasing	3.31	0.46			

Appendix 4-3: Importance and Usage Rate- Logistics Services and Activities

Factor	Importance	Usage Rate	Factor	Importance	Usage Rate
Warehousing	4.44	0.84	Help desk	4.19	0.75
Inventory management	4.38	0.73	Shipment planning	4.19	0.73
Auditing	4.31	0.77	Order management	4.19	0.73
Traffic management	4.31	0.73	Invoicing (Freight payments, customer clearance)	4.13	0.75
Handling	4.31	0.71	Carrier selection	4.00	0.61
Fleet management	4.31	0.69	Labelling	3.81	0.67
Customer services	4.25	0.75	Product return	3.81	0.59
Tracking & tracing	4.25	0.73	Packaging	3.81	0.54
Transportation	4.25	0.73	Cross docking/reshipment	3.81	0.54
Freight consolidation and distribution	4.25	0.71	Rate negotiation	3.69	0.54
			Product making	3.31	0.46

Appendix 5-1: Logistics Resources and Capabilities

Tangible Resources and Capabilities			
	Resources	**Measures**	**References**
Physical Resources	Warehousing facilities	Warehousing area. Vehicles' age, numbers and capacity. Automation levels.	(Lai 2004); (Selviaridis et al., 2007); (Karia and Wong 2013); (Efendigil et al., 2008); (Rajesh et al., 2011); (Falsini et al., 2012)
	Transportation facilities	Types, size, purpose and ages of: trucks, train, planes and ships.	(Stefansson 2006); (Selviaridis et al., 2007); (Rajesh et al., 2011)
	Production and Packaging facilities	Assembly lines; Packaging equipment; Labelling equipment.	(Stefansson2006); (Selviaridis et al., 2007); (Falsini et al., 2012)
	Improvements and maintenance of tangible logistics resources	Maintenance contracts; Periodic maintenance; Periodic training to use physical and technological resources; New technology adaptation.	(Selviaridis et al., 2007); (Karia and Wong 2013)
Technological Resources	Physical IT	Computers and platform networks. Databases equipment.	(Selviaridis et al., 2007); (Rajesh et al., 2011)
	Communication systems and tracking and tracing tools	RFID, GPS, GPD, GIS. Internal connectivity coverage. External connectivity coverage.	(Marasco 2008); (Karia and Wong 2013); (Rajesh et al., 2011); (Jaimes et al., 2011); (Ramanthan et al., 2014); (Vlachos, 2014)
	Internet-based technology and information systems	Web-based IS. Networking and real-time collaboration.	(Wu et al., 2006); (Selviaridis et al., 2007); (Marasco 2008); (Lai et al., 2008); (Karia and Wong 2013); (Ryoo and Kim, 2015)

Continued over ➔

Intangible Resources and Capabilities				
Resources	**Classifications**	**Description**	**Measures**	**References**
Human resources and capabilities	Skills, Education, Knowledge, Training.	The accumulated employees' logistics education, knowledge, skills and management experiences.	Total investment in terms of salaries and wages. Number/type of certificates. Managerial experience.	(Karia and Wong 2013); (Mehri et al., 2013); (Ryoo and Kim, 2015)
Structural resources and capabilities	Advanced software and databases.	All software used in data processing (collecting, organising, storing, maintaining, mining and sending and distribution) effectively and accurately.	Automated storage and warehousing software (computerised). EDI.	(Wu et al., 2006); (Selviaridis et al., 2007) ; (Marasco 2008); (Rajesh et al., 2011); (Mehri et al., 2013)
	Image and Reputation	Opinion of the public regarding the firm's image, services reputation and satisfaction level (Rajesh et al., 2011).	Firm's local ranking according to logistics associations.	(Boyson et al., 1999); (Jharkharia and Shankar 2007); (Rajesh et al., 2011)
	Cultural and managerial commitment	The shared values, principles and firm's philosophy of various topics such as trust, openness, participation and interaction, TQM and sustainability.	Practices and routines. Values, norms and principles. Participation and empowerment. Innovation, trust and openness.	(Lai et al., 2008); (Karia and Wong 2013)
Relational resources and capabilities	Collaboration and cooperation (information sharing and long-term relationships)	LSP's capability to build and sustain long-term relationships. LSP capability and willingness to share right information at the right time for the right partner. LSP capability and experience to cooperate with other supply chain members.	Long-term relationships. Information sharing. Flexibility in services. (size and direction of shipments, adding manpower)	(Jharkharia and Shankar 2007); (Karia and Wong 2013); (Kayikci and Stix, 2014); (Sprenger et al., 2014).

Appendix 5-2: Relative importance of Metrics under Logistics Resources & Capabilities

Tangible R&C	Relative Importance	Intangible R&C	Relative Importance
Warehousing		**Education**	
Cranes, Winches, etc.	0.205	Number of courses/year	0.300
Special Inventory tools/area: Refrigeration storage, chemical containers, etc.	0.205	Number of Certificates	0.300
Inventory Records/Management	0.188	Type of these courses and certificates	0.233
Handling equipment	0.116	% of employees participate in courses	0.167
Inventory Area	0.098	**Knowledge**	
Automated Material Handling equipment	0.089	Years of logistics experience	0.333
		Level of logistics experience	0.333
Transportation		Years of managerial experience	0.167
Ages of Trucks, Trains, Planes, Ships etc.	0.233	Level of managerial experience	0.167
Availability/Appropriateness of Facilities.	0.233	**Skills**	
Sizes of Trucks, Trains, Planes, Ships etc.	0.217	% employees with decision making authority	0.333
Types of Trucks, Trains, Planes, Ships etc.	0.167	% employees with multi skills capabilities	0.267
Amount Invested in Transport Facilities.	0.150	Employees' Salaries and Wages	0.200
Production and packaging		Quality/Level of employees' skills	0.200
Labelling equipment	0.325	**Collaboration**	
Assembly Lines	0.225	Ability/Willingness to collaborate	0.389
Packaging equipment	0.225	# or % of firms you collaborate with	0.333
Availability/Appropriateness of facilities.	0.225	Number of Supply Chains that you work with	0.278

Tangible R&C	Relative Importance	Intangible R&C	Relative Importance
Improvement and maintenance		**Long-term relationships**	
Number of Periodic maintenance/Year	0.300	Ability/Willingness to build healthy long-term relationships	0.389
Nature of Improvement Actions minor/major	0.250	Number or % of firms that you work with for more than 2 years	0.333
Availability and Sufficiency of Improvement and maintenance Actions	0.250	Number or % of SCs that you work with for more than 2 years	0.278
Amount of Investment in Improvement and Maintenance	0.200	**Information sharing**	
Physical IT		Number or % of firms that share with you POS and Inventory level Data	0.389
Computers and Platforms	0.300	Number or % of firms with direct access to your database	0.333
Networks equipment	0.267	Ability/Willingness to share information-EDI	0.278
Database equipment	0.233	**Databases and Software**	
Mobile data entry equipment	0.200	Databases and Software Updating	0.389
Communication Tracking & Tracing		Amount Invested in Databases and logistics SW	0.333
GIS (Geographical Information System)	0.202	Availability of warehousing, inventory, transport management ...software	0.278
GPDL (Global Personal Digital Location)	0.155	**Image & Reputation**	
External connectivity coverage	0.155	Market share	0.389
GPS (Global Positioning system)	0.131	% of loyal Customers (stay with the firm > 2years)	0.389
Internal connectivity coverage	0.131	Firm's local rank	0.222
Availability and Appropriateness of these facilities	0.131	**Cultural & Management**	
RFID	0.095	Appropriateness of Values, norms and Principles	0.267
Information and Internet based systems		Number of conflicts/problems with customers per year	0.267
Internet services facilities (servers)	0.444	% of employees with decision making Authority	0.200
Amount Invested in IS and internet-based technology	0.333	Innovation, Risk taking and change acceptance	0.156
Availability and Appropriateness of web-based/ IS networking	0.222	Participation and Empowerment	0.111

Appendix 6-1: LKPIs Operational Definitions for each SBSC Perspective

Financial performance			
LKPI	**Metrics**	**Description**	**References**
Profitability	Operational profit	Income resulting from a firm's primary business operations excluding extraordinary income and expenses = sales revenue – (cost of sales + operating expenses).	(Xiaoping and Chen, 2008) (Kaplan and Norton, 1992)
Return and Cash	Total revenue.	The total annual revenue can be used as an indicator for the market size. It also shows the financial performance and market share. Market share reflects customer satisfaction, financial performance and reputation of service providers.	(Jharkharia and Shankar, 2007). (Kumar, 2012)
	ROE.	The amount of net income returned as a percentage of shareholders' equity, measuring the firm's profitability by revealing how much profit a firm generates with the money shareholders have invested= NI/Shareholders'' Equity.	(Liberatore and Miller, 1999) (Rajesh et al., 2012b). (Kaplan and Norton, 1992)
	ROI.	Use to evaluate the efficiency of an investment = (Gain from investment-Cost)/Cost.	(Bhagwat and Sharma 2007) (James et al., 2012)
Costs	Warehousing costs. Inventory/storage cost. Holding cost. Carrying cost.	The cost of keeping and maintaining a stock of goods in storage: it is common to estimate this as at least one-third the value of the stored goods per year. If the opportunity cost is included it is reasonable to use one-half of the value of stored goods.	(Daim et al., 2013).
	Transportation costs.	The costs associated with exchange of goods or services and incurred in overcoming market imperfections.	(Falsini et al., 2012), (Daim et al., 2013). (Jayaswal et al., 2012a)
	Logistics costs. Logistics costs /unit.	It refers to total cost of logistics outsourcing and consists of transportation cost, warehousing cost, freight forwarding, customs and excise duties, security cost, packaging cost, etc.	(Kumar and Singh, 2012) (Wouters and Sportel, 2005) (Zolfani et al., 2012)
	Handling cost.	The handling cost includes the replenishment costs per unit of time and the costs of carrying inventory over a unit time period.	(Hsu et al., 2012)
	Fixed Cost.	A periodic cost that remains more or less unchanged irrespective of the output level or sales revenue, as depreciation, insurance, rent, salaries etc.	(Daim et al., 2013).
Flexibility	Flexible billing system	Customise bills according to customers' needs and preferences.	(Jharkharia and Shankar 2007)
	Discount opportunities	Providing time and quantity discount to motivate early and large shipments	(Jharkharia and Shankar 2007)

Continue ➔

Appendix 6-1

Customer performance			
LKPI	**Metrics**	**Description**	**References**
Service Quality and Reliability	Delivery to correct destination.	Number of deliveries to the correct destination out of the total deliveries at specific time.	(Visuddhisat, 2009)
	On-Time Delivery. (Percentage)	The number of shipments that are delivered on the desired delivery date compared to the total number of shipments at a specific time.	(Bititci et al., 2005) (Ballou, 2004) (Murphy and Wood, 2004) (Kumar and Singh, 2012)
	Order delivery time. (Delivery time)	Average delivery time.	(Jayaswal et al., 2012b)
	Personal Contact Quality. (Quality of employees)	Quality of employees	(Rafiq and Jaafar, 2011) (Jharkharia and Shankar 2007)
Service Flexibility	Increase/decrease delivery volume.	Ability to increase/decrease the volume of delivery.	(Stank and Daugherty, 1997)
	Serious/ Risky Delivery.	Ability to handle hazardous materials.	(Rajesh et al., 2013)
Customer Sustainability	Customer growth. Market share.	The percentage increase in the customer number.	(Brewer and Speh, 2000) (Kaplan and Norton, 1992)
	Avoiding customer discrimination	Avoiding any unfair treatments.	

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Logistics Processes Performance			
LKPI	**Metrics**	**Description**	**References**
Logistics Quality	Inventory accuracy.	All the discrepancies that exist between electronic records that represent the inventory and the physical state of the inventory.	(Krakovics et al., 2008)
	Damage due to transportation.	Percentage of damaged orders to the total number of orders.	(Krakovics et al., 2008)
	Inventory/ internal damage.	Percentage of damaged items to total number of items in storage.	(Rajesh et al. 2012a)
	Thefts during transportation.	Numbers of thefts occur during transportation compared with the average number in the industry during a specific time.	(Krakovics et al., 2008)
	Delay Rate	Average Delay orders per year/ month/ customer	
	Additional of manpower at short notice.	Additional manpower at short notice.	(Marasco 2008)
Logistics Productivity	Order fulfilment rate. Complete order fill rate.	The complete process from point of sales inquiry to delivery of a product to the customer: represents the number of units filled as a percentage of the total orders. For example, if customer orders a total of 100units and only 90 are met then the order fill rate is 90%.	(Lai, 2004) (Ballou, 2004) (Chan et al., 2008) (Coyle et al., 2003) (Bowersox et al., 2002) (Brewer and Speh, 2000)
	Delivery of complete order.	Number of complete orders compared to the total number of orders in a specific time.	(Visuddhisat, 2009)
	Expedite urgent shipments.	Availability of special services, % of risky shipments.	(Visuddhisat 2009)
Timeliness	Days order late.	The average late days for all orders in a specific period.	(Chan and Chung, 2004) (Bowersox et al., 2002)
	Order response time.	Is the length of time an order takes in the system, from the point the order is placed until the order is delivered.	(Rafiq and Jaafar, 2011)
	On-time pick-up	Percentage of orders picked-up on time	(Visuddhisat 2009)
	Shortest lead time.	Lead time is the time it takes for an LSP to process an order from when a customer order is received to the moment the order is delivered, (includes, order, handling, manufacturing, production and delivery lead time).	(Hsu et al., 2012)
Process Sustainability	Work conditions.	The designer and manager of the work environment have a legal obligation to make sure those employees and visitors are healthy and safe during their time within the work environment.	(Hubbard, 2009) (Hsu et al., 2012)
	Internal accident rate.	Numbers of internal accidents compared to the industry.	(Sabóia et al., 2006) (Hubbard2009)

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Appendix 6-1

Learning and Growth			
LKPI	**Metrics**	**Description**	**References**
Human Talent	Employee skills, education and knowledge.	Can be measured using the intellectual capital concept: The difference in value between tangible assets and market value of the firm.	(Hsu et al., 2012)
Innovation and Development	TQM certificates.	Total Quality management engagement.	(Epstein and Wisner, 2001)
	Profit from new products/services Percent of sales of new product.	Measuring the profitability of the new firm's products/services individually.	(Kaplan and Norton, 1992)
	R&D budget.	Amount of the annual budget allocated for R&D.	(Mingming et al., 2010)
	Training budget.	Amount of annual budget allocated for employees training.	(Mingming et al., 2010)
Resources Sustainability	Employee/Job satisfaction.	How content the employee is with his/her job. These are affective and cognitive satisfaction levels measured by self-report based on a multi item scale.	(Hubbard, 2009), (Hsu et al., 2012)
	Employee training and educating.	Budget, number and evaluation of training courses arranged for employees	(Epstein and Wisner, 2001**; and** 2005)**;** (Crutzen and Herzing, 2013)
	Employee safety and health.	Can be measured through number of internal accidents	(Hubbard, 2009) (Hsu et al., 2012)
	Cost reduction percentage.	Annual % of cost reduction as a result of improvement and development	(Xiaoping and Chen, 2008) (Rajesh et al. 2011)
	Avoiding employee discrimination.	Rules and regulations that prevent any kind of employee discrimination. Number of employee discrimination cases compared to other firms.	(Kaplan and Norton 1996) (Hsu et al., 2012)
	ISO 14000/28000 certificates.	Environment and risk management in SC.	(Epstein and Wisner, 2001)

Appendix 6-2: Rankings of some Relative Metrics under each LKPI

Perspectives	LKPIs	Metrics	Evaluation	Importance
Financial	Profitability	Operational profit	4.563	0.913
		Profit margin	4.313	0.863
		Economic value added	3.625	0.725
		Profit/employee	3.438	0.688
	Return & Cash-flow	Total revenue	4.500	0.900
		ROE (return on equity)	4.063	0.813
		ROI (return on investment)	4.063	0.813
		Cash-to-cash ratio	4.000	0.800
		ROA (return on assets)	3.750	0.750
	Costs	Warehousing cost	4.313	0.863
		Transportation cost	4.250	0.850
		Logistics cost/unit	4.188	0.838
		Handling cost	4.063	0.813
		Logistics fixed cost	4.000	0.800
		Logistics cost as % of sales	3.625	0.725
		Packaging cost	3.625	0.725
		Ordering cost	3.563	0.713
	Flexibility	Flexible billing system	3.438	0.688
		Discount opportunities	3.375	0.675
Perspectives	**LKPIs**	**Metrics**	**Evaluation**	**Importance**
Customers	Quality & Reliability	Delivery to correct Destination	4.438	0.888
		On-time delivery	4.313	0.863
		Quality of employee	4.188	0.838
	Service Flexibility	Increase/decrease delivery Volume	3.688	0.738
		Increase/decrease shipment	3.625	0.725
		Cargo space confirmation	3.313	0.663
	Customer Sustainability	Customer growth	4.125	0.825
		Avoiding customer discrimination	3.875	0.775
		Customer health and safety	3.750	0.750
		Customer value added	3.500	0.700

Continue ➔

Appendix 6-2

Perspectives	LKPIs	Metrics	Evaluation	Importance
Processes	Processes Quality	Inventory accuracy	4.125	0.825
		Damage due to transportation	4.125	0.825
		Internal damage	3.875	0.775
		Thefts during transportation	3.750	0.750
		Expedite urgent shipment	3.750	0.750
		Additional workers at short notice	3.625	0.725
	Processes Productivity	Order fulfilment	4.250	0.850
		Complete order fill rate	4.063	0.813
		Delivery complete order	3.938	0.788
		Serious delivery	3.750	0.750
	Timeliness	On-time pick-up	4.188	0.838
		Delivery time	4.188	0.838
		Order response time	4.188	0.838
		Days of order late	4.188	0.838
		Delay rate	4.063	0.813
		Average order cycle time	4.000	0.800
		Shortest lead-time	3.875	0.775
	Processes Sustainability	Work Condition- Health/safety of	4.063	0.813
		Internal accident rate	4.000	0.800
		Waste volume	3.813	0.763
		Quantity of HO, CH and	3.500	0.700
		Corporate sustainability report	3.500	0.700
		Employee value added	3.375	0.675
		Average age of vehicles	3.375	0.675
		Green design	3.375	0.675
		Green purchasing	3.313	0.663
Perspectives	**LKPIs**	**Metrics**	**Evaluation**	**Importance**
Learning & Growth	Human Talent	Employee training, educating	4.438	0.888
		Employee skills and knowledge	4.438	0.888
		Training budget	3.875	0.775
		Intellectual capital	3.563	0.713
	Innovation & Development	Rate of costs reduction	4.375	0.875
		Profit from new Products/services	3.938	0.788
		R&D budget	3.938	0.788
	Resources Sustainability	Employee safety and health	4.438	0.888
		TQM certificates	4.188	0.838
		Avoiding employee discrimination	4.188	0.838
		Employee satisfaction	4.125	0.825
		ISO 28000 certificates	3.875	0.775
		ISO 14000 certificates	3.563	0.713
		Resource productivity	3.375	0.675
		Environmental accounting	2.750	0.550
		Green product/service profit	2.750	0.550

Appendix 7-1: Logistics Services Operational Definitions

Main Services	Sub-Services	Activities measured	Description
Inventory and Warehousing	Flow-in activities	Receiving and sorting items.	The basic function of inventory centres is to receive and store items for the time they are needed.
		Handling.	Include all the movement of the items inside the centres (manually or automatically).
		Quality assurance.	All inspection activities of items' type, time, place and features.
		Documenting and inventory control.	Activities related to data entry and record documentation of all items across all stages.
		Monitoring and tracking activities.	Internal monitoring and controlling system inside the inventory centres to ensure the smooth flow, right sequence and high quality of logistics activities.
		Maintaining and optimising activities.	Activities related to development and optimisation of logistics activities to provide more efficient logistics services.
		Barcoding and radio frequency.	Item barcoding to facilitate storage, handling and monitoring activities.
	Flow-out activities	Order filling.	Receiving customers' orders.
		Preparing (planning) shipments.	Planning shipments' items to be picked.
		Picking items	Pre-allocation allocates inventory before the items are picked. Grouping shipment's items in one place for transfer
		Loading items	Loading order's items to vehicles.

Continue ➔

Main Services	Sub-Services	Activities measured	Description
Transportation	In-bound transportation	Putting away received items	Transfer received items to storage locations.
		Cross docking	Receiving and directly transferring shipments to vehicles within 12hours, to reduce time and cost of inventory.
		Shipping items	Transfer selected items to shipping point.
	Out-bound transportation	Freight forward.	Purchasing long-distance transport services from carriers and reselling it to LSUs.
		Customised transportation.	Specific logistics employees with vehicles dedicated to a specific customer to provide customised logistics services.
		Consolidated transportation	Receiving customer's requests products from different source and delivers them together to the customer.
		Frequent operations	Providing fixed schedules of transportation services on a daily, weekly or monthly basis.
		Product return	Moving back returned items (reverse LSP).
Production and Postponement	Assembly	Providing assembly services for industrial firms, such as geographical and production postponement.	
	Packaging	Providing Packaging services, such as first layer packaging, second layer packaging and logistics packaging	
	Labelling	Providing labelling services to facilitate storing, handling, picking and transporting activities.	

Continue ➔

Main Services	Sub-Services	Activities measured
Customers Services	Freight payment and auditing	A freight payment service consists of one or more levels of combined services: may include freight audit, information reporting for logistics and work with a combination of both EDI and paper freight bills. Many companies providing freight payment services offer auditing for both small parcel and small package carriers.
	Help desk	LSP's help desk provides the LSUs with information and support relating to orders, shipments, prices, inventory levels, shipments' location/stages, etc.
	Rate negotiation	Collecting and analysing logistics information and shipping characteristics in the industry to provide freight rate structure to negotiate the best price/service combination.
	Carrier selection	In the case of freight forward "carrier selection services" give the LSUs the chance to select a suitable carrier.
	Order management/fulfilment	Order management integrated system includes: item information, inventory availability, order entry, financial processing, order processing and data analysis and reporting, Order fulfilment is The way LSPs respond to customer orders, Beginning with item inquiry to order configuration, order booking, invoicing, processing, shipment and delivery. It may include order sourcing, planning and changing if necessary.
	Packaging and labelling	Packaging logistics is an approach which aims to develop package and packaging systems in order to support the logistics process and to meet customer/user demand (Dominic et al., 2000). In order to help LSUs to focus on their core function LSPs provide a value-added service related to hand assembly, labelling and bar coding to facilitate item handling, storage and shipment.

Continue ➔

Main Services	Sub-Services	Activities measured
E-logistics Services	Global visibility and tracing	Top strategic Actions: Collaboration and Visibility (**Heaney, 2013**): Internal cross-departmental visibility and integration. Streamline processes for easier monitoring, enhance usability or efficiency. Timeliness and accuracy of exchanging SC transactions data. B2B connectivity/visibility.
	Real-time information sharing	Using cloud-based capabilities and other advanced data storage and sharing technologies to help SC members overcome the challenges of managing complex global SC through providing real-time information-sharing and decision-making. These capabilities enable firms to track the SC flows to see how and where decisions are needed.
	Real-time collaboration and decision-making	
	E-logistics training and education	Providing e-logistics training and education for SC members: quantity and quality of such training courses.
Safety & Security	Risk Assessment	Experience, equipment and tools to assess risks in logistics operations and stages
	Shipment & Equipment Security	Providing security options for shipments and equipment to reduce theft and damage risks
	People Safety & Security	Providing safety and security services to ensure people safety and security throughout the logistics processes

Appendix 9-1: Case Study Data collection Tools

Strategic objectives- Logistics Requirements

	Logistics Requirements											
Strategic Objectives	Reduce Total Logistics Costs	Reduce Cycle Time	Assure Quality in Distribution - Delivery	Acquire the Needed Logistics Resources and Capabilities	Possess State-of-the Art Hardware and Software	Provide Customised Logistics Services	Provide Value-added Logistics Services	Increase Customer Satisfaction	Provide Guidance on Time	Resolve Problems Effectively	Assess Logistics Risks	Build and Sustain Long-Term Collaborations
Profitability												
Financial Resources												
Market Position												
Innovation and development												
Productivity												
Physical Resources												
Human Resources												
Social Responsibilities												

Logistics Requirements – LSP ISFs

	LSP ISFs – Evaluation Criteria										
Logistics Requirements	**LSPs Returns**	**LSPs' Logistics Costs**	**LSPs' Service Quality & Reliability**	**LSPs' Service Flexibility**	**LSPs' Logistics Processes Quality**	**LSPs' Logistics Processes Productivity**	**LSPs' Processes Sustainability**	**LSPs' Human Talent**	**LSPs' Physical Warehousing Resources**	**LSPs' Physical Production & Packaging Resources**	**Logistics Risks Assessment**
Reduce Total Logistics Costs											
Reduce Cycle Time											
Assure Quality in Distribution - Delivery											
Acquire the Needed Logistics Resources and Capabilities											
Possess State-of-the Art Hardware and Software											
Provide Customised Logistics Services											
Provide Value-added Logistics Services											
Increase Customer Satisfaction											
Build and Sustain Long-Term Collaborations											

LSP ISFs (Evaluation Criteria) – LSP Alternatives

	LSP Alternatives											
LSP ISFs – Evaluation Criteria	**LSP1**	**LSP2**	**LSP3**	**LSP4**	**LSP5**	**LSP6**	**LSP7**	**LSP8**	**LSP9**	**LSP10**		**LSPn**
LSPs Returns												
LSPs' Logistics Costs												
LSPs' Service Quality & Reliability												
LSPs' Service Flexibility												
LSPs' Logistics Processes Quality												
LSPs' Logistics Processes Productivity												
LSPs' Processes Sustainability												
LSPs' Human Talent												
Logistics Risks Assessment												

Appendix 9-2: Crucial Logistics Requirements for each Strategic Objective (1st Case Study)

#	Strategic Objectives	Weight	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	Average
1	**Profitability**	0.1131	0.78229	0.68229	0.47321	0.60000	0.78660	0.67321	0.73229	0.78660	0.67321	0.78660	0.60000	0.77321	0.77321	0.77321	0.78660	0.71217
2	**Financial Resources**	0.1180	0.78660	0.65000	0.60000	0.62321	0.78660	0.56202	0.57321	0.62321	0.50000	0.55000	0.61283	0.62321	0.62321	0.62321	0.61202	0.62329
3	**Market Position**	0.0996	0.37639	0.35000	0.62247	0.68229	0.78229	0.77321	0.73229	0.78660	0.67321	0.55000	0.32679	0.77321	0.73229	0.73229	0.78229	0.64504
4	**Innovation**	0.0865	0.20635	0.78229	0.73229	0.63229	0.75000	0.63229	0.77321	0.78229	0.78229	0.78229	0.73229	0.62321	0.51202	0.62321	0.78660	0.67553
5	**Productivity**	0.1444	0.27679	0.75000	0.63229	0.57321	0.73660	0.55000	0.58229	0.68229	0.67247	0.73660	0.60000	0.72321	0.50000	0.66213	0.75000	0.62853
6	**Physical resources**	0.0975	0.20635	0.62247	0.72321	0.50000	0.78660	0.55000	0.65000	0.55000	0.55000	0.71213	0.60000	0.55000	0.57321	0.57321	0.63229	0.58530
7	**Human Resources**	0.1301	0.37679	0.67321	0.62321	0.37639	0.78229	0.60000	0.62321	0.63229	0.62247	0.78660	0.68229	0.78660	0.68229	0.67321	0.68229	0.64021
8	**Social Responsibility**	0.0460	0.24083	0.15635	0.57321	0.60000	0.51202	0.56202	0.62321	0.57321	0.56202	0.60000	0.37639	0.52321	0.47321	0.52321	0.50000	0.49326
9	**Excellent Handling**	0.0927	0.68660	0.75000	0.73229	0.58229	0.78660	0.68229	0.68660	0.68229	0.51202	0.67247	0.66202	0.61202	0.55000	0.68229	0.68660	0.66443
10	**Customer Satisfaction**	0.0719	0.20635	0.73660	0.67906	0.15635	0.78229	0.50000	0.67906	0.67906	0.67247	0.73660	0.57247	0.51213	0.68229	0.67321	0.78660	0.60364

Appendix 9-3: Crucial LSPs Criteria for each Logistics Requirement (1st Case Study)

#	Logistics Requirements	Weight	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	Average
1	Reduce Total Logistics Cost	0.048	0.712	0.326	0.550	0.313	0.787	0.612	0.773	0.773	0.682	0.450	0.462	0.412	0.313	0.500	0.600	0.450	0.400	0.376	0.291	0.377	0.712	0.518
2	Reduce Cycle Time	0.069	0.673	0.213	0.650	0.513	0.787	0.787	0.762	0.750	0.650	0.650	0.600	0.762	0.450	0.600	0.762	0.600	0.450	0.612	0.600	0.612	0.612	0.624
3	Assure Quality Distribution-Delivery	0.066	0.732	0.450	0.762	0.600	0.737	0.750	0.612	0.787	0.600	0.700	0.550	0.712	0.500	0.400	0.700	0.700	0.550	0.550	0.550	0.500	0.550	0.619
4	Acquire the Needed Logistics Resources and Capabilities	0.057	0.737	0.750	0.600	0.650	0.712	0.762	0.562	0.723	0.600	0.662	0.700	0.712	0.550	0.650	0.550	0.550	0.263	0.550	0.350	0.550	0.500	0.604
5	Possess State-of-the Art Hardware-Software	0.080	0.673	0.623	0.600	0.513	0.632	0.662	0.712	0.773	0.650	0.612	0.712	0.700	0.400	0.600	0.750	0.550	0.263	0.650	0.463	0.500	0.500	0.597
6	Provide Customised Logistics Services	0.063	0.750	0.623	0.612	0.700	0.463	0.700	0.712	0.787	0.613	0.762	0.600	0.712	0.362	0.612	0.700	0.550	0.463	0.562	0.700	0.450	0.450	0.614
7	Provide Value-added Logistics Services	0.069	0.612	0.712	0.682	0.700	0.762	0.662	0.773	0.787	0.679	0.512	0.750	0.662	0.400	0.612	0.700	0.550	0.450	0.550	0.712	0.700	0.600	0.646
8	Increase Customer Satisfaction	0.071	0.687	0.363	0.750	0.673	0.712	0.737	0.623	0.737	0.562	0.762	0.762	0.773	0.450	0.612	0.762	0.623	0.623	0.773	0.750	0.750	0.773	0.679
9	Provide Guidance on Time	0.065	0.463	0.612	0.682	0.650	0.762	0.682	0.662	0.773	0.650	0.600	0.562	0.700	0.500	0.600	0.700	0.750	0.463	0.600	0.550	0.550	0.750	0.632
10	Resolve Problems Effectivity	0.073	0.363	0.662	0.512	0.712	0.762	0.513	0.762	0.762	0.650	0.700	0.550	0.762	0.600	0.612	0.463	0.700	0.463	0.500	0.600	0.550	0.762	0.617
11	Assess Logistics Risks	0.062	0.563	0.650	0.563	0.650	0.700	0.463	0.750	0.662	0.513	0.413	0.700	0.750	0.600	0.500	0.650	0.600	0.413	0.463	0.700	0.563	0.762	0.601
12	Build and Sustain Long-Term Collaborations	0.070	0.673	0.600	0.673	0.600	0.550	0.413	0.700	0.600	0.650	0.450	0.650	0.750	0.600	0.500	0.600	0.650	0.513	0.700	0.550	0.650	0.550	0.601
13	Providing Sustainable Logistics Services	0.064	0.723	0.650	0.732	0.550	0.700	0.650	0.762	0.750	0.613	0.600	0.700	0.550	0.350	0.600	0.550	0.550	0.413	0.600	0.400	0.650	0.700	0.609
14	Strategic Compatibility	0.069	0.682	0.673	0.600	0.600	0.600	0.782	0.650	0.750	0.613	0.550	0.700	0.700	0.550	0.400	0.500	0.450	0.263	0.413	0.500	0.450	0.500	0.568
15	Continuous Measuring of Results	0.075	0.463	0.623	0.712	0.550	0.500	0.550	0.612	0.762	0.613	0.563	0.750	0.650	0.412	0.550	0.400	0.450	0.263	0.413	0.400	0.300	0.550	0.528

Appendix 9-4: Crucial Logistics Requirements for each Strategic Objective (2nd Case Study)

#	Strategic Objectives	Weight	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	Average
1	Profitability	0.125	0.7500	0.5000	0.5000	0.5000	0.2500	0.5000	0.5000	0.7500	0.7500	0.2500	0.7500	0.5455
2	Financial Resources	0.125	0.5000	0.5000	0.2500	0.0732	0.5000	0.0732	0.7500	0.7500	0.5000	0.5000	0.5000	0.4451
3	Market Position	0.125	0.2500	0.7500	0.7500	0.7500	0.7500	0.5000	0.2500	0.7500	0.7500	0.5000	0.5000	0.5909
4	Innovation and development	0.125	0.5000	0.7500	0.7500	0.2500	0.2500	0.5000	0.2500	0.2500	0.2500	0.2500	0.5000	0.4091
5	Productivity	0.125	0.7500	0.7500	0.5000	0.5000	0.7500	0.7500	0.7500	0.5000	0.5000	0.0732	0.2500	0.5521
6	Physical Resources	0.125	0.5000	0.5000	0.7500	0.5000	0.5000	0.7500	0.5000	0.7500	0.5000	0.5000	0.2500	0.5455
7	Human Resources	0.125	0.5000	0.2500	0.5000	0.7500	0.7500	0.7500	0.7500	0.7500	0.7500	0.5000	0.7500	0.6364
8	Social Responsibilities	0.125	0.5000	0.5000	0.2500	0.5000	0.0732	0.5000	0.5000	0.5000	0.0732	0.7500	0.5000	0.4224

Appendix 9-5: Crucial LSPs Criteria for each Logistics Requirement (2nd Case Study)

#	Logistics Requirements	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	Average
1	Reduce Total Logistics Costs	0.750	0.750	0.750	0.250	0.500	0.500	0.500	0.250	0.750	0.500	0.750	0.500	0.500	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.606
2	Reduce Cycle Time	0.250	0.750	0.500	0.500	0.500	0.750	0.750	0.750	0.500	0.750	0.500	0.500	0.500	0.500	0.750	0.750	0.750	0.750	0.500	0.500	0.750	0.584
3	Assure Quality in Distribution -	0.250	0.750	0.500	0.250	0.073	0.750	0.500	0.073	0.250	0.750	0.500	0.500	0.500	0.500	0.750	0.500	0.750	0.750	0.500	0.750	0.750	0.499
4	Acquire the Needed	0.750	0.750	0.750	0.750	0.500	0.500	0.750	0.250	0.750	0.750	0.500	0.750	0.750	0.750	0.500	0.500	0.750	0.750	0.750	0.250	0.750	0.618
5	Possess State-of-the Art	0.750	0.500	0.250	0.750	0.500	0.500	0.500	0.500	0.500	0.750	0.750	0.750	0.750	0.750	0.500	0.750	0.750	0.750	0.750	0.500	0.250	0.583
6	Provide Customised	0.500	0.500	0.500	0.250	0.750	0.750	0.750	0.750	0.250	0.750	0.750	0.500	0.500	0.750	0.500	0.750	0.750	0.750	0.500	0.500	0.500	0.573
7	Able to Provide Value-added	0.500	0.750	0.750	0.250	0.750	0.500	0.750	0.750	0.750	0.750	0.500	0.750	0.500	0.500	0.750	0.750	0.750	0.750	0.750	0.500	0.500	0.618
8	Increase Customer	0.500	0.500	0.750	0.750	0.250	0.250	0.500	0.250	0.750	0.750	0.750	0.750	0.500	0.250	0.750	0.500	0.750	0.750	0.750	0.250	0.500	0.539
9	Able to Resolve Problems	0.750	0.750	0.250	0.500	0.500	0.750	0.250	0.750	0.750	0.500	0.500	0.750	0.500	0.750	0.750	0.750	0.500	0.750	0.750	0.500	0.500	0.584
10	Able to Assess Logistics Risks	0.750	0.750	0.500	0.500	0.750	0.750	0.250	0.500	0.750	0.500	0.750	0.750	0.750	0.750	0.750	0.750	0.500	0.750	0.500	0.250	0.500	0.594
11	Able to Build and Sustain	0.750	0.750	0.750	0.500	0.500	0.750	0.500	0.250	0.750	0.750	0.500	0.250	0.500	0.500	0.750	0.750	0.750	0.750	0.500	0.500	0.250	0.561

Appendix 10-1: SCM Platform: Real-time information sharing and decision-making